

THE SECOND WORLD WAR
1939-1945
ARMY

MAPS AND SURVEY

COMPILED BY
BRIGADIER A. B. CLOUGH
C.B.E., M.C.

THE WAR OFFICE
1952

FOREWORD

This book is one of a series of volumes, compiled by authority of the Army Council, the object of which is to preserve the experience gained during the Second World War, 1939–1945, in selected fields of military staff work and administration. The author has been given access to official sources of information, and every endeavour has been made to ensure the accuracy of the work as a historical record. Any views expressed and conclusions drawn are those of the author, and do not necessarily reflect those of the Army Council, which, so far as they relate to current training, are to be found in the official manuals, training memoranda, etc., issued from time to time by the War Office.

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ABBREVIATIONS

A.A.I.	Allied Armies in Italy.
A.B.S.	Atlantic Base Section.
A.D.	Assistant Director.
A.D.G.B.	Air Defence of Great Britain.
A.E.A.F.	Allied Expeditionary Air Force.
A.F.H.Q.	Allied Forces Headquarters.
A.G.R.A.	Army Group, Royal Artillery.
A.L.F.S.E.A.	Allied Land Forces, South East Asia.
A.M.D.	Advanced Map Depot.
A.M.S.	Army Map Service (U.S.).
A.P. and S.S.	Army Printing and Stationery Service.
A.P.I.S.	Air Photographic Interpretation Section.
A.P.I.U.	Army Photographic Intelligence Unit.
A.T.S.	Auxiliary Territorial Service.
B.C.	Bureau de Cadastre.
B.E.F.	British Expeditionary Force.
B.T.	Bureau Topographique des Troupes du Levant.
B.T.E.	British Troops in Egypt.
C.B.O.	Counter Battery Organization.
Com. Z	Communications Zone.
C.O.S.S.A.C.	Chief of Staff to the Supreme Allied Commander.
C.R.A.	Commander, Royal Artillery.
D.G.O.S.	Director General, Ordnance Survey.
D.M.O. & I.	Division of Military Operations and Intelligence.
E.A.E.	East African Engineers.
E.T.O.U.S.A.	European Theatre of Operations, United States Army.
F.A.A.A.	First Allied Airborne Army.
F.M.S.	Federated Malay States.
F.U.S.A.	First United States Army.
G.S.G.S.	Geographical Section, General Staff.
I.A.S. & T.	Indian Air Survey and Transport Ltd.
I.G.N.	Institut Géographique Nationale.
I.H.B.	International Hydrographic Board.
I.P.C.	Iraq Petroleum Company.
I.S.T.D.	Inter-Service Topographical Department.
K.A.R.	King's African Rifles.
L. of C.	Line of Communications.
M.A.I.U.	Mediterranean Air Intelligence Unit.
M.A.P.R.W.	Mediterranean Allied Photographic Reconnaissance Wing.
M.E.I.U.	Middle East Interpretation Unit.
M.S.S.	Map Supply Section.
N.A.P.R.W.	North African Photographic Reconnaissance Wing.
N.C.A.C.	Northern Combat Area Command.
O.C.T.U.	Officer Cadet Training Unit.
O.P.	Observation Post.
O.S.	Ordnance Survey.
Paiforce	Persia and Iraq Force.
P.C.G.N.	Permanent Committee on Geographical Names.
P.R.	Photo Reconnaissance.
P.R.U.	Photo Reconnaissance Unit.

R.A.M.O.	Rear Airfield Maintenance Organization.
S.A.A.F.	South African Air Force.
S.A.C.S.E.A.	Supreme Allied Commander, South East Asia.
S.A.E.C.	South African Engineer Corps.
S.E.A.C.	South East Asia Command.
S.G.A.	Service Géographique de l'Armée Française.
S.H.A.E.F.	Supreme Headquarters Allied Expeditionary Force.
S.O.S.	Services of Supply (U.S.).
S.P.C.	Survey Production Centre.
S.R.	Southern Rhodesia.
S.T.C.	Survey Training Centre.
S.W.P.A.	South Western Pacific Area.
T.A.F.	Tactical Air Force.
U.S.A.A.F.	United States Army Air Force.
W.A.	West Africa.
W.A.A.F.	Women's Auxiliary Air Force.

PREFACE

A few words of comment and explanation concerning this Survey History may assist the reader to appreciate its purpose, the sources from which the information was obtained, and the basis on which comments are offered.

The object of the book is to present in a convenient and accessible form the principal facts and features concerning Maps and Survey during the Second World War for the benefit of instructors and students at Military Educational Establishments, of staff officers, and of others who will be responsible for the organization, training and development of the Army for any future war which may arise.

The subject matter has been compiled from the following sources:—

The personal experience of officers who held appointment as Directors of Survey, Survey Staff Officers, or as officers serving with survey units.

A study of reports, diaries, correspondence, and other documents dealing with survey activities on the home front and in the various operational theatres.

This is not in any way a text-book. It does not lay down policy but purports to state only historical facts. Whatever comments and suggestions there may be are obviously matters of opinion, and are included primarily to form a basis for further thought and discussion, when those who will be responsible for future survey policy, or for the employment of survey personnel, will require to make their appropriate decisions.

The limiting size and scope of this book do not permit it to be a complete history of all the survey units concerned. Certain units are mentioned by name in connection with specific incidents and tasks; there are many units, however, to which no special reference is made, but whose achievements during the war, and whose contribution to final victory were of the highest order. With regard to individuals, named reference is made, generally speaking, only to those who held the higher survey appointments.

For certain phases of survey operations the writer had some difficulty in finding any written records or reports. In some cases this was owing to the overriding need for extreme security at the time, which reduced the information that could safely be recorded on paper to a minimum. In other cases the war diaries and other records were lost either by enemy action or by deliberate destruction to avoid risk of capture.

For each campaign an attempt has been made to provide an operational background against which the narrative of survey activities could be written. This is considered of importance, as survey officers must always make themselves fully conversant with the current operational picture and future plans if they are to provide efficient service. This fact should be realized by all staff officers.

A sketch map is included for each of the main operational theatres, on which the majority of place names mentioned in the text will be found.

At the end of the book will be found a number of map specimens. It was, of course, impossible to include a specimen of each of the very large number

of map series produced during the war, but those now shown provide a fair cross-section of the principal varieties of maps which were used operationally. The preparation of these specimens for printing and publication was undertaken by members of the staff of the Directorate of Military Survey and the Ordnance Survey. The author acknowledges the valuable assistance given by these officers, and by all those others, including survey officers of the Dominion and Colonial Forces and of the United States Army, who have assisted in the compilation of this history with their notes and criticisms.

The Titles of Survey units used in the text are those which were current during the war. Some have since been altered.

Whenever India is mentioned in the text it refers to the period before partition.

At the date of publication it is of interest to note that action has been taken concerning certain of the aspects of Survey policy discussed in this history. Amongst them may be mentioned the following:—

- (a) The execution of surveys in the Colonies is now organized and controlled by a Directorate of Colonial Surveys with headquarters in London, and the mapping of large areas in East Africa and elsewhere has already been completed by air survey methods. (See page 150.)
- (b) There is now a School of Military Survey, which is the direct successor to the Survey Training Centre R.E. (See page 12.)
- (c) The adjustment of the European national triangulations has been completed, and it has been decided to adopt a Universal Transverse Mercator Grid with 6 degree belts for the military maps of Europe. This will have the great advantage of reducing the number of grid junctions in a potential operational area. (See page 413.)

HISTORICAL NOTE

By way of introduction to this volume it is of interest to refer to a document concerning Maps and Survey during the First World War entitled "Report on Survey on the Western Front 1914-1918." In the first paragraph it was stated that the organization for map provision with the original Expeditionary Force in 1914 was as follows:—

- "(a) The topographical sub-section of the General Staff at G.H.Q. consisting of one officer and one clerk.
- "(b) One officer and a clerk attached to H.Q. Lines of Communication to look after reserve map supplies.
- "(c) One Printing Company R.E. which had its H.Q. Section on the Line of Communication, and a small mobile section with each corps."

This provision was based on the anticipated needs of a small force operating under favourable conditions, and on the supply of nothing but small scale maps produced in England. As events turned out, it showed a totally inadequate conception of the probable survey requirements of an expeditionary force embarking on a modern war.

The growth of the survey organization between 1914 and 1918 was extensive and rapid. The size of the British Force expanded to an extent quite undreamed of in August, 1914, and the technical development of survey activities in connection with mapping, map supply, artillery control, sound ranging and flash spotting was as remarkable as it was unforeseen. The evolution of static or trench warfare resulted in a demand for large scale maps, not only for use by the artillery, but also as tactical maps on which the trench systems could be overprinted. The development of aerial photography for intelligence and mapping purposes introduced a new factor in which the Survey Service was very vitally interested.

It should be noted that, in the First World War, there were no artillery survey regiments. The development and the execution of all work concerning artillery control surveys, sound ranging, and flash spotting was in the hands of Royal Engineer survey units. It will be seen, therefore, that between 1914 and 1918, R.E. Survey developed into a highly technical and quite indispensable organization of ample proportions.

With the scientific development of survey methods for artillery control, it was natural that, when the British Army was being reorganized for the post-war period, plans were laid for the Royal Artillery to take over the responsibility for those activities which were peculiarly required for their own domestic purposes. As a result, the sappers handed over to the gunners the responsibility for survey work connected with sound-ranging, flash-spotting, and the fixation of gun positions to the survey grid. Artillery Survey Regiments were formed and a Survey Wing was organized at the School of Artillery. It was agreed policy, however, that the Royal Engineers would continue to be responsible, on active service, for producing and maintaining the basic triangulation network, for all survey work other than that of a purely artillery nature, and for the production and supply of all maps which the ground and air forces would require.

The effect of this reorganization on the R.E. Survey Service was unfortunate. After the war all the R.E. survey units disappeared altogether except for one small unit which was located near the Ordnance Survey Office at Southampton. This was, in effect, a training and depot unit only where training courses in military subjects and field survey were held for the military personnel serving with the Ordnance Survey. Occasionally during the few years before 1939, when important training exercises were held in one or other of the Home Commands, a small R.E. Survey party was scratched together on an *ad hoc* basis, partly from the Ordnance Survey and partly from the Depot Company, to represent the R.E. Survey organization and to provide the necessary triangulation control for the Artillery Survey Regiments. These exercises were spasmodic, and the R.E. personnel employed on them was almost always different on each occasion. Add to this the fact that, during pre-war years, Survey was not represented in any shape or form at the headquarters of any Home Command or formation, and that map supply and distribution to the troops under training was an almost automatic supply direct from the War Office to the Commands, and it will be realized that, during the critical years leading up to the Second World War, there was little if any opportunity for R.E. Survey personnel to learn and practise their war-time survey duties or to accustom themselves to army organization or procedure. Conversely, the rest of the Army, and especially the General Staff, were not able to gain any knowledge about the Survey Service, what it could do for them in the way of map production and supply and field surveys, or what facilities, in return, Survey would require from them.

It is a platitude to state that co-operative training during peace is essential for success in war. The lack of it, as concerning Survey, proved to be a considerable handicap during the early periods of operations in all theatres. The Survey Directorates and units which were mobilized in the late summer of 1939 to take their places with the British Expeditionary Force had no pre-war nucleus, the personnel, both officers and other ranks, having been drawn mainly from the Ordnance Survey. They had never worked together as a team before, many of them were not sufficiently conversant with the organization of a modern army, and their peace-time occupation, though technically valuable in many respects, was not adequate to fit them for their immediate duties under active service conditions.

CHAPTER I

BASIC SURVEY ORGANIZATIONS IN THE UNITED KINGDOM

Page

The following diagram is relative to this chapter:—

Diagram 1. *The British Military Survey Organization (May, 1945)* 4

SECTION 1. DIRECTORATE OF MILITARY SURVEY (WAR OFFICE) (GEOGRAPHICAL SECTION, GENERAL STAFF)

Pre-war status and functions

For many years before the 1939–45 war, the responsibility for dealing with Survey matters at the War Office had been vested in the Geographical Section of the General Staff, known as M.I. 4. This section, which operated under the Director of Operations and Intelligence, was headed by a Royal Engineer Colonel, and worked on a branch level. The officer staff consisted principally of R.E. officers with survey qualifications, assisted by one or two R.A. or infantry officers.

The staff, other than officers, consisted mainly of technical civil assistants and clerks, and a small number of Royal Engineer other ranks. The total number employed at M.I. 4 during the early part of 1939 amounted to about 70.

The principal functions of M.I. 4 during peace included the following items:—

- (a) The preparation and supply to British forces, both at home and abroad, of all maps required for defence, local administration, military training and any local operations which might arise.
- (b) The preparation and supply, to all branches of the War Office staff, of all standard or special maps which they required in connection with their work.
- (c) The collection of information about, and, if possible, copies of, all maps which were current or were newly produced by foreign countries, so as to build up a War Office map library and ensure that map material was available for the preparation of operational map series in the event of war.
- (d) The collection of data concerning foreign survey systems and their triangulation networks, in order to build up a War Office technical library dealing with such subjects.
- (e) Advice to the General Staff on all subjects of survey policy concerning training and preparation for war, and the arrangements for implementing such approved policy. This included such items as the design and formation of survey directorates and units, the provision of survey equipment and stores, and the issue of general instructions as to survey methods and practice.
- (f) The initiation and execution of all necessary programmes of mapping, and the preparation of survey data to meet the probable requirements of an Expeditionary Force in the event of mobilization for war.

- (g) Advice to the Colonial and Foreign Offices on matters concerning Boundary Commission Surveys and any special survey work required in any of the Colonies, and the provision of assistance regarding the formation and equipment of survey parties for carrying out such work.

Pre-war organization

The pre-war organization of M.I. 4 was inadequate both in size and general arrangement for dealing with all the problems that arose when preparing for a major war. An "Organization" sub-section was responsible for all matters concerning the design, formation and mobilization of survey staffs and units and the provision of technical equipment and stores. It proved to be very much under-staffed for this purpose. The mapping organization was largely based on a system of geographical regions whereby sub-sections, controlled by separate officers, made a special study of particular continents or areas, collecting all the relevant information thereof, and supervising the preparation of maps of their own region. This often led to an unequal and uneconomic distribution of work, and to compensate for this it was customary to allocate *ad hoc* jobs to one sub-section or another, cutting right across the regional organization. A geodetic sub-section concerned itself with the acquisition of foreign survey and triangulation data, and with the day to day technical investigations and work connected with geodetic problems both at home and overseas. M.I. 4 had under its direct control a staff of high-grade topographical draughtsmen and a small map-reproduction installation comprising cameras, lithographic printing machines, and all the other necessary ancillary equipment to enable map production and printing to be carried out on the spot on a limited scale. The Map Library concerned itself with the acquisition of map specimens from all parts of the world and cartographic intelligence data.

Preparations for war

In the spring of 1936 the evidence that Germany was intending and preparing to launch another world war became so strong that the D.M.O. and I. authorized the start of a large programme of new mapping at a scale of 1/50,000 to cover the whole of north-eastern France and Belgium. Other ancillary mapping was also authorized, and the Treasury was approached for the necessary financial provision. Funds ten times in excess of the normal annual vote for M.I. 4 were made available in April, 1936, and the extensive mapping programme was initiated by Colonel P. K. Boulnois who was at that time at M.I. 4. The amount of work entailed was so great that it was decided to allocate practically all of it to the Ordnance Survey for execution by them under War Office control. After the Munich meeting it was considered advisable to hasten production, and an extra officer was added to the establishment in order to exercise specific control of this vital programme. An additional officer was also obtained for duties connected with survey organization in the event of mobilization, but this was by no means adequate to deal with the situations that arose as the date for mobilization drew closer.

M.I. 4 moves to Cheltenham on the outbreak of war

In the event of war it had been intended that many of the War Office departments should move to Cheltenham. These moves were contemplated mainly in order to provide room in London for the expansion of those branches which

it was deemed essential should stay in Whitehall, and in some measure also to give protection against air attack.

In spite of urgent representations as to the unfortunate effects of such a move M.I. 4 was ordered to transfer to Cheltenham in September, 1939. As things turned out very few of the other War Office branches left London until late 1940, and the move of M.I. 4 had the serious effect of putting it out of daily touch with the General Staff at a critical period. Further, the Map Library, which obviously had to be located alongside M.I. 4 at Cheltenham, where it was required for new map compilation, was now cut off from General Staff officers still working in London.

Another difficulty created by these conditions was the distance which now separated M.I. 4 from its main Map Depot at Alperton, in one of London's north-western suburbs, where it remained during the whole war.

Organizational changes in M.I. 4

With the outbreak of war M.I. 4 was organized into three main sub-sections:—

- (a) One for map design and production, under which was placed the Map Library.
- (b) One for general organization, *e.g.*, all "A.," "Q.," and "S.D." matters and technical stores.
- (c) One for geodesy, grids, trig records, etc.

War Office-Air Ministry mapping policy

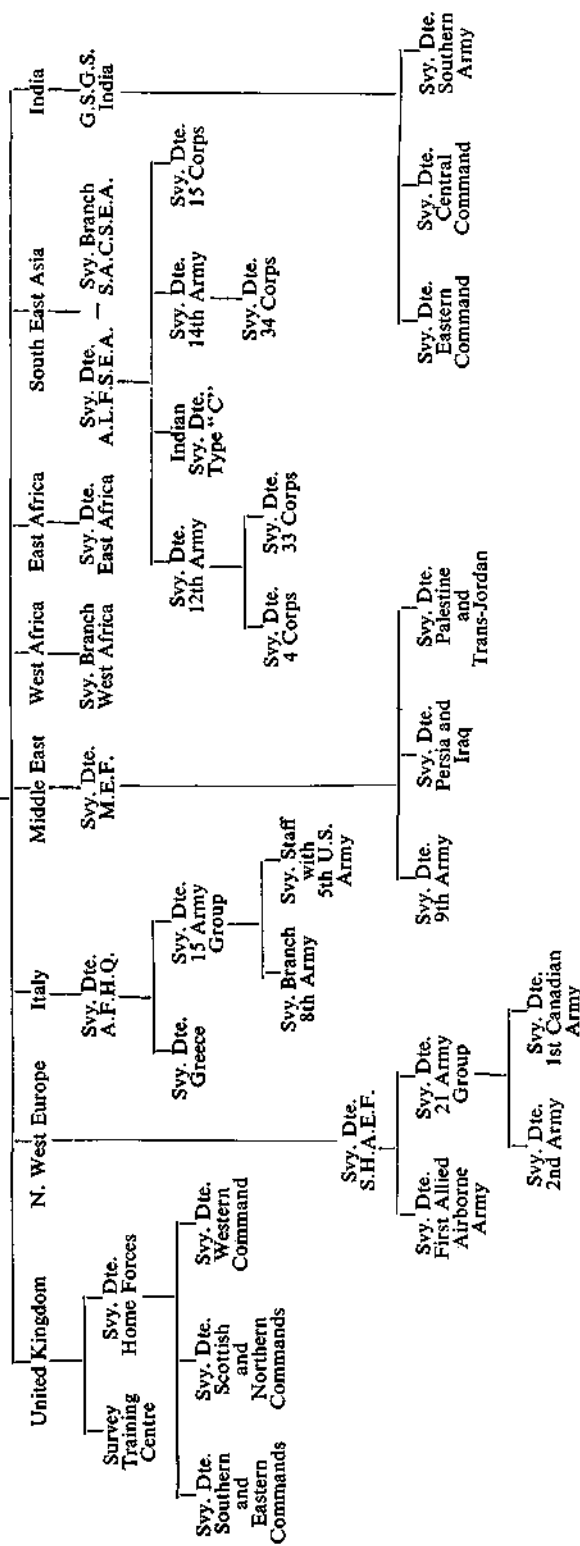
At this stage it is necessary to consider the arrangements that existed between the War Office and the Air Ministry concerning map policy and supply for the Royal Air Force. As far back as 1919 it had been agreed that the War Office should accept responsibility for Air Ministry and R.A.F. mapping requirements. During the pre-war years this was implemented by the formation of a map section at the Air Ministry which was under the technical supervision of one of the M.I. 4 officers, and maintained a small staff of clerks and draughtsmen held on Air Ministry establishment. The officer, as representing M.I. 4 (Colonel), was the technical survey and mapping adviser to the Air Staff and, when policy agreement was reached on matters of map design, production, and supply for R.A.F. requirements, M.I. 4 was then responsible for putting the programme into execution. It was not a satisfactory arrangement even in peace-time and, during the early war years, it proved so unsatisfactory that, as will be seen later, it gave place to a more efficient and economical system.

About the same time as M.I. 4 moved to Cheltenham, the Air Ministry Map Section was moved to Harrow, and this wide geographical separation between the two produced the undesirable situation of the Air Ministry Map Section functioning more or less independently. Quite apart from the vital necessity of having and maintaining one firm, central mapping policy and control, especially with the ever increasing need for Army/Air co-operation, it was essential that the arrangements for meeting overseas map demands and their subsequent shipment should be centralized under one control. This would prevent duplication of map orders and despatch, with its attendant confusion and waste of material and effort.

During the latter part of 1941 Colonel M. Hotine succeeded Colonel P. K. Boulnois as head of the Geographical Section, and held the appointment till the end of the war.

The British Military Survey Organization (May, 1945)

DIRECTORATE OF MILITARY SURVEY WAR OFFICE



NOTE:—The Australian Survey organization, which was operating in the Pacific under U.S. control, is not included in the above, nor are the American or other Allied Survey organizations.

G.S.G.S. moves back to London and is reorganized

The unsatisfactory situation whereby M.I. 4, located at Cheltenham, was separated from the Operations, Intelligence and Planning Staffs at the War Office and from the Air Ministry Map Section at Harrow, continued for some months, to the disadvantage of all concerned. Unsuitable and inadequate accommodation at Cheltenham added to these difficulties, especially in view of the augmented staff of draughtsmen, increased map printing plant, and rapidly growing map stores. It was realized that the complete move of the whole Section at a critical stage of the war might cause a serious dislocation of work, but on balance it was decided that such a move was essential for the following main reasons:—

- (a) To re-establish close and constant daily touch with the General Staff.
- (b) To absorb the Air Ministry Map Section from Harrow.
- (c) To obtain bigger and more satisfactory accommodation.

Suitable premises were eventually found at Eastcote on the outskirts of London, and the move of M.I. 4, now redesignated G.S.G.S., was satisfactorily carried out. At this juncture a new Distribution Section was formed to handle the rapidly increasing volume of work involved in the assembly and despatch of map stocks to all parts of the world, and the supply of maps to the various overseas expeditions which were now beginning to take shape. At the same time it was decided to divide the actual mechanics of map reproduction from the staff planning side with a view to reducing the load on the latter. The staff planning side would then be able to exercise a better and more even control over all production, whether this was carried out in the directly controlled War Office reproduction installation, or by some outside agency such as the Ordnance Survey or civilian printing firms. Unfortunately the accommodation at Eastcote was not sufficient to allow the drawing and printing installation to be housed alongside the rest of the Section, which would have been the ideal, and it was necessary, by force of circumstances, to put up with its geographical separation a few miles away at Hanwell, in a suitable factory building known as "Hygrade," where its productive capacity was doubled and it was re-equipped with modern equipment.

In view of the extensive map printing resources which exist at the Ordnance Survey and, with the civilian lithographic printing firms in Great Britain, it might be well to state some of the principal reasons why it is essential for the War Office to maintain under its control an adequate printing plant of its own:—

- (a) During peace and, to a much greater extent during war, there are always countless demands for special maps, diagrams, situation overprints, etc., which are required at short notice by the various War Office branches. Many of these are of a high security nature, involving very close control, which precludes the possibility of having the work done outside.
- (b) During peace, the Ordnance Survey printing resources are usually stretched to capacity with their own programmes of national mapping, and it is essential that the War Office shall be able to produce without delay stocks of any maps which are urgently required for training or other purposes, when time is short.

- (c) During war there are constant requirements for urgent, last minute, high-security map stocks for special purposes such as commando raids, special air operations, etc., and these jobs must be done under direct close control in order to ensure secrecy and punctual delivery. A very striking example of this was in connection with some of the many planned airborne operations during the last year of the war. Very often there were only a few hours available to prepare special maps, print stocks of large scale maps, and deliver them to the waiting formations.
- (d) When considering new map design, it is necessary that the War Office shall be able to carry out its own experimental research and trials.

G.S.G.S. becomes a War Office Directorate

The extension of active operations over wide areas and the large amount of planning that was involved made it more and more necessary that the War Office Survey staff should be kept fully and punctually informed as to current operational situations and future plans. The Geographical Section, so long as it remained on a "Branch" level, was not getting sufficient information, even though headed by a full Colonel. Most matters of policy in the War Office were circulated on a Directors' level, and it was always possible that the Directors of Operations and Planning might fail to detect a survey repercussion in such policy directives. The survey organization was in any case under-graded for the responsibility which it was by now undertaking. Action was therefore taken to have the Section re-established as a Grade "B" Directorate with its various sub-sections graded as branches, which could thereby deal direct on an appropriate level with other branches in the War Office.

The move of the Geographical Section to Eastcote and its reorganization as the Military Survey Directorate brought to a head the necessity for the recognition by the Air Ministry of an integrated Survey staff to serve both Services. This was at last effected with the result that the entire Survey Service, both at home and overseas, became recognized as a common user service, which was to everyone's advantage.

The responsibilities and activities of the Directorate of Military Survey will be appreciated from a study of Diagram 1. This shows in skeleton form the general organization of the Military Survey Service which was operating under the Survey policy control of Brigadier M. Hotine, who was Director of Survey at the War Office during the last three years of the war. The Directorate of Military Survey was responsible also for the training of Survey personnel and the design and provision of technical survey equipment and stores.

SECTION 2. THE ORDNANCE SURVEY OF GREAT BRITAIN

The Ordnance Survey has, during both World Wars, played such a prominent part in the production of maps for the armed forces that it is well to consider its organization, characteristics and potentialities, and to discuss the relations between it and the War Office, not only as they have existed in the past, but also as they may be affected in the future.

The reputation and achievements of the Ordnance Survey, not only as the official British national mapping institution, but also in its relation to Inter-

national cartography and geodesy are well known. The national maps of Great Britain are second to none in their variety, accuracy and quality of reproduction. In the day to day administration and general activities of the country, Ordnance Survey maps, especially those on large scale, play a leading part in connection with town planning, engineering projects, land registration and conveyancing, and a host of other purposes. They are accepted as evidence in courts of law. The smaller scale maps, such as the One-Inch, Quarter-Inch and smaller, have always had a ready sale with the public for walking, motoring, etc., and they are the official maps for military training, defence and other such purposes. The organization has, in short, always been one of high repute and efficiency, and its contribution towards the production of maps for the ground and air forces during two wars has been remarkable.

Although originally founded under the Board of Ordnance (hence the name Ordnance Survey), the Department has for many years been controlled by the Ministry of Agriculture and Fisheries. Since its inception it has always had, as Director General, an officer trained in the Royal Engineers, and it has always been customary for R.E. officers to fill the remaining senior appointments in the Department. With regard to the rank and file, before 1939 there was a mixed staff of civilian and military personnel. A number of R.E. other ranks, held on an establishment known as the Survey Battalion R.E. and paid for out of the Ordnance Survey (O.S.) vote, were employed on every form of technical duty, working alongside their civilian colleagues. As a general rule these men completed their full Colour service with the Survey Battalion R.E. and were then retained for work at the O.S. as civil servants until reaching the normal age limit for retirement. Thus a large proportion of the civil staff consisted of ex-R.E. personnel. There were also a number of direct civilian entrants to the Department for both clerical and technical duties.

The principal peace-time duties of the O.S. during the period leading up to the 1939-45 war were:—

- (a) The establishment of a new triangulation network over the whole country to replace the old out-of-date system.
- (b) The production and maintenance of the levelling network.
- (c) The maintenance of existing small and medium scale maps of Great Britain and the production of new ones.
- (d) The maintenance of the large scale maps of the country, their revision, and the production of new editions. This task of field revision was a major one during the years between the two wars owing to the complete cessation of revision work during the 1914-18 war, the post-war cuts in the strength of the Department, and the extensive development of new roads and housing that took place.
- (e) The preparation of special maps for Land Registration and other such purposes.
- (f) The printing of maps required for military training and defence purposes by the War Office, and the production of special maps for overseas areas for the War Office, on an agency basis in preparation for possible or probable operations.

The technical personnel, both military and civil, embraced roughly the following categories:—

Trig Surveyors (for work on the new triangulation).

Levellers (for the levelling network).

Field Revisers (for the revision work in the field on all scales, but more especially for the large scale maps on the scale of 1/2,500).

Draughtsmen (for the drafting of new maps).

Lithographic Printers, Photographers, and other technicians employed on the actual reproduction processes and printing of the maps.

The reproduction workshops were equipped with up-to-date cameras, printing machines and other plant in a wide and extensive variety. Thus it will be appreciated that the Department possessed large potential resources both in personnel and static equipment for mass map production in time of war, and a part of their peace-time work, especially map drawing and reproduction, was of a somewhat similar nature to that which would be required for war purposes.

During pre-war years it was accepted policy that, not only would the O.S. be called upon to assist largely in the production of maps for war purposes, but also that the officers and other ranks required for the mobilization of the early Survey Directorates and units would be drawn very largely from the O.S. This, of course, was a not a very suitable arrangement for the Department itself because, just when it had to take on large war mapping programmes, it lost a large number of technical personnel required for mobilization, including officer supervision and control. Fortunately, during the immediate pre-war period, an extensive programme of expansion had been in force at the O.S., and large numbers of youths had been recruited as technical civil assistants, principally for large scale revision. It should be emphasized here that, during the war years, a great deal of map drawing and other forms of technical work was carried out by women who were recruited and specially trained at the O.S. for such tasks, and who proved very competent. This facilitated the release of large numbers of the young male technical civil assistants for duty with the Field Survey units.

There is no question that the established traditions of the O.S. produced a number of technical tradesmen who possessed unrivalled skill in their respective categories and a high sense of individual responsibility. Some amongst the R.E. personnel so employed had been fortunate to gain experience of topographical field survey on Boundary Commissions and Colonial Surveys where they had learnt initiative and how to make good under difficult conditions. On the whole, although continuous full-time service at the O.S. could not be regarded as an adequate preparation for survey duties in war, the groundwork was of considerable value both for officers and other ranks. On active service it is often necessary to sacrifice a meticulous standard of finish for speed in execution and many of those mobilized from the O.S. took some time to adapt themselves to the changed conditions.

Before the war there was no effective military survey service and no survey representation with either the home commands or field formations. The unfortunate effects of such a situation have already been stressed in the Historical Note preceding this chapter. It would seem, therefore, that notwithstanding the undoubted value of the technical experience gained by service on the O.S., it is desirable to maintain an adequate military survey organization in peace-time, including representation at staff level, and survey units for carrying out productive work for the Army and the Royal Air Force. This organization should take part in regular survey training for war.

The relations between the War Office and the O.S. under war conditions demand some consideration. It had always been accepted that the O.S., on the outbreak of war, should reduce its civil mapping commitments to a minimum and become fully available for whatever mapping tasks the War Office might require. In September, 1939, this principle was implemented, and the O.S. became, in effect, a War Office controlled factory for map production, though it still remained under the administrative control of the Ministry of Agriculture and Fisheries.

M.I. 4 (Colonel) who, as head of the Geographical Section at the War Office, was responsible to the General Staff for the control of mapping policy and its execution, found himself placed in a somewhat anomalous position as junior in rank to the Director General of the Ordnance Survey (a Major-General), whose technical activities for war mapping now came under War Office control. The maintenance of administrative control by a civil Ministry also produced some complications and difficulties. There were many occasions, in cases of accommodation for example, when the War Office, having calls on higher priority, had to take appropriate action in order to overcome administrative difficulties and intolerable delays. Even in the War Office itself it was often difficult to persuade a constantly changing staff that the Army had a very vital interest in the efficient and punctual working of the O.S. which was administered by another Ministry.

By good common sense the effect of these difficulties on the vital work of production was reduced to a minimum but, looking to the future, it may be found desirable to devise a formula which will eliminate some of the anomalies and organizational difficulties which were experienced concerning the control and administration of the O.S. under war conditions.

SECTION 3. THE SURVEY TRAINING CENTRE R.E.

Survey Directorates for G.H.Q. and 1 and 2 Corps, one (Army) Field Survey Company R.E., two (Corps) Field Survey Companies R.E., and one Field Survey Depot R.E. were mobilized to accompany the British Expeditionary Force to France in September, 1939. The majority of the personnel for these units was drawn from the Survey Battalion R.E. which, before the war, held on its strength the Royal Engineer survey officers and other ranks who were employed with the Ordnance Survey Department at Southampton. There existed at that time, under the administrative and technical control of the Director General of the Ordnance Survey, a small Survey Training Unit and depot located at Fort Southwick, near Fareham, Hants. Through this unit passed all newly recruited personnel destined for the Survey Battalion R.E. It also ran courses and a small amount of military training for existing Survey Battalion personnel and formed the nucleus around which, and by whose aid, the newly forming units were equipped, disciplined, and given some essential final training before going overseas.

The original intention was that, on mobilization, two identical training units should be formed, to be located at the neighbouring Forts Southwick and Widney, but this was altered, and a new establishment for one training unit only was submitted to the War Office. Meanwhile the original Survey Training Unit moved to Fort Widley and the first few field survey units were being mobilized at Fort Southwick. As soon, however, as the field units had gone overseas, the Training Unit became free to undertake its proper commitment

of receiving and training officers and other ranks as military survey personnel, for maintaining the existing field survey units, and for forming new ones.

In April, 1940, the Survey Training Centre was authorized with an establishment of approximately twenty officers and 630 other ranks. Its original organization divided the unit into eight groups as under:—

- H.Q. Staff.
- Military Training (Recruits).
- Cadet Training (Military and technical).
- Field Survey technical training.
- Air Survey technical training.
- Reproduction technical training.
- Quartermaster Stores.
- Mechanical Transport.

The above organization was later revised. Three Companies were formed and the new formation became:—

- H.Q. Staff.
- Administration. "A" Company.
- Military Training. "M" Company.
- Technical Training. "T.T." Company, which was subdivided into three wings:—
 - F. Wing. Field Survey.
 - S. Wing. Air Survey.
 - P. Wing. Reproduction Trades.
- Officers' Technical Training, under the supervision of O.C. "T.T." Company.

From its formation until about March, 1941, it was divided between Forts Southwick and Widley, near Fareham, Hants. In January, 1941, the S.T.C. began its move to Wynnstay Hall, near Ruabon in N. Wales, the seat of Sir Watkin Williams-Wynn, where part of the house itself, and other buildings were used for accommodation and lecture rooms, and the stables were converted for the erection of litho printing machines, proving presses, cameras, and other plant necessary for instruction in the reproduction trades. In addition, a hutted camp was erected in the grounds for the men's living and dining accommodation.

The following officers served as commandants at the S.T.C. during the war:—

- Lt.-Col. E. B. Elkington, from Sept., 1939–July, 1940.
- Lt.-Col. H. A. Shewell, from July, 1940–Oct., 1941.
- Lt.-Col. C. K. Davies, from Oct., 1941–Aug., 1943.
- Lt.-Col. A. C. James, from Aug. to Sept., 1943.
- Lt.-Col. R. P. Wheeler, from Sept., 1943–June, 1945.

The Survey Training Centre was under the direct control of the Director of Military Survey at the War Office. Its main function was to train officers and men as military surveyors, who would then be available to act as reinforcements for existing survey units, and for the formation of new units. From the outbreak of war, recruits were sent direct to the S.T.C., so it was imperative to form a military training branch there to train them as soldiers as well as surveyors.

Officers holding Emergency Commissions, including Colonial Survey officers and others already experienced in technical field survey practice, and many executives from commercial printing firms already experts in their own line of reproduction technology, began to report for duty at the S.T.C., and arrangements had to be made to give them the specialist training in field survey or reproduction duties necessary to fit them for service with field survey units and, in particular, to train them to undertake military and administrative duties.

Officer cadets then appeared, so a Cadet Training Wing had to be organized. The cadets consisted partly of recently recruited personnel and partly of ex-regular soldiers of the pre-war Survey Battalion R.E. who were recommended for commissions as a result of their experience with survey units in the B.E.F. in France during 1939-40. The syllabus for their training course had to cover full military and technical training. All of them received instruction in administrative duties, and on the technical side the cadets were given a full training in the particular branch of survey for which they were qualified, with a brief run through the remaining trades. For example the field survey cadets were given an insight into the reproduction trades and *vice versa*.

Recruits' military training included the use of the rifle, automatic weapons, hand and rifle grenades, anti-tank bombs and weapons, tank-traps, obstacles, wiring, demolitions and booby-traps, mines and, finally, training over a full assault course. The result of this training was found exceedingly valuable as, in many cases in the operational theatres, mines and booby-traps were found on roads, tracks and other approaches to trig points, and even the cairns and beacons on the hill-tops were found to be mined. On many occasions also survey troops took their share in military action against the enemy when occasion demanded it.

Every opportunity was taken to exercise men in day and night tactics in co-operation with the local Home Guard in the Ruabon area. This not only was good military training for the survey personnel, but also served to show up weaknesses and gaps in the Home Guard defensive plans.

Technical training was divided into three main categories:—

- (a) *Field Survey*, comprising triangulation, computations, and topographic surveys. Preliminary and advanced courses in each were given. The preliminary stage taught the basic principles of the subjects, including the use of all the instruments involved. The advanced courses were based on field exercise lines, and were confined very largely to methods for rapid surveys such as would be required under active service conditions. Normal triangulation, including resection and intersection methods, levelling, subtense, tachymetric and traverse methods were taught. Astronomy included star and sun azimuths. The use of the plane table was taught, but experience in most theatres indicated that not sufficient prominence was given to this most valuable and basic fundamental of topographic training.
- (b) *Air Survey*. This dealt with the compilation of contoured maps from air photos, with special emphasis on the production of accurate, large scale maps (e.g. 1/25,000) for use by the artillery. Basic training was given using the "Arundel" method of graphical plotting, the instruments chiefly in use being the ZD 4 Topographical Stereoscope and the Parallax Bar. Then followed the use of the Slotted Template equipment and, at a later stage of the war, training in the use of the Multiplex plotter.

- (c) *Reproduction trades.* Many of the recruits who passed through the S.T.C. were personnel from the printing trade who already had experience in one or other of the various activities connected with litho printing, proving or photographic work. It was necessary, however, to train them in the use of the types of equipment which were standard for the survey units in the field, and the technical methods which had been laid down as standard in the military Survey Service.
- (d) *Officers' technical training.* The courses for field survey officers included triangulation, astronomy, computations, topography, the compilation of a composite map from various types of material, and air survey methods. Printing officers took a full course in the reproduction trades. They all received instruction in administrative duties, and were given a general working knowledge of the work of other branches of survey work besides their own.
- (e) *Clerks.* These were trained in military clerical work including a knowledge of regulations, pay, messing, and Quartermaster procedure.
- (f) *Cadet Wing.* This closed early in 1942 when all cadets were receiving military training at O.C.T.U.s, and were then posted as commissioned officers. The Cadet Wing then became the officers' technical training wing of "T.T." Company.

The above brief notes indicate the general scope, purpose, and organization of the Survey Training Centre, R.E. During close on six years of war the Survey Service expanded to an extent undreamed of in September, 1939. The achievements of the S.T.C. in training officers and other rank personnel for new units, and for maintaining existing units, were outstanding. It served also as a centre and research nucleus of military survey thought and development. Looking to the future it would appear that the maintenance of some form of military survey training school is of considerable importance. The lack of one in the pre-war years undoubtedly added to the difficulties of mobilization in 1939.

CHAPTER II

FRANCE AND BELGIUM, 1939-40

The following Maps and Plates are relative to this chapter:—

<i>Sketch Map</i>	1. <i>N. France and the Low Countries, page 15</i>
<i>Plates</i>	1. <i>N.W. Europe 1:250,000</i>
<i>at</i>	2. <i>France 1:250,000</i>
<i>end of book</i>	3. <i>France and Belgium 1:50,000</i>
	4. <i>N. France 1:50,000</i>
	5. <i>N.E. France and Belgium 1:25,000</i>

SECTION 1. SURVEY ORGANIZATION

During the pre-war years before September, 1939, there were, as has already been pointed out, no R.E. survey units in existence other than one small depot (or training) company, and no survey representation at any staff level other than the Geographical Section of the General Staff at the War Office.

When considering probable survey requirements for a major continental war it was however realized that, in order to meet the survey and mapping needs of an Expeditionary Force, it would be necessary to arrange for the mobilization of Survey Directorates and field survey units. War establishments for these were therefore prepared, and were implemented during the latter part of August, 1939, the personnel being drawn primarily from the principal available source of military surveyors, the Ordnance Survey. Fortunately, there were known to be a number of civil survey officers employed on topographical survey duties in the Colonies, and their names had been registered as potential officers for survey units on mobilization. These individuals proved to be an asset of great strength to the Survey Service owing to their sound practical experience.

The British Expeditionary Force which proceeded to France during September, 1939, consisted of a General Headquarters and two army corps, each of two divisions. A third corps took the field in the spring of 1940, and others would have followed as mobilization proceeded but, although plans were in hand to create an army headquarters to assume executive control between G.H.Q. and the increasing number of corps, these had not been put into effect by the time that the B.E.F. was evacuated through Dunkirk in June, 1940.

The survey organization as mobilized to take its place with the B.E.F. was as under:—

GENERAL HEADQUARTERS

Survey Directorate. This was of modest dimensions, consisting of four officers and a small number of other ranks. The officer ranks allowed by establishment were:—

- Director of Survey (Colonel).
- Two Deputy Assistant Directors (Major).
- One Captain or Lieutenant.

For 8 months, from September, 1939, to the end of April, 1940, conditions were more or less static. During this time although there was plenty to keep this small Directorate fully occupied, there was no operational movement. However, the sorting out of the geodetic systems in Western Europe, the general control of field surveys, the acquisition of air photographs from the R.A.F. and the revision of existing maps therefrom, the preparation of new and special maps for planning and other G.H.Q. purposes, and the control of map supply to formations was a full-time job.

When the German offensive started on 10th May, the conditions that ensued, leading up to the evacuation from Dunkirk, were so confused that it was no fair test for judging the adequacy or otherwise of the Directorate organization. In the light of subsequent experience elsewhere, it seems safe to say that, though it sufficed for the small size of the B.E.F., it would have had to have been expanded as the size of the force increased and active operations were pursued.

G.H.Q. TROOPS

(a) *No. 1 Field Survey Depot.*

The authorized establishment allowed for one officer and 18 other ranks. The unit was designed on the assumption that, in accordance with policy existing at the time Survey held no responsibility for map distribution to units. It had, therefore, no transport for such a purpose, or for moving itself, and was completely immobile. Once established, the movement of the unit including its map stocks, was a considerable transportation problem.

The L. of C. from the Belgian frontier back to the bases extended through Normandy and Brittany to Brest and Nantes. So far as maps were concerned, this necessitated splitting the Depot into two parts. The main base depot was installed at Rennes with a warrant officer in charge, and this depot, in addition to receiving and storing bulk stocks from the United Kingdom, sent forward consignments to the advanced depot at Doullens, just west of Arras. It served also as a map issuing store for units on the L. of C. The officer commanding the Depot was brought in to work with the G.H.Q. Survey Directorate near Arras, where he was well placed for dealing first hand with map requirements for G.H.Q. and for field formations, and was also in daily touch with his advanced depot at Doullens.

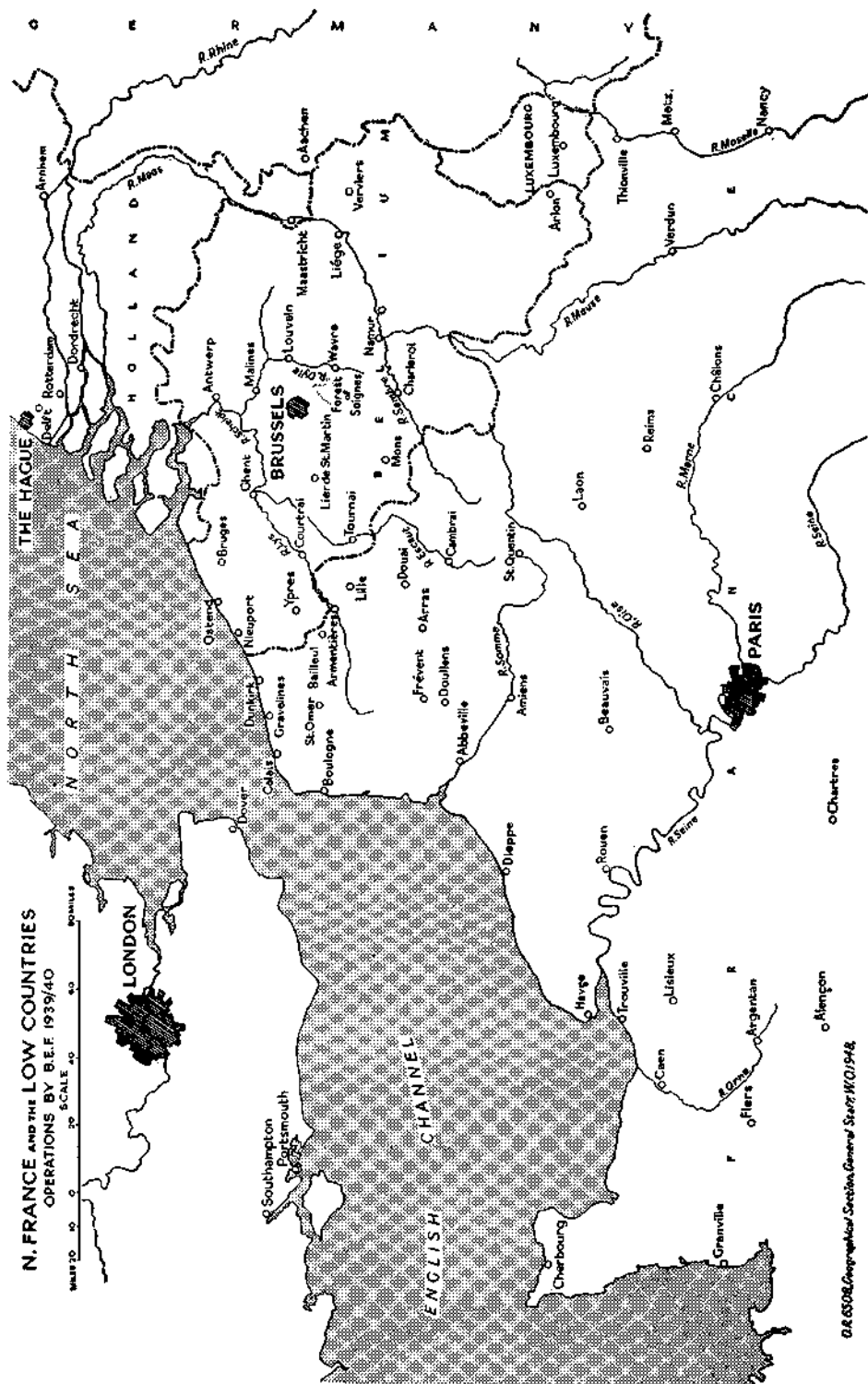
When active operations started in May, 1940, and the British forces moved forward into Belgium, an advanced echelon of the Field Survey Depot was sent forward to form a semi-mobile map store near Brussels.

During the confused fighting that ensued, the bulk map stocks near Doullens and at Rennes were cut off from the retreating British corps by German panzer thrusts, and the Field Survey Depot could no longer function. It was becoming quite obvious, however, that if normal active operations had continued, with an ever-lengthening L. of C., the existing machinery for map supply would not have been adequate. It must be remembered also that, at that time, the Depot was not handling survey stores. These latter were, according to current policy at the time, an Ordnance responsibility. Later operations, in other theatres, were to be experienced before there was any radical change in the organization of the Field Survey Depot.

N. FRANCE AND THE LOW COUNTRIES
OPERATIONS BY B.E.F. 1939/40

OPERATIONS BY B.E.F. 1939/40

A vertical scale with the word "SCALE" written vertically along the left side. The scale has major tick marks at 0, 20, 40, and 60. The word "MILES" is written at the bottom of the scale.



D.R. 6508 Coopers and Lybrand Staff W.O. 1948

(b) *Army Field Survey Company R.E.*

The 19th (Army) Field Survey Company R.E. was mobilized to accompany the B.E.F. as a G.H.Q. troops unit. It was somewhat of a mixed formation, consisting of Headquarters, a mobile echelon of topographical sections for field survey work and an immobile echelon of drawing and reproduction sections. It was equipped with photographic plant and six double-demy static printing machines. Considerable difficulty was experienced in finding suitable accommodation in which to instal the printing equipment within the G.H.Q. area. Eventually two machines were erected in old saw mills at Frévent, near G.H.Q., for dealing with the considerable quantity of printing work required by the various headquarter branches, and the four remaining machines were installed in a Paris factory. All this equipment was lost.

The unit was not well designed for the purpose in view. It certainly was not suitable, owing to its immobility, to function, as its name seemed to imply, as an army unit during active operations. From the point of view of map reproduction, its immobile machines were suitable for a base printing installation but not for any other purpose.

CORPS SURVEY ORGANIZATION

When planning the organization of the Survey Service to accompany the B.E.F. it was decided that each corps should have a Survey Directorate at corps H.Q. and also a Corps Field Survey Company R.E. In view of the lack of previous co-operative training between Survey and the rest of the Army, and the lack of knowledge which each had about the other, this decision was probably a wise one. As events subsequently turned out it was most fortunate, as the corps themselves, in the course of their retreat from Belgium to Dunkirk, became more or less cut off from G.H.Q. assistance as regards map supply and were therefore fortunate in each having its own Survey Directorate and Field Survey Company. The latter, with their mobile printing equipment, were able to print supplies of large scale maps as they retreated from Belgium towards Dunkirk.

The Survey organization for each corps was as follows:—

Corps Survey Directorate, consisting of:—

Assistant Director of Survey—Lieutenant-Colonel.

Assistant to above—Captain.

Other ranks—five.

(Corps) Field Survey Company R.E. This unit, as originally designed, consisted of a headquarters, two topographical sections for field triangulation and other survey work, a small drawing section, and two printing sections, each of which was equipped with one double-demy printing machine mounted in a trailer and towed by a Scammel tractor. These tractors were provided by a Medium Regt. R.A. and their availability for moving the trailers was therefore dependent on whether they could be spared by that unit. This proved to be an intolerable source of anxiety to the Survey unit commanders, especially during the retreat from Belgium, and the lesson was soon learnt that these survey technical vehicles must be independently mobile. Although modified in detail during the subsequent war years, including the addition of a photographic section and

the substitution of smaller (demy) machines in specially designed lorries instead of trailers, this type of unit, in all its essentials, retained its original identity during the whole war and proved to be a very useful, well balanced unit for general service in the field.

The A.D. Survey, with his intimate daily contact with the corps H.Q. staff and easy access to divisions, was able to look after their mapping and survey requirements in a very thorough manner. He was in a good position to maintain very close liaison with the R.A. Survey Regt. (also corps troops), and the triangulation and other field work carried out for checking and establishing the survey data required by the gunners was done on a corps area basis. It was the responsibility of each A.D. Survey to co-ordinate the work on his own corps front with that in adjacent corps areas.

Under the circumstances prevailing at the very beginning of the war, it was probably a good thing that Survey staff representation and field survey units were on a corps basis. This policy was, however, subsequently altered so that normally there were no directorates or units below army level, which proved undoubtedly to be a decision correct in changed circumstances. Where, however, a corps was likely to be operating on its own, having no army troops immediately to its rear, Survey representation was usually added.

The short period during which the B.E.F. was in France and Belgium, and the conditions under which it operated, did not constitute a proper test of the Survey organization. Many lessons were, however, learnt and, when the Directorates and units returned from Dunkirk, having lost all their equipment except a few theodolites which were carried out by hand, there was opportunity to start afresh with a clean slate and rebuild anew.

The Survey order of battle with the B.E.F. in May, 1940 was as under:—

G.H.Q. Survey Directorate

Director of Survey—Colonel A. B. Clough.

G.H.Q. Troops

19 (Army) Field Survey Company R.E.

1 Field Survey Depot R.E.

1 Corps

Survey Directorate (A.D. Survey—Lt.-Col. R. E. Fryer).

13 (Corps) Field Survey Company R.E.

2 Corps

Survey Directorate (A.D. Survey—Lt.-Col. V. E. H. Sanceau).

14 (Corps) Field Survey Company R.E.

3 Corps

Survey Directorate (A.D. Survey—Lt.-Col. R. P. Wheeler).

514 (Corps) Field Survey Company R.E.

SECTION 2. MAPS AND MAP PRODUCTION

British military mapping policy

As a result of the experiences and lessons gained during the 1914–18 war, and the development of survey and mapping technique during the subsequent years, including especially the evolution of rapid methods of mapping from aerial photographs, it became possible, in 1931, for a statement of mapping policy to be laid down by the Chief of the Imperial General Staff.

It was therein postulated that, wherever possible, the scales of maps to be provided for operational purposes would be as follows:—

Small scale, 1/250,000, for strategical and general use.

Medium scale 1/50,000, for use as a tactical map and for general administrative purposes.

Large scale 1/25,000, for deliberate battle, and especially for use by the R.A.

It was stated that these military maps should normally be gridded and map references given on the Modified British System. It was also stated that, as any prospective European ally would be using a metric grid system, and as all existing European survey data were recorded in metres, the British maps would use a metric grid. The 1914–18 war had shown that a map on a scale of about 1/50,000 was much more suitable as a tactical map than one on the smaller scale of 1/100,000 which had been used up till then. Apart from any other consideration, the small size of a 1,000 metre grid square on the 1/100,000 scale was a decided disadvantage. For training purposes during the period between the two wars the 1-inch to 1 mile map of Great Britain had become the standard map for tactical use, and this approximated close enough to the basic 1/50,000 scale laid down.

It may be noted here, however, that later in the course of the war the map requirements of fast-moving armoured forces and motorized infantry reintroduced the 1/100,000 map for use with quick-moving armoured troops.

The new mapping policy differed from that which existed before in that the latter would have supplied an Expeditionary Force only with reproductions of existing maps, whatever their scale or type, whereas the new policy aimed at producing maps of a scale and style which it was considered would be most helpful to the fighting troops. The effect of this was considerable. Not only did it entail the need for using extensive cartographic resources for the initial production of the various map series in preparation for a possible war, but it also made it necessary to draw up war establishments for adequate resources in survey units and equipment for the mapping and map production work that would be required in the field with an Expeditionary Force.

Map preparations for a European War

GENERAL POLICY

The increasingly aggressive attitude shown by Nazi Germany following Hitler's rise to power during the early 1930s indicated that at no great distant date there was a grave possibility that Great Britain and France as allies would be dragged into a conflict against Germany. The initiation of a mapping programme therefore became a matter of urgency and, during 1936, the General Staff indicated to the Geographical Section at the War Office (G.S.G.S.) an area in north-western Europe which should receive priority treatment for map preparation. This area, which was based on an appreciation of probable German offensive strategy, comprised the whole of Belgium and that portion of north-eastern France which was bounded on the north-east by the Belgian frontier from the sea to Luxembourg, in the west by the sea coast of the Pas de Calais and an extension of this line to the south, and in the south by a line running approximately from Paris to the Luxembourg frontier.

In accordance with the mapping policy laid down it was decided to begin

the preparation of map series covering this area on the standard scales of 1/250,000, 1/50,000 and 1/25,000. As a first measure the available basic mapping material had to be investigated, sorted out and selected, and in that connection staff liaison was established between G.S.G.S. and the French Service Géographique de l'Armée in Paris so as to obtain the best and most modern material and to agree on essential technical matters.

It should be noted that, on the principle of trying to preserve neutrality, neither Belgium nor Holland were prepared to co-operate before 1939 with regard to survey and mapping problems for a war which seemed imminent.

EXISTING BASIC MAP MATERIAL

The following is a brief summary of the principal national map series of France, Belgium and Holland which were available in varying stages of modernity as a basis for the preparation of British military maps:—

(a) *France.*

1/200,000. A good, clear, coloured map covering the whole of France.

1/80,000. An old staff map originating from Napoleon's day. It was the largest scale map that covered the whole of France. It was reasonably detailed, fairly accurate, and had received periodic revision. It was printed in black only and was *hachured* to show relief, becoming almost illegible in mountainous areas.

1/50,000 (black). This was a direct enlargement of the 1/80,000 map. The sheets were gridded, and the series formed the standard French military map outside those areas which were covered by the modern 1/50,000 described below.

1/50,000 (Type 1922). This was based on the new 1/20,000 series (see below) and was begun by the French after the 1914–18 war. With a view to future strategic requirements, they naturally gave priority to the eastern zones along the Belgian, German and Italian frontiers. The style was good, and the map was well detailed and reproduced in full colour. Only a portion of the potential operational area in the east was covered by sheets of this new series. The western part of the area was still uncovered by 1940.

1/20,000 (New). This series was produced from new surveys as the basic map for the new 1/50,000 series described above. They both therefore covered approximately the same area. It was a clear and accurate map, and was generally published in black only.

1/20,000 (Plans Directeurs de Guerre). These were produced before and during the 1914–18 war and were of very varying reliability, some of them being grossly inaccurate.

(b) *Belgium.* The principal map series, published by the Institut Cartographique Militaire in Brussels are given below. As the Belgian Government did not co-operate before 1940 the only material available was that which existed in the War Office Map Library, some of which was not fully up to date.

1/20,000. This covered the whole country. It was published both in black and colour and was a good accurate map.

- 1/40,000. This also covered the whole of Belgium, and was published both in black and colour. A clear and accurate map with latest editions dating from 1933.
- 1/100,000. Prepared (since 1931) from the 1/40,000 series. It was produced in colour and was a highly detailed but clear map.
- (c) *Holland*. A policy of neutrality placed Holland in the same category as Belgium as regards co-operation on mapping questions before the war.
- 1/25,000 (old). Covered the whole country and ranged in date from 1904 to 1934. It was a very detailed, clear and, where modern, accurate map.
- 1/25,000 (new). In 1934 a new series was started, very similar in style to the old series but on different sheet lines and gridded with the Dutch grid. Only a few sheets were available by 1939.
- 1/50,000 (old). Based on the old 1/25,000 map, and was very similar in style.
- 1/50,000 (new). Based on the new 1/25,000 series, and only very few sheets were available.
- 1/200,000. This was the principal Dutch series on a scale smaller than 1/50,000. The dates of the sheets ranged from 1927 to 1938.
- (d) *Germany*. As no British maps of Germany were prepared before the B.E.F. operations of 1939-40, any reference to existing German map series is deferred till later in this history.

BRITISH "REARMAMENT" MAP SERIES

The military maps on various scales which G.S.G.S. initiated in 1936 were known as the British "rearmament" series. The work of preparation was contracted out by the War Office to the Ordnance Survey where a special group of cartographers was employed from 1936 onwards on the compilation, drawing and reproduction of the maps required. Detailed specifications for style, design, etc., were supplied by G.S.G.S. Brief details of the principal map series are given below.

Small scale (1/250,000). This was in two series:—

- (a) *GSGS 4042 (Plate 1).* A new series embracing the whole of Belgium and Luxembourg and that portion of north-eastern France lying approximately to the north-east of a line Havre-Paris. It purported to represent the ground as it was in 1936 and was based on the best material available at the time. The sheets, which were printed in four colours, were bounded by grid lines based on the Lambert Nord de Guerre grid, and had an overlap of 25 kms. on the north and east edges.
- (b) *GSGS 2738 (Plate 2).* This consisted of 16 sheets of a 1914-18 series in which the communications were brought up to date. It covered an extension of the probable operational area to the west, south, and south-east of GSGS 4042. The series was originally produced by direct reduction from the French 1/200,000 map and was printed in four colours, the final result being somewhat unsatisfactory. It was not possible to extend the Lambert Nord de Guerre grid over this more westerly area without either introducing negative co-ordinates or altering the values of the eastings for the other map series further east. The sheets therefore carried a system of reference squares only, and no grid.

Medium scale (1/50,000). There were two series:—

- (a) *GSGS 4040 (Plate 3).* This series was built round the new French 1/50,000 map where it existed in the frontier zone. Some of the sheets were made by direct facsimile reproduction from the French printing plates fitted together into the British system of grid sheet lines. The remaining sheets were newly compiled and drawn from French, Belgian, British (1914–18 war), German and Dutch maps of varying dates. Some sheets consisted partly of facsimile reproduction from new French sheets, and partly of newly drawn detail, which gave a very patchy effect. It was generally considered that the newly drawn sheets were somewhat over-generalized, a good deal of important tactical detail having been omitted.
- (b) *GSGS 4040 A (Plate 4).* The series described above did not cover the south-west portion of the area covered by the small scale series (GSGS 4042). In view of the limited time that was probably available for preparation, it was decided to cover this missing area by direct enlargement from the all-black French 1/80,000 map and to add the Nord de Guerre grid. These sheets, which just overlapped GSGS 4040 in the east extended only a short distance westwards to about the longitude of Le Havre. Further to the west, over the remainder of Normandy and Brittany, there was no British map coverage on a scale greater than 1/250,000.

Large scale (1/25,000).

GSGS 4041 (Plate 5) embraced the whole of Belgium and nearly the whole of the area of north-east France covered by GSGS 4040 (1/50,000). There was, however, a gap in the west along the coast of the Pas de Calais, where no original basic material was available.

The series was produced by a compilation of the best available material into the British sheet lines. Although some of the original material was printed in colour, film negatives were made for each sheet which combined all colours together so that the maps could be rapidly printed in black only by Survey units in the field.

OTHER MAPS FOR GROUND, AIR, AND STAFF USE

In addition to the small, medium, and large scale maps of the “rearmament” series referred to above, the War Office had published sheets covering western Europe based on the 1/1 million International map. These were suitable for air use, for general strategical planning, and for use as wall maps, etc.

The pre-war expansion of the R.A.F., with special reference to Bomber Command, gave rise to a demand for specially designed maps for air navigational use in which certain topographical features such as water, woods, railways and certain roads were given special emphasis, and such detail as was considered superfluous to ordinary navigational requirements was omitted. This requirement led to the production of special air series on the 1/250,000 and 1/500,000 scales, with carefully chosen colouring, especially for the height layers, which would be legible in the special lighting conditions within the aircraft.

PRINTING OF OPERATIONAL STOCKS

As the compilation and drawing of the various sheets was completed they were photographed, and printing plates were prepared. Then, in accordance

with the policy laid down for map issues to an Expeditionary Force proceeding to the Continent, bulk stocks were printed at the O.S. of all maps other than the large scale (1/25,000), and duplicate printing plates were prepared for issue to the G.H.Q. Survey Directorate to enable stocks to be printed overseas in emergency. For the 1/25,000 maps, kodaline film negatives were issued to each of the Field Survey Companies accompanying the B.E.F. so that they could print stocks in the field as required on their mobile printing equipment.

Mapping with the B.E.F. overseas (1939-40)

The survey organization available to the B.E.F. for map production and printing within the theatre has been described earlier in this chapter. Briefly there were the following units:—

- (a) With G.H.Q.:—19 (Army) Field Survey Company R.E., with it topographical, drawing, photographic and printing sections, equipped with 6 non-mobile double-demy printing presses (auto-feed), and ancillary plant including camera. This unit worked under the direct control of the Survey Directorate.
- (b) With each Corps:—One (corps) Field Survey Company R.E., with its topographical, drawing and printing sections, equipped with 2 double-demy, hand-fed printing presses mounted in trailers, and ancillary plant, but no camera. These units worked under the direct control of the Corps Survey Directorates.

The G.H.Q. Survey Directorate went over to France in skeleton form on the day following the declaration of war, was soon completed to strength, and for a short period was the only survey representation overseas until the corps directorates and field survey companies arrived, followed by 19 Field Survey Company. There was a very early requirement for a simple and clear road map for use by convoys proceeding from their ports of disembarkation to the concentration area. A tracing was quickly made from the relevant Michelin sheets and this was reproduced by a firm of local printers in Rennes. Stocks were supplied to the base commandants at each of the principal ports so that every driver could have a copy. This was the first item of local map production overseas.

The concentration zone for the 1 and 2 Corps, which formed the original B.E.F., was the Rennes, Laval, Le Mans area and this was too far west to be covered by the British 1/50,000 series. For purposes of billeting and administration, and for training exercises while waiting to move forward towards the Belgian frontier, a 1/50,000 map was almost essential. By local contact with the French military authorities, and also with the Service Géographique in Paris, limited stocks of the French 1/50,000 sheets (plain enlargement from the standard 1/80,000 map) were obtained and issued. While G.H.Q. was back at Le Mans during September there were other special requirements of a minor nature which were met by means of utilizing local civilian resources.

MAPPING ACTIVITIES BY 19 (ARMY) FIELD SURVEY COMPANY R.E.

As soon as the B.E.F. moved forward to its allotted sector along the French-Belgian frontier to the east of Lille and Douai, an extensive reconnaissance was made to try and find suitable accommodation for the whole of 19 Field Survey Company in the B.E.F. area. The agricultural nature of the zone, and the fact

that full operational conditions had not yet arisen made it very difficult to find what was wanted. Factories, where they did exist, were still in full production. The result was that within a reasonable distance of G.H.Q. it was only possible to find accommodation suitable for installing two of the printing machines together with the drawing and photo sections. This was at Frévent, a few miles to the west of Hauteville, near Arras where the G.H.Q. Survey Directorate was located. Here the immobile echelon of the unit remained until it was forced to evacuate under German pressure in May, 1940. The two machines installed at Frévent, as also the remaining four which were operating in Paris, together with the rest of the technical equipment had to be left behind.

The following are typical examples of the tasks undertaken by this unit which, from the moment its machines were installed, was working at full pressure on almost continuous shifts:—

- (a) *Stock printing.* Stock printing of the standard 1/250,000 and 1/50,000 maps to meet emergency shortages in bulk stocks. The Base Map Depot was back at Rennes in Normandy with an Advanced Depot at Doullens, only a few miles from Frévent. Bulk stocks were shipped over from the United Kingdom, but there were occasions when large urgent issues had to be made and, for safety, the stock was replenished by 19 Field Survey Company, printing from the duplicate plates which had been supplied by the War Office.
- (b) *Revision of 1/250,000 and 1/50,000 sheets.* While awaiting developments along the Belgian frontier from October, 1939 until May, 1940, opportunity was taken to check up road classification within the British zone, and to revise topographical detail on the ground. Air photos taken over parts of north-eastern France were also used for revision purposes and, although not officially permitted owing to neutrality restrictions, a considerable amount of patchy photography from high altitude was obtained over Belgium.

Revision traces were prepared by the drawing sections of all survey units, and they were sent back to the United Kingdom so that revision work could be carried out on the original material under War Office arrangements. Meanwhile road and canal corrections were made on the printing plates so that new provisional editions could be printed.

- (c) *Preparation of special maps for the occupation of the R. Dyle position in Belgium.* As soon as a decision had been made to move forward to the R. Dyle, east of Brussels, in the event of a German offensive, special map preparation of all sorts was undertaken to meet G.H.Q. needs. To illustrate their planning directives and operational instructions, there was need for a variety of overprints on standard maps, and special productions such as route diagrams, administrative traffic maps, town plans, etc. For the actual defence position along the R. Dyle a special series of layered 1/50,000 sheets was issued.
- (d) *German defences along the Siegfried Line.* G.H.Q. (Intelligence) was paying constant attention to the German defence system along the Siegfried Line immediately to the east of the German frontier. No basic German mapping material had been taken over to France, so it was necessary to contact the French Service Géographique and obtain from them duplicate printing plates of their 1/25,000 sheets covering the western frontier zone of Germany. The French had already

prepared overprints showing some of the German defences, and these were brought up to date as far as was possible from air photos, and editions were published for intelligence purposes.

Opportunity was taken to start building up a comprehensive collection of reproduction material from which to print maps of Germany in the event of an allied move through Belgium into Germany.

- (e) *Miscellaneous jobs.* As always happens at any headquarters, there were innumerable requests from Engineer, Signal and other staff branches for the reproduction of technical diagrams, sketches and other such documents, and this work was also done by 19 Field Survey Company.

THE WORK OF THE CORPS FIELD SURVEY COMPANIES R.E.

- (a) *Revision.* The topographical and drawing sections of these units were employed from the early days of the waiting period from October to May on the revision of the 1/25,000 maps of their respective corps areas. This was done both by ground and air photo methods. Deletion and addition traces, registered closely to the grid, were drawn up and sent back to the War Office, and in the case of those sheets of special operational importance, local corrections were made to the kodelines carried by the units.
- (b) *Printing (1/25,000).* No printed stocks of 1/25,000 maps had been taken overseas, so the corps field survey companies were entirely responsible for printing stocks of these to meet the total corps requirements.
- (c) *Defences.* As the defence works along the British sector grew and developed, a complete record of them was maintained by each corps in the form of defence work overprints on the standard 1/25,000 maps and also on larger scales (1/10,000) for which printing plates were obtained from the French.
- (d) *Staff requirements.* With a Survey Directorate at Corps H.Q., and a field survey company at its disposal, it was inevitable that there should be a constant demand for all sorts of special maps, overprints, etc., to satisfy the needs of the various staff branches. The corps' Christmas cards naturally took their place amongst the many tasks!
- (e) *The move forward into Belgium.* When the German offensive started on 10th May, 1940, and the allied forces moved forward to the R. Dyle the field survey companies accompanied their corps, ready to print on their mobile equipment whatever 1/25,000 maps should be wanted. One topographical section of 13 Field Survey Company was at this time on detached duty in the Saar where French and German forces were in contact. To this area each British division in turn was being sent for a short tour of duty to gain experience of actual battle conditions in contact with the enemy. Foreseeing the possibility of a German attack A.D. Survey 1 Corps had asked for the loan of a topographical section from 19 Field Survey Company and this section went forward to the R. Dyle with 13 Field Survey Company. The absent topographical section was recalled from the Saar and, after a forced march across the line of the German Panzer thrust, arrived in Brussels in time to take part in the operations in that area and during the subsequent retreat.

- (f) *The retreat.* The swift German thrusts towards the coast along the southern flank of the B.E.F. cut off the British force from its main L. of C. including both the Advanced Map Depot near Doullens and the Base Map Depot back at Rennes. As the B.E.F. retreated towards Dunkirk it entered an area for which no 1/50,000 maps had previously been issued, and for which no stocks could now be obtained from the map depots, though they were available there in large numbers. Under these circumstances the only maps available to the troops were the small scale sheets (1/250,000) already issued and the 1/25,000 maps which the corps field survey companies were able to print and issue as they moved back with their corps through Belgium to Dunkirk.

Except while actually on the road, their machines hardly stopped day or night, in an attempt to keep pace with the rapidly changing situations. Their work was invaluable, and did not end until they had to destroy and abandon their printing vehicles just outside Dunkirk.

Miscellaneous comments

- (a) *Sheet lines and overlaps.* All the newly compiled maps of the "Re-armament Series" covering north-eastern France and Belgium were made up on grid sheet lines, and bore therefore no direct relation to the sheet lines of the national maps (French and Belgian) from which they had been compiled. The result of this was that, if and when a more modern edition of a French 1/50,000 or Belgian 1/40,000 sheet should be obtained, it was liable to affect the detail on as many as four sheets of the British GSGS 4040 series, and could not be directly reproduced as a sheet by itself to take its place in the British series.

The policy governing the selection of sheet lines for a military map series is one which deserves most careful consideration. References to this matter will be found in this history under other theatres (e.g., Chapter XII, Section 3, Greece). When the national sheet lines are retained unaltered it is obviously simpler and quicker to make use of a newly obtained edition of any sheet. In emergency it can be reproduced in facsimile and used without delay, fitting naturally into its place in the series.

The sheets both of the 1/250,000 (4042) and 1/50,000 (4040) series were compiled with overlaps on their north and east edges. Though helpful in some respects, these overlaps involved a lot of trouble and extra work in connection with revision. The revision of the overlap area on one sheet might affect eight adjoining sheets, and, unless they were all revised at the same time, there would be discrepancies of detail in any one specific area between one sheet and another. Later in the war these overlaps were eliminated.

- (b) *Communications and road classification.* One of the most constant and serious criticisms which was heard regarding the British maps issued to the B.E.F. concerned the showing of roads and tracks and their classification. Conditions of transport in modern war demand the most up-to-date and accurate information regarding road communications, to facilitate movement control, and to avoid congestion and chaos leading possibly to tactical disaster. There is no doubt that there was a lack of accurate and timely knowledge regarding road widths, surface

conditions and modern road development in north-eastern France and Belgium when the new British military map series were in preparation, and a certain lack of judgment and imagination in portraying the known information.

There was also a lack of up-to-date information regarding canal development, especially in Belgium, and as the principal canal systems formed topographical features of great tactical significance, this was a serious matter. The acquisition of modern information regarding roads and waterways was, therefore, one of the most important tasks confronting the Survey Directorate with the B.E.F., and this was rendered especially difficult owing to the maintenance of neutrality by Belgium until the German offensive was launched.

On the first edition of the 1/50,000 (4040) sheets, the roads carried no colour filling to denote their classification. The latter was indicated solely by the weight of the black lines and their distance apart. The adoption of the French system of classification into "Routes Nationales," "Grandes Communications," etc., indicated little of importance with regard to the traffic value of the roads from the military aspect as, though a road might have a good pavé surface of granite sets, the actual width of the pavé might be small, with an unmetalled verge on either side. After reaching their sectors on the Belgian frontier the corps field survey companies were therefore given a priority task of checking up the road classification on a system of single and double convoy capacity, and new editions were printed showing this by means of colour road fillings.

It is desirable that the General Staff should enunciate a clear policy of the system of road classification which should be adopted for any particular theatre and agree on the method by which it should be shown on the military maps. Different theatres will probably require different treatment owing to the diversity of topographical character.

SECTION 3. TRIANGULATION AND FIELD SURVEYS

Amongst the various duties of the Survey Service are the following:—

- (a) Surveys for, and the production of, new maps.
- (b) The establishment and maintenance of a triangulation framework on which maps and all field and artillery surveys can be based.

Before a satisfactory map of any area can be produced, it is necessary to establish a framework of points whose relative positions on the earth's surface can be determined. This framework is usually provided by undertaking a programme of triangulation over the entire area. Starting off with a base line, whose length is accurately measured, a series of triangles is built up, the angles of which are very accurately measured by theodolite observations. If, then, the position of one of these points is known and if the length and bearing of one of the sides is also known, then the triangles can be computed, and the positions of all the points can be determined with relation to each other. These positions can be calculated in terms of latitude and longitude referred to the earth's surface but, for military purposes, it is more convenient to compute them in terms of easting and northing co-ordinates based on a rectangular system of grid squares and referred to an origin whose co-ordinates are zero.

Having established this fixed framework, the topographical detail can then be surveyed, either by ground methods (*e.g.*, the plane table), or by plotting from air photographs, all the detail being fixed in position with reference to the triangulation framework. Thus, on the finished map, when it is provided with the military grid, the co-ordinates of any point marked on the map can be measured off in relation to the grid, and this gives its map reference.

There is another requirement for this triangulation framework apart from its necessity for mapping purposes. During the 1914-18 war a new artillery technique was developed which utilized survey principles. If the position of a gun, with reference to the map grid, can be determined by survey methods, and if the map reference of an enemy target can also be found with reference to the same grid, then it is easy to work out the range and bearing from gun to target and, by survey methods, lay the gun accordingly. It will be obvious that, as the map grid extends over the whole battle area, it is possible by these methods to lay an indefinite number of guns, even though widely dispersed, on to any selected target. This not only gives intense concentrations of fire, but enables such fire to be brought down on to a target without previous registration, thus giving the element of surprise.

A technique has been developed for plotting topographical detail from air photographs. For the making of a new map it is necessary that the photographs shall be taken in a certain manner, the area being covered by a series of longitudinal flights or strips, each strip consisting of a number of overlapping photographs, and each strip having a lateral overlap with its neighbour. The photographs themselves must have a minimum of tilt from the vertical. From these survey photographs the detail is plotted in relation to control points of fixed detail which can be recognized on the photographs and whose co-ordinates are known, either from existing trig lists, or by actually surveying their positions on the ground. In most countries it will be found that many of the national trig points are church spires, and these can usually be located on the photographs and used as control points.

Methods have also been evolved whereby the positions of enemy gun positions, defence works, etc., which are visible on air photographs, can be accurately transferred to a large scale map, and it is normal practice for the Survey Service, when so required, to produce special maps overprinted in colour, which show this information. The Artillery can then measure off on the maps the map references of their targets, and the Infantry and other arms can plan their tactical movements based on a knowledge of the enemy dispositions.

It will thus be realized that the existence of a triangulation framework in a theatre of operations is essential for several purposes. Fortunately most countries have established such a framework in their own homeland and also, to a greater or lesser degree, in their colonial possessions. Unfortunately, however, the quality of some of the work is poor, and as each country has established its own triangulation system independently, there are usually discrepancies of position along the frontiers between adjacent systems. In some countries, as for example in France during the last war, complications may arise owing to the fact that a newly observed triangulation system to replace the old one is only partially completed, and there are two systems in existence, side by side, with discordant values.

The above introductory notes may help to clarify the references in this and subsequent chapters to the triangulation and other survey systems which were

either in existence in the various operational theatres or were created by the Survey Service after its arrival.

The outbreak of war in 1914 had found the European nations unprepared in a survey and mapping sense for the requirements of modern war. Little serious study had been given to the national survey systems of potential friend or foe, and few large scale maps existed of any potential theatre of operations. The long period of trench warfare between 1914 and 1918, and the rapid development in accuracy and range of modern artillery led, naturally, to a demand for accurate large scale maps. Also a close system of fixed survey points was required for many purposes, above all for the determination of position and bearing for indirect artillery fire and accurate shooting by the map. The demand was so insistent and urgent during 1914-18 that little opportunity was available, amid the stress of operations, to study fully the geodetic problems concerning the various national surveys, or to initiate in the field a new comprehensive survey and mapping system adequate to the needs of the situation. The solution of the problem in western Europe during the 1914-18 war was achieved, in the case of the British Army, by the acceptance of the Belgian triangulation system and its extension southwards to cover the areas of France in which the British forces were operating. This procedure, though apparently straightforward and simple, produced many complications owing to various factors such as a discontinuity between the French and Belgian triangulations, and the varying quality of the French work within itself, much of which was old and of doubtful accuracy. On the whole, however, the system proved fairly satisfactory and served its purpose.

The experience of the combatant nations in the 1914-18 war gave a great impetus to survey and mapping during the years between the two great wars, and extensive programmes of work were initiated and vigorously pursued, partly to meet the needs of ordinary civil development, but also to provide reliable data and maps for a future war if this should arise.

The survey position in western Europe at the outbreak of war in 1939 was, therefore, very different from what it was in 1914, but the survey records and data referring to the pre-1914 and post-war periods were considerably intermingled, a fact which produced many difficulties.

It will be apparent that a comprehensive knowledge of the triangulation systems existing in a potential war theatre is an indispensable asset to the armed forces of a nation which may be involved in war. It is therefore an urgent responsibility of the Survey Directorate at the War Office to collect and tabulate the geodetic data referring to such areas, and to hold it ready in convenient form for issue to the Director of Survey of any Expeditionary Force proceeding overseas on active service.

There were two triangulation systems in France, an old one dating back nearly 150 years, and the new, which was begun in 1870. These two systems, which contained many points in common, were on different scales. This was not only because of a discrepancy in the measurements of the old and new base lines, but was also due to the fact that the systems were based on different values for the length of the earth's radius of curvature, a factor which enters largely into the computation of the spherical triangles which make up the triangulation. There was also the fact that the common point of origin for the new system was given a different value from what it had held for the old, and there was a discrepancy in the observed azimuths of the basic sides.

Between the two wars the French resumed work on observations for the

new triangulation and, by September 1939, the area of north-eastern France in which it seemed likely that British forces would operate had been completed on the new system. With an eye to future possible trouble with Germany, the French had naturally concentrated their efforts along the frontier regions facing Belgium, Luxembourg, and Germany, comprising roughly that part of France lying to the east of a line running southwards from Gravelines near the Belgian frontier to Perpignan near the Spanish frontier. To the west of this general line there was little new triangulation completed by the autumn of 1939, and the situation as a whole was therefore patchy, incomplete, and confusingly inconsistent. For the probable operational area in north-eastern France, the War Office had obtained triangulation data from the French Service Géographique, and had prepared lists of co-ordinates (trig lists) of the French national trig points in that area in the form of rectangular co-ordinates referred to the Lambert projection and the "Nord de Guerre" military grid. This latter, which was a relic of the 1914-18 war, had been adopted by the French, and the British War Office agreed to accept and use it to preserve essential uniformity in map referencing between the Allied Armies.

The triangulation of Belgium was more modern, dating from the middle of the nineteenth century. Having been observed later than the old French system, it had the advantage of more modern instruments and methods in accordance with the growing necessity for greater precision. The War Office trig lists covering Belgium were made up by transforming the co-ordinates from the national Belgian grid system to the "Nord de Guerre" grid, so as to have the trig values of points in France and in Belgium all on the same system.

As soon as the B.E.F. had landed in France in September, 1939, and while the two British corps were concentrating back in Normandy, the G.H.Q. Survey Directorate at once started to examine the lists and found that considerable errors and discrepancies existed in them. These were partly owing to faulty transcription and transformation from the original lists, and partly to a lack of sympathy between the values of common points along the frontier between France and Belgium. With the possibility of having to fight astride the frontier region, it was considered desirable to ensure a homogeneous system of co-ordinates which would enable the R.E. and R.A. survey organizations to carry forward from France into Belgium and well into the forward areas without encountering the difficulties due to discordant values when crossing the frontier.

A comprehensive adjustment of triangulation values was therefore undertaken, extending from the French side of the frontier right through Belgium, to link up smoothly with the values already available for Holland and Germany. As a result of much intensive investigation a new series of trig lists was published by G.H.Q. Survey Directorate. A full explanation and description of the work completed under Colonel Hotine's direction can be read in a pamphlet entitled "Triangulation situation in Northern France, Belgium, Holland and Western Germany 1944" (Second Edition), which was compiled by Lieutenant-Colonel W. E. Browne, R.E. and published by the Survey Directorate, S.H.A.E.F., at the time of the Normandy invasion in 1944.

When the B.E.F. had taken up its allotted position in the Lille sector of the Belgian frontier in October, 1939, the topographical sections of the R.E. field survey companies at once began their check surveys of the local French triangulation to test the accuracy of the published trig lists, and to extend the survey, where necessary; the latter to provide the R.A. survey regiments with any

extra control points which they might require for fixing the gun positions of the two corps on to the map grid. In many cases they found that there was a significant and disturbing lack of sympathy between the co-ordinate values of certain adjacent points, as shown on the published trig lists, and the values obtained by direct observation on the ground. It was found that this was due to the French method of adjustment which, for the lower category of triangulation, was apparently done on a patchy map sheet basis instead of on a regular comprehensive system. In most areas there were, however, a large number of points available in the trig lists and, by the application of normal common-sense methods in the use of the available data, adequate results could generally be obtained, taking into account the purpose for which the work was required. While 13 and 14 Corps Field Survey Companies were engaged on this work in their corps areas, 19 (Army) Field Survey Company was undertaking similar work in the back areas, checking up and thickening the existing triangulation. Several special tasks were undertaken in connection with the establishment of triangulation at base ports, the fixation of anti-aircraft gun positions, the establishment of fixed ranges for gun calibration, and the surveys of base depots, etc.

During the seven months' occupation of the frontier sector a large amount of defensive development work was undertaken. This included an organized system of anti-tank ditches, pill-boxes, gun emplacements, obstacles, etc., and it was decided that all these should be surveyed and plotted on large scale maps, not only as a means of recording progress, but also to facilitate the handing over of a sector from one formation to another. Some of this work was plotted from air photographs, but a considerable amount was surveyed by normal ground methods by the Corps Field Survey Companies.

In view of a probable German offensive through Belgium, the High Command prepared a plan whereby British and French forces would move forward into Belgium and occupy a position along the R. Dyle, to the east of Brussels, as soon as the German armies should cross the frontier into Belgium. Anticipating such a move, the possible trig situations which might arise in the event of operations along the river lines in Belgium were carefully considered in co-operation with the R.A. survey regiments. Paper schemes for the establishment of triangulation along such lines were worked out beforehand. Arrangements were also made whereby the topographical sections of the field survey companies would move forward in close touch with the R.A. survey regiments, so that work on the ground could begin in complete liaison and with the least possible delay.

On 10th May, 1940, the German offensive was launched. 13 and 14 Field Survey Companies moved with 1 and 2 Corps respectively to the R. Dyle, where they immediately began their check surveys of the local triangulation by ground observation, and the fixing of extra points as required by the gunners. This work extended both east and west of the river so as to cover both the gun and target areas. Meanwhile, 514 Field Survey Company remained on the line of the R. Escaut, where it undertook similar work for 3 Corps. This was to prove of much value a few days later when the British force retired through that position.

Up forward on the R. Dyle, the original paper schemes for the trig plan were carried out in the face of many difficulties. The country was close and difficult for resection methods. The shortage of despatch riders and motor-cycles was found to delay the sending in of results to the report centres.

However, the trig work done on the position was on the whole successfully completed according to plan by the night of 13/14th May, in spite of considerable disturbance due to enemy shelling and low flying air attacks.

The next few days were confused. Topographical sections of 13 Company worked in the Forest of Soignes revising roads and tracks on the 1/50,000 maps; as much trouble and confusion had been caused by troops losing their way in this area. They were then instructed to carry out a triangulation to cover the ground between the Charleroi Canal and the Forest of Soignes, in case that area had to be held to protect Brussels from the south but, before any work could be started, they received orders to retire to the west of Brussels on the evening of the 15th. Orders for further survey work along the line of the Charleroi Canal were received on the 16th and, by daybreak on the 17th, the topographical sections were out on the job. Orders for a further retirement put an end to this work, however, and their next task was to provide the gunners of 1 Corps with survey fixations along the R. Escaut defence line on the southern flank of the British area. All this work checked in very well and, when the Germans eventually came up against this position, the artillery fire laid down on the enemy concentrations was most effective.

After finishing its task on the R. Escaut 13 Company retired further to the north-west, and was engaged in a series of jobs for artillery control along the R. Lys and in the vicinity of Lille and Armentières. After assisting in the defence of Nieuport 13 Field Survey Company was ordered to proceed to the beach at La Panne where it embarked and crossed over to Dover on 31st May.

Meanwhile 14 Field Survey Company completed its share of the survey on the R. Dyle position in the neighbourhood of Louvain, and then retired to the R. Escaut where, in conjunction with the Corps Survey Regiment R.A. it completed the survey for artillery fixation at the northern end of the river line. Subsequently it carried out further work of a similar nature in the area Bailleul, Kemmel, Messines and Ploegsteert, and in due course embarked from the Dunkirk beaches.

The role of 3 Corps had been to remain on the line of the R. Escaut pending the development of operations further forward. 514 Field Survey Company surveyed the front in order to provide control for fixing both gun and target areas in conjunction with the R.A. Survey Regt. When the corps eventually came into action the guns, using predicted shooting, were hitting their targets with remarkable accuracy. In the words of A.D. Survey 3 Corps:—"this part of the survey duties was so successful that it is difficult to offer comment except that it must not be forgotten that the careful adjustment of the triangulation during the winter of 1939-40 was probably responsible for such good results."

So ended the field work of the survey units with the B.E.F. in 1939-40. Once battle had been joined to the east of Brussels, it was a case of rush jobs carried out on a succession of rearguard positions, all of them against time, and in face of great difficulties. The seven months of static conditions between September and May had given the units the opportunity of learning many valuable lessons of a practical nature, the most important of which was a growing knowledge of what an army in the field requires in the way of survey, how to provide it, and how best to co-operate with the artillery survey regiments, none of which can be learnt except by constant practical experience. The field survey companies and the Field Survey Map Depot had done excellent work and had developed into good efficient units. It is well that the crisis did not happen early after their arrival in France in 1939. With so little previous

practical training they could not possibly have rendered at that time the valuable service which they undoubtedly gave during the short campaign in May, 1940.

With regard to the available triangulation data and records, there seems little doubt that more attention could have been paid to the sorting out and adjustment of the French and Belgian material before the outbreak of war. There is no doubt also that it would have been helpful if the Director of Survey (designate) for the B.E.F. had been brought into the picture early during the planning stage so that he could have had some say in the preparation of the material which would be placed at his disposal.

SECTION 4. MAP SUPPLY AND DISTRIBUTION

It is a platitude to state that, to be of any value, maps must be in the hands of the users in plenty of time for the operation or other purpose for which they will be used. On the other hand it is important to remember, from the security standpoint, that the issue of maps before an operation could give a fair indication of where such an operation is likely to take place. A well thought out and well controlled organization for map supply and distribution is therefore essential, full consideration being given to the proper provision of personnel and transport, and not forgetting the important security aspect.

In those pre-war official manuals which referred in any way to Survey activities, it was quite clearly laid down as existing policy that the Survey Service was not responsible for the detailed distribution of maps to formations and units. Its duty was to produce the maps required for a campaign in accordance with General Staff policy, and to assemble the necessary stocks ready for issue, either in Map Depots in the United Kingdom for issue to an Expeditionary Force before embarkation, or in Map Depots within the overseas theatre. Experience during the war has generally shown, however, that in order to ensure the safe and proper receipt of maps by the troops, especially in mobile operations, the Survey Service should as a rule accept responsibility for distribution down to headquarters of divisions. It is indicated, therefore, that future policy and war establishments should fully allow for this, so that there may be adequate personnel and transport allotted for the task.

At the outbreak of war, the Geographical Section at the War Office controlled a map store at Alperton (N.W. London), and a small detail issue store in Whitehall for the use of the War Office staff. Both of these remained in the same location throughout the war. Their commitments, however, steadily increased, both had to be considerably reinforced, and other depots were opened up.

The first operational map issues that the War Office had to make were those for the B.E.F. in September, 1939. The provision of these stocks was dependent on the following policy that had been agreed by the General Staff:—

- (a) That all units should have an issue of small scale (1/250,000) maps before proceeding overseas.
- (b) That issues of medium scale (1/50,000) maps should only be made in the theatre of overseas operations.
- (c) That no large scale (1/25,000) maps would be printed except in the battle area.
- (d) That issues would be made in accordance with a table of unit entitlement which was prepared by the War Office before the war.

To put this policy into effect, stocks of small scale maps of the concentration and probable operational areas were issued to the Home Commands during the emergency period, for distribution by them to the units before embarkation. The medium scale (1/50,000) stocks were packed in wooden cases and sent to a store depot near Portsmouth, so as to be ready for shipment overseas as soon as the G.H.Q. Survey Directorate and Depot should be ready to receive them. No stocks of the 1/25,000 maps were printed, but kodak negatives were prepared for each sheet of the series, and a complete set was issued to each of the field survey companies so that they could print them in the field on their mobile printing equipment as and when required. Printing plates of all the map series on all scales were issued to the army field survey company which would be working at the direct disposal of the Director of Survey at G.H.Q.

To receive, hold, and issue the bulk map stocks overseas, No. 1 Field Survey Depot was assigned to the B.E.F. which, as already stated, consisted of General Headquarters and G.H.Q. Troops, L. of C. Troops, and two corps (subsequently increased to three). The Depot had an establishment of one officer, two warrant officers, and 16 other ranks, together with one 3-ton lorry. It was installed first at Le Mans, alongside G.H.Q. in the concentration area. The bulk stocks arrived from the United Kingdom a few days after G.H.Q. had reached Le Mans. The consignment amounted to over 500 tons, and at that time little transport or labour was available to move it from the station to the depot. There was also considerable difficulty in requisitioning a suitable building for the Depot, no allowance having been made for this item in the key plan drawn up by the War Office. As soon as the B.E.F. moved forward to occupy its allotted sector along the Belgian frontier, it was necessary to split the Depot in two parts. A small rear party of one warrant officer and four other ranks moved back from Le Mans to Rennes with the main stocks to set up a Base Map Depot, where they would receive and hold further map supplies from the United Kingdom, and despatch consignments forward as required. The remainder of the unit went forward with stocks of the operational area to Doullens, where an Advanced Map Depot was set up within easy reach of the G.H.Q. Survey Directorate which was at Hauteville, near Arras. This split of the Depot immediately caused a shortage to be felt in personnel, and of course one lorry could not be in two places at once. With the main supply base ports back in Brittany there was no other course.

During the seven months leading up to the German offensive in May, 1940, conditions within the British Zone were more or less static. At that time there was a Corps Survey Directorate with each of the corps, and the A.D.s Survey were able to look after the map requirements of their own corps H.Q., corps troops and divisions. They co-ordinated the demands and sent back indents to the Advanced Map Depot, through G.H.Q. Survey Directorate. Corps transport was then sent back direct to the Depot to collect the maps. The corps H.Q. staff, usually through a junior intelligence staff officer, was officially responsible for distribution down to divisions, the latter then making their own arrangements for further distribution to brigades. In actual fact, the A.D. Survey at corps H.Q. took most of the responsibility for seeing that the distribution to corps troops and divisions was properly effected, though he had no direct responsibility for this, nor had he any transport at his own disposal for getting it done.

The one 3-ton lorry belonging to the Field Survey Depot was quite inadequate. It could not serve both the rear and advanced echelons, it was extra-

gant and quite unsuitable for the daily domestic requirements such as drawing rations, mail, etc., and it was not sufficient for the task of moving bulk map stocks. In May, when the B.E.F. moved into Belgium to meet the German offensive, it was necessary to organize a mobile map depot detachment to supply the corps which were operating east of Brussels. With considerable difficulty some lorries were borrowed from a G.H.Q. transport pool, and this forward echelon installed itself at Lierde St. Martin, just west of Brussels. At this time, the map stocks within the theatre were divided between this mobile detachment, the Advanced Map Depot near Doullens, and the Base Map Depot at Rennes. With the rapid German advance, Lierde St. Martin soon had to be evacuated. To save transport the stocks covering eastern Belgium were scuttled, and the remaining stocks of western Belgium and north-eastern France were soon exhausted during the retreat. Owing to the swift enemy armoured thrusts further south to Amiens and the Channel ports, the B.E.F. was soon cut off from its main L. of C., and the Advanced Map Depot near Doullens was lost. Thus, while the British force was fighting its way back towards the Dunkirk perimeter, map stocks of that vital area ceased to be available from normal map depot channels, and except for the small rear party at Rennes, the Field Survey Depot, to all intents and purposes, ceased to function as such. The B.E.F. then became entirely dependent on the stocks of large scale maps which could be printed by the corps field survey companies with each corps during the retreat. A last minute attempt to obtain stocks by sea from Rennes *via* Cherbourg and Dunkirk provided small quantities, which were, however, insufficient and too late. The French liaison officer attached to the G.H.Q. Survey Directorate who sailed from Boulogne on this mission in a small motor boat in a very rough sea to Cherbourg, will no doubt retain many unhappy memories of this episode.

No real opportunity occurred during these early operations in France and Belgium to test out map distribution arrangements under normal mobile field conditions, but it was quite obvious that the organization of the Field Survey Depot, both in personnel and transport, was not adequate to deal with a field formation equivalent to an army. It was also clear that, if map supplies were to reach divisions in the field without fear of failure, it was desirable that the Survey Service should take a hand in the distribution problem and be properly organized and equipped to do the job.

CHAPTER III

HOME DEFENCE AND PREPARATIONS FOR OFFENSIVE OPERATIONS

The evacuation of the B.E.F. from Dunkirk, and the enemy occupation of the north-western European coast line and the Channel ports, introduced a new phase of the war. In the space of a few days during June and July, 1940, it was necessary to reorient policy and action so as to concentrate all efforts on defence.

The available survey resources in Great Britain at that time consisted of the Geographical Section, General Staff at the War Office, which had moved to Cheltenham, the Ordnance Survey at Southampton, one or two newly raised field survey units which were in process of formation and training, a small depot and training unit, and the personnel of the survey units which had returned from France and which were disorganized and without any equipment.

It was known that small stocks of maps covering various training areas in Great Britain were available in map stores at the headquarters of the home commands, but their numbers were insufficient for immediate defence operations, and urgent action was necessary to print large stocks of vital areas. It was also certain that survey work would be required round the coasts and elsewhere to fix the positions of coast defence artillery, anti-aircraft batteries, and radar stations which were under construction.

G.H.Q. Home Forces had taken over control of all available forces in the United Kingdom and was responsible for organizing military measures for the defence of the country. It was suggested that survey representation should be included at G.H.Q., but this was refused on the grounds that no increase of staff could be entertained and that a liaison officer from the Geographical Section would be sufficient. This decision was typical of current opinion at that time regarding maps and survey, and was no doubt a legacy of the pre-war era when, owing to the non-existence of any survey organization with the Army, and the automatic supply of training maps from the War Office and the Ordnance Survey, there was little or no appreciation amongst staff officers of the necessity for a survey service under war conditions.

At the above juncture an Army Order was published directing the mobilization of a force of 12 divisions, less certain services of which survey was one. This would have entailed the practical elimination of the Survey Service at a critical time when the need for maps and field surveys was of vital importance.

Major-General MacLeod, the Director General of the Ordnance Survey (D.G.O.S.), who well knew the serious situation with regard to available map stocks, was anxiously awaiting information and guidance on area priorities for map printing. In the absence of survey representation at G.H.Q. Home Forces this information was not forthcoming. He therefore asked that the Director of Military Operations should appoint a Committee to consider the problem of maps and surveys for defence. This was arranged, and a case was presented for including a survey organization within the framework of the defence forces. As a result it was agreed that there should be a Director of Survey at G.H.Q., with an A.D. Survey and one Field Survey Company R.E. in each of the home commands.

Meanwhile Lieutenant-Colonel M. Hotine, who had recently returned from France after serving with the G.H.Q. Survey Directorate (B.E.F.) and was in close touch with the D.G.O.S., visited G.H.Q. Home Forces in order to obtain an operational appreciation which would serve as a basis for planning a map printing programme. He obtained an interview with the Chief of Staff who gave him an outline of the defence plan sufficient to enable the D.G.O.S. to draw up his programme and start printing maps in great quantity.

Pending his appointment at the end of June as Director of Survey, Home Forces, Lieutenant-Colonel Hotine vigorously undertook the preliminary steps necessary to ensure the proper supply and distribution of maps immediately they were available. He organized map depots to serve each of the home commands, the personnel for manning these being obtained largely from ex-B.E.F. survey units. He also investigated the requirements for field surveys in connection with coast defence artillery, anti-aircraft positions, etc., and prepared plans for putting this work into effect.

At G.H.Q. Home Forces many daily problems involving map supply and field surveys started to come in from the commands, and they were unable to deal with them without technical assistance. Happily during this period the enemy failed to carry out his threatened invasion.

At the end of June the survey organization referred to above came into being with Colonel Hotine as Director of Survey at G.H.Q., an A.D. Survey and a field survey company in each of the home commands, and a small survey staff at each of the headquarters concerned. Their responsibilities included the provision of maps for training and defence, the control of field surveys all over the country, and the training of survey units which were, or would be, in process of formation.

The latter part of 1940 and all 1941 was devoted to a combination of two main objects, the development of plans and action to counter a possible invasion, and the build-up and training of British forces which would be required for other theatres and for the ultimate offensive operations in western Europe. So far as the survey units were concerned, these conflicting responsibilities were a constant source of difficulty. There was always such a lot of operational survey and mapping work to be done that there was little time or opportunity for undertaking those items of military and other forms of technical training that were so essential.

The Survey Directorate at G.H.Q. remained practically unchanged throughout 1941 with a Director (Colonel), a Deputy Assistant Director (Major), and a small staff of clerks, draughtsmen and map storekeepers. Colonel Hotine, who had been appointed to East Africa in October, 1940, had been replaced by Colonel R. E. Fryer as D. Survey. During January there were, in addition to the small directorates at the headquarters of commands, two corps directorates, one with the Canadian Corps, and one with 4 Corps which was in G.H.Q. reserve. When the latter was disbanded, its survey directorate was switched over to the new South Eastern Command, which was formed in February when Eastern Command was split. During April, 10 Corps was mobilized for overseas, and a directorate was formed to accompany it. In March, 5 Corps was mobilized for a special role and, though it did not go overseas, a survey directorate was formed and remained with it for the rest of the year. During the early part of 1941 the Canadian Corps took the necessary steps to replace British personnel on their survey directorate by Canadians, and a Canadian A.D. Survey was appointed (Lieutenant-Colonel H. Meuser, R.C.E.).

It will be well now to consider the situation as it existed at that time regarding survey units in the United Kingdom. At the beginning of January, 1941, there were nine Field Survey Companies R.E. under Home Forces control, and they were located in the commands as shown below:—

Southern Command	No. 519 (just formed)
	No. 516 (with 5 Corps)
Eastern Command	No. 14 (ex-B.E.F.)
	No. 1 Canadian (with Canadian Corps)
Northern Command	Nos. 13 (ex-B.E.F.) and 521 (just formed)
Western Command	Nos. 517 and 520 (just formed)
Scottish Command	No. 518 (just formed)

Of the above, 517 Field Survey Company moved overseas to the Middle East during January, leaving eight field survey companies in the United Kingdom, four of which were in the early stages of formation and training.

When British troops were sent to Iceland, 19 Field Survey Company accompanied them on a special mission, but with a reduced establishment. On its return during 1941 it remained in the United Kingdom for two months before proceeding to the Middle East.

In September, 518 Field Survey Company was detailed for special assault training with the Combined Training Centre in Scottish Command, and 519 Company was sent to take its place, being replaced in Southern Command by 516 Company which had just been released from 5 Corps. In December, both 13 and 518 Field Survey Companies were mobilized for service overseas.

Reference has already been made to the assembly of bulk map stocks in the commands. At the beginning of 1941, there were four field survey depots under Home Forces control looking after the four main Reserve Map Depots at Aldershot, Towcester, Swindon and Tadcaster, and staffing, in addition, a number of subsidiary map stores required for defence measures in some of the districts and areas.

During 1941, two additional Reserve Map Depots were established at Penicuik (near Edinburgh) and at Newton Hall (near Newcastle) and the Chester store for Western Command was enlarged. A new unit (No. 10 Field Survey Depot) was formed in March and, by readjusting the provision of detachments, it was arranged that each command should have a Reserve Map Depot of its own and, in addition, set up a small map store at command H.Q. to meet their daily needs. The organization then became

South Eastern Command	No. 3 Field Survey Depot at Aldershot.
Eastern Command	No. 4 Field Survey Depot at Towcester.
Northern Command	No. 7 Field Survey Depot at Newton Hall (near Newcastle).
Western Command	Det. from No. 4 at Delamere, near Chester.
Southern Command	No. 5 Field Survey Depot at Swindon.
Scottish Command	No. 10 Field Survey Depot at Penicuik (near Edinburgh).

None of the Field Survey Depots were warned for overseas service during 1941 but, at the end of the year, No. 12 Field Survey Depot was formed at Swindon under War Office control to enable one at least of the existing units to be available for overseas early in 1942 if required.

With the entry of the United States into the war in December, 1941, after Pearl Harbour, the potential mapping picture became fundamentally altered. The geographical scope of operations assumed a wider aspect, the date for a resumption of the offensive against Germany began to look nearer, and the possibility, or rather the necessity, of co-operating without delay with the American mapping service with regard to high level mapping policy assumed immediate importance. A War Office survey representative went to Washington for discussions, and fuller notes on this will be found in Chapter IV.

In January, 1942, an armoured corps was formed under Home Forces. It was thought that a special survey unit might be required to deal with its mapping and survey requirements. 97 (Armoured Corps) Field Survey Squadron was therefore formed, equipped with the new lorry-mounted reproduction plant and it was organized on a very mobile basis. It had a short life of about three to four months only, after which it was agreed that no special unit of this type was justified. It was therefore converted to 523 (Corps) Field Survey Company of the normal type.

During June, 13 (Corps) Field Survey Company went to Middle East, and one topographical section of 521 Field Survey Company was detached to South Eastern Command for special work in connection with the survey fixation of heavy guns, which were then being installed in the Dover area, as an answer to the German "heavies" which were firing across the Channel from the French coast around Calais. It was necessary to establish accurate cross-Channel observations to connect up the triangulations of Great Britain and France, and this was successfully accomplished.

By about mid-1942 anxiety about an enemy invasion grew considerably less. Strong well-trained British forces were by now available and, with the prospect of large concentrations of American formations assembling in the United Kingdom, thoughts and plans were switched from the defensive to the offensive. At this time G.H.Q. Home Forces was instructed to assemble a planning staff to consider how, when, and where an assault operation could be launched against the Germans in north-western Europe. During the summer there was also the planning for operation "Torch," the invasion of North Africa by combined British and American forces. These two major items, together with increasing demands for new units and reinforcements for the Middle East and other theatres, began to have a considerable and ever-increasing effect on the training, dispositions, and availability of the survey units under Home Forces control. With the rapidly increasing activities of the planning staffs it was found necessary to add one D.A.D. Survey to the G.H.Q. Survey Directorate. His principal responsibility was to organize and supervise the production of all the special maps, diagrams, etc., which were required in ever-increasing numbers for planning purposes, and to illustrate reports, projects, and intelligence and engineer summaries.

The early findings of the planning staff who were dealing with the north-western European theatre indicated the need for the production of 1/25,000 maps covering those parts of northern France which were not already covered by maps at that scale. For this purpose six General Survey Sections R.E. were raised and trained in air-photo mapping, and were then concentrated as an Air Survey Group under the immediate control of D. Survey, Home Forces. One Air (Survey) Liaison Section was also formed to work alongside the R.A.F. Squadron which was undertaking the air photography for this mapping project and also for the investigation of the beach gradients along the enemy-occupied

coastline. The technical training of selected A.T.S. personnel was begun in order to raise A.T.S. drawing sections, thereby helping to alleviate the growing man-power difficulties. By mid-1942 topographical units from the United States were beginning to arrive, and U.S. mapping liaison officers were available for co-operative action concerning map supply and production.

Survey Directorates were assembled for the Allied Planning Headquarters for operation "Torch," and for the British First Army which was to take part. 518 Field Survey Company R.E. was mobilized for this operation and ceased to be under Home Forces control. By October, 1942, the Survey organization in Home Forces was as under:—

Director of Survey, with Survey Directorate at G.H.Q. (now Colonel A. B. Clough who replaced Colonel Fryer on his appointment to Middle East in January, 1942).

A small Directorate with each of the Home Commands and certain Corps. Field Survey Companies Nos. 14, 516, 519, 520, 521, 523 (515 in Northern Ireland), 1 Canadian.

General Survey Sections Nos. 1, 2, 3, 4, 5, 6.

Field Survey Depots Nos. 3, 4, 5, 7, 10 (No. 6 in Northern Ireland).

Air (Survey) Liaison Section No. 1.

In December, 1942, 516 Field Survey Company was transferred to War Office control pending its move to North Africa, in January.

The field survey companies which had operated with the B.E.F. during 1939-40 had been equipped with double-demy size printing machines mounted in trailers. Experience in that campaign had shown that complete mobility was essential, and it was therefore decided that all further such units would be equipped with smaller size demy machines mounted in specially designed lorries. It was realized also that there would be a need for larger size machines in any European or other major theatre, for printing bulk stocks of those standard maps which were of larger, double-demy, size, and for the reproduction of those enemy maps which were too big for the smaller, mobile, machines carried by field survey companies. Map Reproduction Sections R.E. were therefore designed to meet such requirements and Nos. 11, 13, and 14 were formed under Home Forces during February, 1943. No. 11 was soon transferred to War Office control for service in North Africa. From its formation, No. 13 was employed on urgent, highly secret map production for the planning staffs, and it continued to be so employed until the end of the war, doing duty in turn for G.H.Q. Home Forces, H.Q. 21 Army Group, C.O.S.S.A.C., and S.H.A.E.F.

No. 7 Field Survey Depot passed to War Office control in February, 1943, for transfer to the North African theatre, being replaced by No. 21 which had just been formed. During the spring of 1943 there were several prospective moves of units for planned operations which were subsequently cancelled. Units were mobilized and then released. This considerably interfered with the programmes of productive mapping work which all units were now undertaking, and upset also their training programmes. The 1/25,000 ("Benson") project of northern France was by now being shared by all the field survey companies as well as by the six General Survey Sections. The extent of the project, and the limited time available for completion, made it necessary to concentrate on it all the resources at the disposal of D. Survey Home Forces, and the loss of a unit, even though only temporary, was a considerable embarrassment.

The plan for operation "Overlord" (invasion assault on the French coast) was now firm enough to justify further detailed survey activities being undertaken in preparation for it. This included an investigation into the geodesy of north-western Europe, and the preparation of triangulation and other survey data which would be required by both R.E. and R.A. Survey units in the field. One A.D. Survey (Lieutenant-Colonel W. E. Browne, R.E.) was therefore added to the Survey Directorate at G.H.Q. for this purpose. In the late spring of 1943, Headquarters for the British Second Army was formed, and this included a Deputy Director of Survey (Colonel A. W. Heap) with his directorate staff. Concurrently, similar action was taken for the First Canadian Army.

During May, two further General Survey Sections (Nos. 8 and 9) completed their formation and training and were added to the Air Survey Group. In the following month 515 Field Survey Company with No. 6 Field Survey Depot, crossed over from Northern Ireland where they had been doing duty for some months. Another field survey depot being required for overseas, No. 10 was released from Home Forces and was replaced by the newly formed No. 23. During the summer months the survey units scheduled for operation "Overlord" were one by one mobilized.

In July, 1943, Headquarters of 21 Army Group was assembled. This headquarters, which was to command the British forces on the Continent, consisting primarily of the Second British and First Canadian Armies, took over responsibility for continuing the high level planning studies. So far as Survey was concerned, almost the entire personnel of what had been the Home Forces Survey Directorate switched over to 21 Army Group. A small new survey directorate for Home Forces was then formed. By this means there was no discontinuity in the survey planning.

The majority of the survey units in the United Kingdom were now allocated to 21 Army Group to take their place as army group troops and Second Army troops respectively. The Canadian survey units, of course, formed part of the First Canadian Army. As each unit completed its task on the 1/25,000 mapping of Northern France, it started at once on an intensive period of training to fit itself for field service conditions.

The Air Survey Liaison Section R.E. was located on the Blackbushe Airfield near Camberley, with 140 Squadron R.A.F. which was undertaking the survey photography. The Section's special task was to give technical briefing to the pilots, and carry out investigational work concerning the photography for mapping, for the determination of beach gradients, and for the selection of potential airfield sites in the prospective Normandy bridgehead.

Some important establishment changes were now effected in survey units as a result of recent experience in the Middle East, so as to facilitate exchange of units if so required. The most far-reaching change concerned the Field Survey Depot which would be operating with an army. Experience overseas had shown that the standard establishment of one officer, 18 other ranks and only one lorry was totally ineffective to ensure the adequate supply and distribution of maps to formations moving fast over long distances. Big increases were therefore authorized, both in personnel and transport. This applied to No. 3 Field Survey Depot which was allocated to the Second Army and also, of course, to the depot with the Canadian Army. In order to release Nos. 4 and 5 Field Survey Depots to H.Q. 21 Army Group, American units took over the Swindon depot from No. 5, and No. 6 Field Survey Depot (Home Forces) took over the Towcester depot from No. 4.

The Survey organization for "Overlord" was now becoming firm. Pending the appointment of a Supreme Commander the high level planning for the Allied Forces was taken over by Chief of Staff to the Supreme Allied Command (C.O.S.S.A.C.) with an integrated British-American staff, and for this new headquarters a Survey Directorate was authorized. To meet this contingency Brigadier A. B. Clough, with a proportion of his key personnel, moved over to C.O.S.S.A.C., where the Survey Directorate was completed by the posting of U.S. personnel.

With the formation of Supreme Headquarters Allied Expeditionary Force (S.H.A.E.F.) in January, 1944, the survey organization in preparation for "Overlord" was as under:—

S.H.A.E.F. D. Survey (Brigadier A. B. Clough) and Survey Directorate (British-U.S. integrated staff).

H.Q. 21 Army Group.

D. Survey (Brigadier A. Prain) and Survey Directorate.

No. 515 Field Survey Company R.E.

No. 1 Air Survey Liaison Section R.E.

Nos. 4, 5 and 9 General Survey Sections R.E.

Nos. 4. and 5 Field Survey Depots R.E.

Nos. 13, 14, 15 and 16 Map Reproduction Sections R.E.

First Canadian Army.

D.D. Survey (Colonel H. Meuser) and Survey Directorate.

Nos. 2, 3 and 4 Canadian Field Survey Companies R.C.E.

No. 1 Canadian Field Survey Depot R.C.E.

No. 30 Air Survey Liaison Section R.C.E.

British Second Army.

D.D. Survey (Colonel A. W. Heap) and Survey Directorate.

Nos. 14, 519 and 521 Field Survey Companies R.E.

Nos. 1, 2 and 3 General Survey Sections R.E.

No. 3 (Army) Field Survey Depot R.E.

Remaining with Home Forces:—

Small Survey Directorate at G.H.Q.

One small Survey Directorate at each of the home commands.

Nos. 520 and 523 Field Survey Companies R.E.

Nos. 6 and 8 General Survey Sections R.E.

Nos. 6, 21, 23 and 25 Field Survey Depots R.E.

With the assumption of map supply and distribution responsibility by 21 Army Group and the two field armies, survey responsibilities in the home commands were greatly reduced. In January, 1944, therefore, the appointments of A. D. Survey in Northern, Western and South Eastern Commands were cancelled. Commands were then grouped in pairs for Home Forces Survey control.

In April, 1944, active steps were taken to organize the special map depots that would be required in the marshalling areas for mapping up the assault and followup formations. This work, under the general direction of 21 Army Group and the two armies, was undertaken by survey units under Home Forces control.

Operation "Overlord" was launched on 6th June, 1944. From that date onwards, the responsibilities and activities of the Home Forces Survey organ-

ization steadily decreased, though the units were kept busy on operational map printing, especially in connection with the requirements for airborne operations which were mounted from the United Kingdom.

The somewhat unexpectedly large demand for 1/25,000 maps during the operations in Normandy and beyond led to an increased requirement in mobile printing equipment for Second Army. It was found necessary, therefore, to despatch overseas the greater part of the reproduction tradesmen of 520 and 523 Field Survey Companies and their printing lorries and by November, 1944, 520 Field Survey Company and 8 General Survey Section had been disbanded.

CHAPTER IV

BRITISH-AMERICAN MAPPING POLICY

The following map is relative to this chapter:—

Sketch Map 2. The World.

Facing page 48

When the United States entered the war in December, 1941, the need was recognized for a definite working arrangement regarding the preparation and production of mapping material for a global war. Quite apart from the waste of effort caused by a duplication and overlap of mapping programmes it was essential that, when allied forces were likely to be closely associated in any potential theatre of operations, they should use the same maps.

Colonel M. Hotine (Director of Military Survey, War Office) and Colonel H. B. Loper (Chief of the Intelligence Branch of the Chief of Engineers, U.S. Army) met in Washington in May, 1942, to discuss the mapping situation. As a result they drew up a Memorandum of Agreement on mapping and survey policy between the War Office (G.S.G.S.) and the U.S. Chief of Engineers representing the War Department. The Chief of Engineers was responsible for executive action in connection with map production and supply for the U.S. Army. This agreement, which became known as the Loper-Hotine Agreement, dealt with three main subjects, namely, the division of responsibility for map production, the exchange of mapping material and other survey data, and the selection of military map grids.

The United States assumed complete responsibility for the production and supply of maps and survey data, including the provision of survey units or any necessary reinforcement of existing allied military survey organizations, in the following areas:—

North and South America, Australia, New Zealand, Pacific Ocean Islands, Dutch East Indies, Japan, West Indies, Iceland, Greenland, and Bermuda.

The War Office (G.S.G.S.), either direct or through its representatives in overseas theatres, continued to accept responsibility for initial map preparation in other areas. It was made clear, however, that American help would be required to meet the following contingencies:—

- (a) The reproduction and printing of initial map supplies from material to be supplied by G.S.G.S., for pre-operational use in the United States, and for initial issues to U.S. troops which would proceed direct to an operational theatre without passing through British map supply channels.
- (b) The provision of U.S. survey units and staffs in support of major U.S. army or air forces, and arrangements for the exchange of survey liaison officers where considered advisable.
- (c) The provision of air photographs for mapping purposes, to supplement where necessary the resources of R.A.F. Photo Reconnaissance Units, first priority being given to areas of north-western Europe which were not already covered by reliable large scale maps.

It was agreed that G.S.G.S. would automatically supply to the Chief of Engineers, U.S. Army, colour pulls or other suitable material for rapid reproduction of the following:—

- (a) All new G.S.G.S. publications.
- (b) All current air and strategic maps on a scale of 1/500,000 and smaller.
- (c) All current tactical maps in the area of American mapping responsibility, together with the overlapping areas of Malaya, Thailand, Indo-China, Atlantic Islands, West Africa, N. West Africa, N. West Europe, and the China Coast.
- (d) Any G.S.G.S. maps not included in the above which might be specifically requested.

The Chief of Engineers agreed to reciprocate with regard to U.S. productions.

It was agreed that the Chief of Engineers, U.S. Army, would provide G.S.G.S. with full details of any fresh military grids which would be laid down in the areas of American responsibility. In the case of grids covering Australia, New Zealand, Canada, etc., it was further agreed that the survey authorities in those countries should first be consulted.

The above Agreement formed the original basis on which plans were formulated for the production and provision of maps and other survey data which might be required by the Allied Forces in the various potential operational theatres. As time went on and conditions changed, it naturally became necessary to modify and supplement the details of the Agreement, but the basis of co-operation had been well and truly laid, and during the whole course of the war the relations and spirit of mutual help between the British and American mapping organizations continued to be of the happiest and most satisfactory nature.

The problem of the spelling of place names and the system of grid referencing to be employed was discussed at an International Mapping Conference held at the War Office in March, 1943. It was agreed that the problem was so intimately connected with the business of map production that the map-producing organizations ought to co-ordinate the production of gazetteers and glossaries. They would not, however, necessarily undertake the production themselves, but would use any other organization which was qualified to do the work. The division of responsibility was to follow that which might be agreed on from time to time for the production of the largest scale map series, as these latter would necessarily contain more names than the smaller scale maps, and would be gridded.

It was decided that, in principle, the responsibility for the adoption of a particular transliteration system should go with the area responsibility for map production. At the same time, owing to the fact that the system adopted would affect not only maps, but also all Intelligence and other reports, etc., it was considered most desirable that there should be agreement between British and U.S. organizations on the system to be adopted. This applied particularly to Russia, Japan, China, and Siam.

At this same Conference held at the War Office in March, 1943, a fresh division of area responsibility was agreed on. The principal items agreed on were as follows:—

(a) *Europe.*

The United States accepted a commitment for the 1/100,000 series of Germany except for such blocks of sheets in the west as were already

in preparation by the War Office. They also accepted responsibility for map production in the Iberian Peninsula, and for a new 1/50,000 series of the Balearic Islands.

So far as base production was concerned, the responsibility for preparing all future editions on all scales of French and Spanish Morocco and Algeria passed to the United States.

They assumed responsibility also for the production of a newly drawn and revised 1/25,000 Dutch series, and for a block of 1/100,000 sheets in south and central France.

Except for the above, the War Office retained responsibility for maps of Europe and the Mediterranean Islands.

(b) *Asia, Australia and the Pacific.*

A new dividing line of responsibility for map production on 1/M scale and smaller was agreed on whereby the United States accepted responsibility for areas further to the west than had been previously arranged.

On scales larger than 1/M the United States assumed responsibility for:—

The East Indies, Phillipines, Formosa, Korea, Japan, and all areas lying to the east, North East China, Mongolia, Manchuria, Russia (east of 60° E. and north of Lat. 44° N.), Australia, New Zealand, and islands in the Indian Ocean to the east of 108° E.

The War Office became responsible for:—

India, Burma, Malaya, Siam, Indo-China, South Western China, Afghanistan, Tibet, Persia, Iraq, Arabia, Trans-Jordania, Palestine, Syria, Turkey, and the islands in the Indian Ocean to the west of 108° E.

(c) *Africa.*

The United States accepted responsibility for:—

All Africa west of 6° E. on the 1/2M, 1/M, and 1/500,000 scales.

Algeria. All scales.

French Morocco. All scales.

Spanish Morocco. All scales.

Tangiers.

The War Office continued to be responsible for the remainder of Africa and Madagascar.

(d) *America and the Atlantic.*

The United States accepted complete responsibility for all scales in:—

North and South America, West Indies, Bermuda, Greenland, and Iceland.

The War Office retained responsibility for other Atlantic Islands, e.g., the Falklands, Azores, Canaries, and Cap Verde.

(e) The acceptance of responsibility by the United States signified production either direct by Washington or by decentralization under U.S. arrangements to other countries such as Australia, etc. In the case of War Office responsibility this signified production either direct by G.S.G.S. or by its agencies in the United Kingdom or by decentralization under G.S.G.S. arrangements to overseas Military Survey Directorates or to India.

The arrangements for supply and exchange of mapping and reproduction material were further amplified and clarified.

The design of air maps for use by the Allied Air Forces was attended by certain inevitable complications and difficulties arising from a variety of factors.

In the U.S. Forces there existed a separate Map and Chart Division for the Army Air Corps. This employed the Chief of Engineers and his map production and supply organization on a contract basis only, the latter having nothing to say with regard to air map design. There was also, at that time, a considerable divergence of ideas about air map design between the British and American air forces as is shown below:—

R.A.F. air map policy was based on a requirement for the following types:—

- (a) An outline plotting series, in which topographical features were shown in one colour and in broad outline only, on which pencil track lines could be drawn and be clearly visible.
- (b) Small scale layered maps showing topographical detail, such as the 1/M Ground/Air edition, which could be used for visual fixes in daylight by long range aircraft.
- (c) Maps in full colour on 1/500,000 scale with the topography shown in less detail than on ground maps of comparable scales. It was considered that this normally represented the largest scale on which special air maps were likely to be required.
- (d) Maps on larger scales, such as 1/250,000, which were required in full detail for use as run-up maps. On these maps such features as railways, woods and water were to be emphasized, and the colours so chosen that they would be readily visible under an amber light. The army/air style satisfied the needs of both ground and air forces in this respect.
- (e) Special purpose bombing target maps.

American design tended towards the production of three main series for navigational use:—

- (a) Small scale charts at 1/3M scale for long-range aircraft.
- (b) World air charts at 1/M scale covering all land areas, designed primarily for aerial navigation.
- (c) A skeleton plotting chart series at 1/M scale. For this the Americans accepted the British design.

At meetings held early in 1943, it was agreed generally that the showing of air information should be dealt with as a map production proposition by means of overprints on either the 1/M ground/air edition or on the 1/M plotting series. The information, being regarded as ephemeral, was preferably to be overprinted in the locality where the maps were being used. This would also facilitate security.

With regard to agreement on scales, it was considered that this should be treated on the basis that different areas required different treatment dependent on the density of population, development, etc.

The question of providing fluorescent maps was subjected to considerable investigation by the R.A.F. Amongst other experts whose views were sought, the ophthalmic consultant to the R.A.F. considered that no specific advantages would be obtained from the adoption of fluorescence in maps, and that certain disadvantages in night vision were likely to accrue. Amongst other

disadvantages it appeared that the Perspex windows of the aircraft would fluoresce under the influence of ultra-violet light, and that it would be impossible to see through them under such circumstances. The Air Staff eventually ruled that fluorescent maps would not be adopted by the R.A.F.

Army Air Corps policy in the United States was in direct opposition to that of the R.A.F. After much investigation it had been decreed by the Army Air Force authorities that all aeronautical charts produced for army/air use in the United States were to be suitable for illumination by either daylight, ultra-violet, red or amber light. As this policy differed from that of the British it was a requirement which could not be accommodated in the European and Middle East theatres where all air map supply was through channels controlled by the War Office and the Survey Directorate in the Middle East.

The British and U.S. views on air survey photography were discussed by representatives of the War Office, the Air Ministry and the U.S. Army in March, 1943. The British approach to the problem at that time was as follows:—

- (a) Wherever possible Mosquito IX aircraft should be employed for photography, as they appeared to have sufficient performance to meet existing operational conditions against enemy opposition, and they also had sufficient navigational facilities in combination with such performance.
- (b) The aircraft should preferably be equipped, for simultaneous vertical photography, with Fairchild 6-inch and 12-inch focal length cameras. The object was to obtain complete coverage with the 12-inch camera and that the addition of the 6-inch photography would serve to fill small gaps which would inevitably be found in the 12-inch coverage, and would enable wide-angle Multiplex plotting equipment to be used if so required. It was considered that the 6-inch photographs alone would provide pictures at too small a scale to give adequate interpretation of detail either for mapping or for general Intelligence purposes.
- (c) Arrangements should be made for the levelling and orientation of the cameras in flight, with particular reference to the 6-inch if both cameras were installed.
- (d) If it should prove impossible to install both 6-inch and 12-inch cameras, then the latter should preferably be adopted.

It is emphasized that the above represented the British view *at that time*. With the development of technique, apparatus and other conditions, such policy was of course liable to considerable alteration.

The American approach differed basically from the British in that, if it was possible to install one camera only, then that camera should be the K.17, 6-inch camera, which was designed specially for use in connection with the Multiplex plotting apparatus. They considered it preferable to omit certain minor details of terrain than to sacrifice speed of operation involving an increase in the flying time required for photography.

Apart from this major point of difference, general technical agreement was reached between the British and American representatives.

During the remaining course of the war between 1943 and 1945 there was a constant interchange of views and information between British and U.S. mapping authorities and, by means of exchange of visits, discussions were held on various subjects connected with the preparation and provision of maps and survey data. As operations developed within the various operational

theatres, a fresh orientation of ideas and responsibilities was necessary, and all possible action was taken to put this into effect. It is unnecessary to quote full details of all such changes. Sufficient data have been given above to indicate the scope and magnitude of the problem and the general principles on which the work of the British and American mapping organizations was co-ordinated with such happy results.



CHAPTER V

THE MIDDLE EAST

The following diagrams, maps and plates are relative to this chapter:

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	16. <i>Tunisia 1:50,000</i>

SECTION 1. SURVEY ORGANIZATION AND NARRATIVE

Early Survey activities in the Middle East

Early in 1940 a Director of Survey was appointed, together with a small Directorate staff, to take up duty with the Military Headquarters in Cairo. Colonel R. L. Brown went out in February, with personnel based on the war establishment for an Army Survey Directorate. Two survey units followed soon afterwards. The first of these, 512 (Army) Field Survey Company R.E. was of similar type to that which had accompanied the B.E.F. to France in September, 1939. It consisted of a mobile echelon of four topographical sections for field survey work, and an immobile echelon consisting of sections for drawing, photography, map reproduction and printing. The other unit was 2 Field Survey Depot R.E., for holding and issuing bulk map stocks. It was of the original standard type of depot with an establishment of one officer and 18 other ranks. These units arrived in Cairo about the middle of March. The Director of Survey soon realized that 512 Field Survey Company as it stood did not possess sufficient potential to deal with the map production programmes which it would have to undertake, and he therefore asked for an extra five drawing sections. By October, 1940, its establishment was increased to about 14 officers and 350 other ranks. The Survey Departments in Egypt and Palestine were also both called on to undertake a considerable amount of reproduction work on an agency basis.

The topographical sections of 512 Company were at first employed on special survey work for the Engineer-in-Chief, including surveys for base lay-out, and also on the fixation of numerous anti-aircraft and coast defence gun positions in Alexandria and Port Said and in Palestine. The immobile echelon, while in Cairo, was engaged on a variety of mapping tasks including the preparation of skeleton 1/M air maps and the reproduction of 1/200,000 maps of Turkey from the Turkish originals.

Mapping Problems

The entry of Italy into the war on 10th June, 1940, made it practically certain that hostilities in Africa would not be long delayed, both in Libya and also in the Italian East African colonies and Abyssinia. The responsibilities of the Director of Survey for carrying out large programmes of mapping over wide areas were intensified. The available map series published by the War Office were neither extensive nor up to date. It was necessary to obtain record copies of the best and most up-to-date maps of the areas involved from a variety of sources and reproduce them locally, overprinting the military grid on them. There was also a great amount of research work to be done in connection with investigations into the local triangulation systems, and the preparation of trig lists for use by field surveyors including artillery survey regiments. Arrangements had to be made with the R.A.F. for air photography of selected areas, not only for the revision of existing maps, but also for the preparation of new ones. With such a wide field for possible operations, not only in Africa, but also in the Balkans, Palestine and Syria, Iraq and Persia, there was a great deal to be done, not much time to complete it, and a definite shortage of survey personnel and equipment.

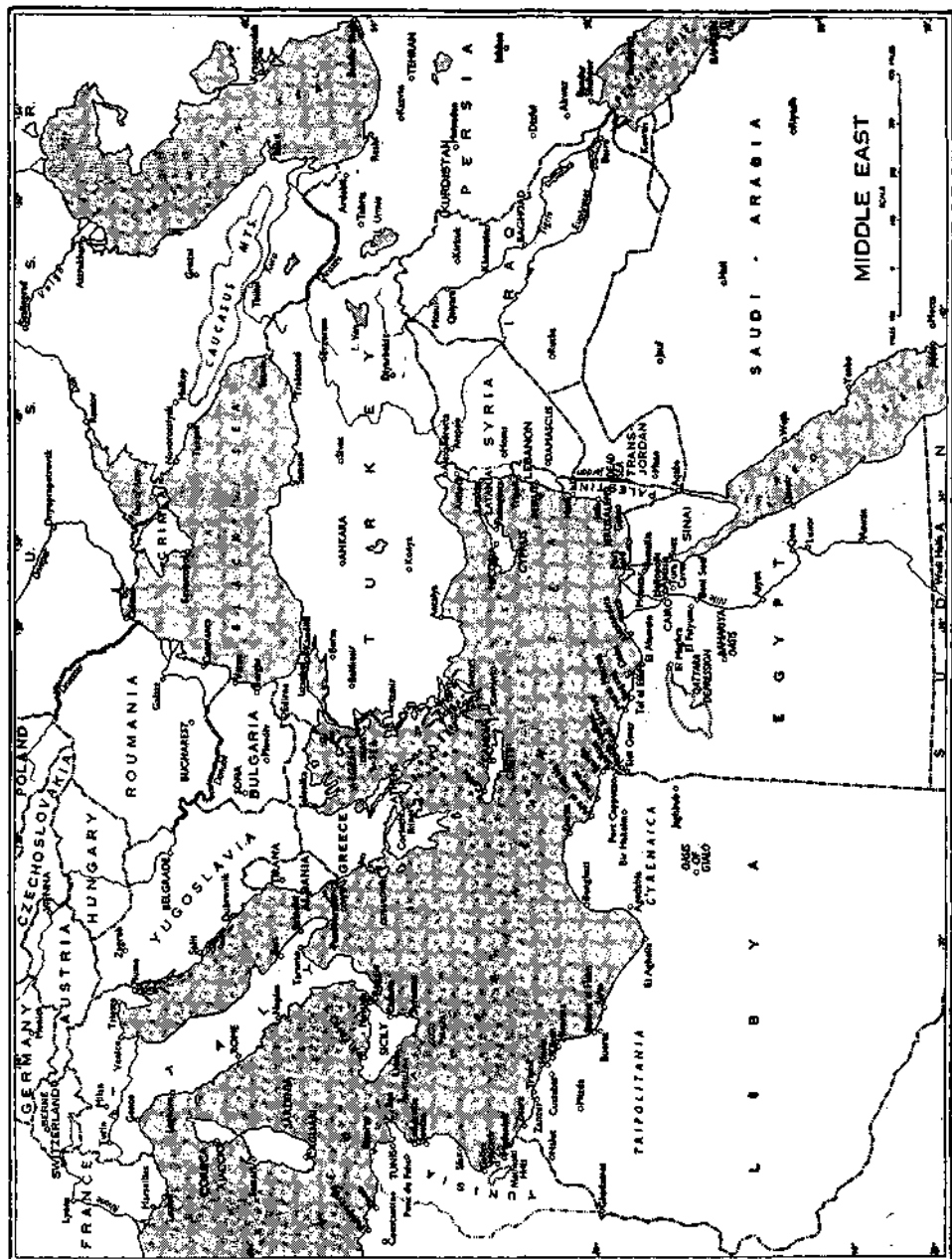
Survey contacts with the Desert Force

Headquarters of the British Troops in Egypt (B.T.E.) was established in Cairo. G.H.Q. Middle East, which was a separate headquarters originally formed for planning, was also in Cairo. This latter rapidly grew in numbers and in the scope of its responsibilities. In the early days H.Q. B.T.E. exercised the immediate command and control of all troops in Egypt including the Western Desert Force, and an A.D. Survey was therefore appointed, with a Corps Directorate, to do duty with this H.Q. An officer (Captain) was detached from the Survey Directorate for liaison duty with the Desert Force. The mobile echelon of 512 Field Survey Company was placed under command of H.Q. B.T.E., and so came under the technical control of the A.D. Survey with that formation. At an early opportunity field observations were made to effect a junction between the Egyptian and Italian triangulations in Cyrenaica by intersecting Italian trig points across the frontier. In August the mobile echelon carried out field work for an extension of the Survey of Egypt 1/25,000 series in the Mersa Matruh area by air survey methods. Concurrently, a 1/12,500 defences map of Matruh was produced, and several subsidiary points were established for use by R.A. survey parties in the Matruh area.

The Italian advance to Sidi Barrani

By 2nd August, 1940, the Italians had massed their forces on the frontier, and on 14th September they crossed into Egypt and advanced to Sidi Barrani, where they dug in. Apart from air action and patrol activity there remained

SKETCH MAP 3



Drawn by Ordnance Survey 1951

nearly three months before any major operations were to begin in the Western Desert. During that period, however, many events occurred which were to affect future policy and which involved the Survey Service in ever-widening activities.

The strategic situation in the Middle East (late 1940)

Late in September, General de Gaulle made his abortive attempt to persuade the French in Dakar to throw in their lot with the Allies. It then became clear that under Vichy influence, French co-operation in North Africa and in Syria was unlikely. They might, in fact, be actively hostile. British Somaliland had been evacuated, and the small British forces in the Sudan and in East Africa were engaged in patrol activities facing greatly superior Italian forces. German troops had entered Roumania and Italian forces crossed the frontier from Albania into Greece early in November. Roumania joined the Axis on the 23rd of that month, and small numbers of British troops, including R.A.F. units, were sent to Greece.

All these events involved the Survey Directorate in an intensive and urgent programme of map production, in anticipation of any emergency situation which might arise.

First British offensive in the Western Desert (December, 1940)

The first British offensive in the Western Desert opened on 9th December and by the 14th the Italians were back over the frontier in Cyrenaica. This unexpectedly quick success was exploited to such purpose that, by 7th February, Benghazi had been captured and El Agheila occupied. The rapid advance threw a great strain on map supply resources which, at that time, had not been fully developed according to subsequent standards.

Capture of Italian mapping material

Together with the capture of thousands of prisoners, many Italian maps were obtained, an item of great importance. These maps were sent back to Cairo and were rapidly reproduced, with the addition of the British military grid. Stocks were then sent forward to the fighting troops with the least possible delay.

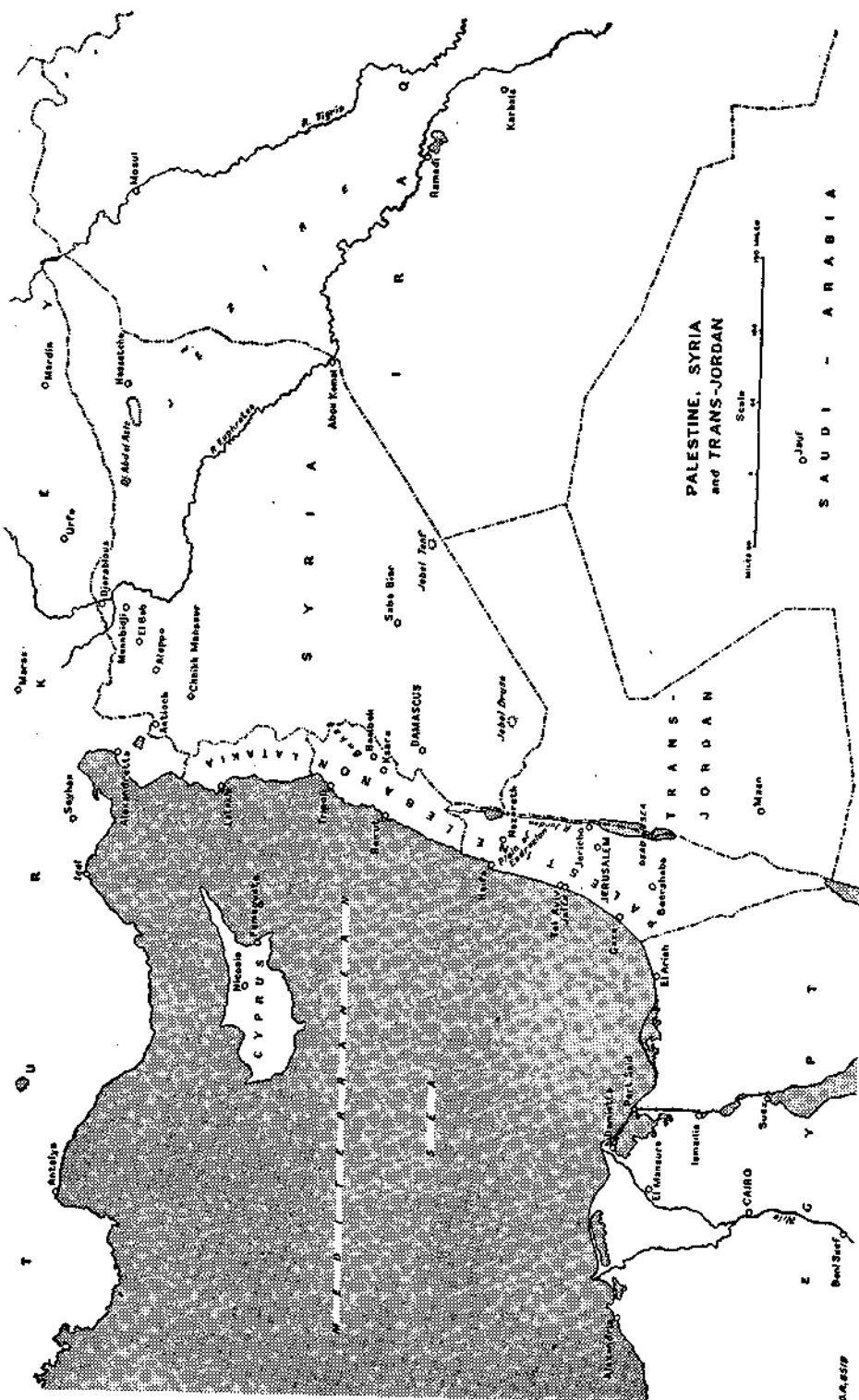
One of the most interesting captures was one isolated copy of an Italian 1/25,000 map of Tobruk. Large scale maps of the Tobruk defences were produced from it, not only for our own use, but unfortunately, as events turned out, for German use as well. The Germans captured a copy of the British reproduction and, in turn, copied it themselves, being apparently unaware up till then of the existence of an Italian map of Tobruk on that scale.

Triangulation in Western Egypt and Libya

The only survey unit which accompanied the Desert Force during this first campaign was the mobile echelon of 512 Field Survey Company. After the move into Cyrenaica, the topographical sections ran a chain of triangulation from Egyptian trig stations to connect up with the Italian triangulation system. Subsidiary points were fixed for use by R.A. survey parties in the attack on Bardia.

Much data concerning the Italian triangulations were captured and made use of by these topographical sections, and this was sent back to Cairo for amendment

SKETCH MAP 4



Geographical Section, Central Staff, (MAD) 1944.

of existing trig lists and the preparation of new ones. As our forces moved west to Benghazi the topographical sections ran chains of triangulation to establish a relation between the two different Italian systems which had come to light after examination of captured documents, and to serve as control for air photography. There was no mobile printing equipment available to operate with the Desert Force during this first campaign. All map printing had to be done back in Cairo.

514 Field Survey Company R.E. arrives in Middle East and moves south to Eritrea

514 (Corps) Field Survey Company reached the Middle East from the United Kingdom during the winter of 1940-41 and was sent south to Khartoum. On arrival at Khartoum it was engaged in many tasks concerned with the planning of operations against the Italians in Eritrea. During this preparatory period, quick reconnaissance surveys were carried out for the Chief Engineer, extra fixes were observed to help the R.A.F. use the existing inaccurate maps, and triangulation was undertaken to form a base from which to carry forward a control during the advance towards Keren. Much special map production and printing was done on the unit's mobile equipment for planning and for the actual operations. When the advance began, the movement was so rapid that the carrying forward of a trig control could not keep pace with it. At Keren, triangulation was based on captured Italian data to cover our own gun positions, and points were fixed in the enemy or target area.

Operations in Italian East Africa and Greece (See also Chapters VI and XII.)

The British offensive against Italian Somaliland and Abyssinia was opened by the crossing of the R. Juba on 20th February, 1941. Although these operations came under the general strategical direction of G.H.Q. Middle East, the actual survey and mapping arrangements were controlled by Colonel M. Hotine (D.D. Survey East African Force). Abyssinia was entered on 7th March, and success was so rapid that Addis Ababa, the capital, was occupied on 5th April. This first week of April was one of mixed successes and misfortunes in the Middle East. Asmara (Eritrea) was taken on the 1st, but on the 3rd an enemy counter-offensive in Libya forced the British to evacuate Benghazi and begin their retreat back to Egypt. On the 6th, German forces invaded Yugoslavia and in conjunction with the Italians operating from Albania, marched into Greece. To meet this threat, and to assist the Greek Army, an Expeditionary Force was hastily assembled in Egypt and sent over to Greece. Colonel Hotine, having been withdrawn from East Africa, accompanied the force as D.D. Survey with a small survey directorate. The units placed at his disposal were the headquarters and two sections of the mobile echelon of 512 Field Survey Company, 517 (Corps) Field Survey Company, which had shortly before arrived from the United Kingdom, and 9 Field Survey Depot, which had just been formed in the Middle East theatre. Of the above, only the topographical sections of 512 Company and 517 Company (less its printing equipment) reached Greece together with the Survey Directorate and 9 Depot. The A.F. G 1098 stores of 517 Company, for its printing and drawing sections, were embarked on a separate convoy and were lost.

A large portion of 9 Field Survey Depot was taken prisoner, together with

personnel from the Survey Directorate and from the topographical sections of 512 and 517 Companies. The shipment of map stocks from Egypt to Greece presented many difficulties. The first problem was to obtain shipping space against the competition of other urgent commodities. It was then necessary to ensure that when the maps reached Greece they were delivered safely to those requiring them. As on so many subsequent occasions it was found essential to have each consignment accompanied by a conducting officer, who saw the maps through to their journey's end.

Iraq and Syria in the spring of 1941 (*See also Chapter VII—Persia and Iraq.*)

With the Germans established in the Balkans and the French Vichy Government definitely hostile, there was cause for anxiety about Syria and the Lebanon, Palestine and Cyprus, Iraq and Persia as possible stepping stones for a German drive to the east. Trouble had already occurred in Iraq, where enemy influence had persuaded a pro-German element to stage a rising on 11th April, 1941. This necessitated the despatch of an Expeditionary Force from India to restore the situation, and it was not until the end of May that the rebels were rounded up. By that date it was clear that there was strong Vichy influence in Syria, and on 8th June an allied force crossed the frontier from Palestine into Syria. A survey officer had been sent up into Palestine during January for liaison duty with the headquarters of the British Forces in Palestine (later the British Ninth Army), and to establish working relations with the Palestine Survey Department. During the operations in Syria an officer was also attached to the Australian Division in order to obtain early access to survey records in Damascus and Beirut. He was able to assist in map distribution, examination of air photos and the correlation of special map demands.

Survey organization in the Middle East (June, 1941)

At the end of June, 1941, the Survey organization in the Middle East was as follows:—

(a) SURVEY DIRECTORATES

G.H.Q. Middle East.

Officially this was on the establishment laid down for an army, but frequent representations had been made that it was inadequate. To ease the situation most of the officers who had been serving with the East African Directorate were moved to G.H.Q. at the beginning of June, by which date the campaign in Abyssinia was to all intents and purposes over. The Directorate was then reorganized into four main branches:—

- (i) Administration and Stores.
- (ii) Map Records and Production.
- (iii) Triangulation Control and Air Surveys.
- (iv) Map Distribution.

East Africa. With the removal of the Directorate staff to the Middle East the remaining functions of this Survey Directorate were exercised by the East African Survey Group which was strong in officers. (*See Chapter VI.*)

Palestine and Trans-Jordan. This was originally a skeleton Directorate consisting of one D.A.D. Survey and two clerks. Temporary reinforce-

ment for the operations in Syria proved unsatisfactory. This was now expanded to an Army Survey Directorate serving the Ninth Army, so as to place the whole of this area (including Syria and later Cyprus) on a sound basis.

Western Desert. A standard Corps Survey Directorate served the needs of this force.

(b) SURVEY UNITS

G.H.Q. Troops.

512 (Army) Field Survey Company R.E. (less detachments).

517 (Corps) Field Survey Company R.E. (less detachments under command Desert Force).

2 Field Survey Depot R.E. (less detachments at El Daba under the control of A.D. Survey Western Desert).

11 Field Survey Depot R.E. (Stores).

(The South African Survey Company was expected to arrive shortly in the Middle East from East Africa.)

(512 Company, the main base production unit, was located on the edge of Heliopolis airfield. This was considered too vulnerable, and arrangements were made for it to be moved to some large caves at Tura, about six miles south-east of Cairo. It was proposed also to move the Map Record and Production Sections from the G.H.Q. Survey Directorate to Tura, together with Nos. 2 and 11 Depots. To deal with the quick revision of maps before urgent reprints were undertaken, a special Revision Group was formed in 512 Company. This group worked in close touch with the R.A.F. Photo Reconnaissance unit which was taking the photographs, and with the Air Photo Interpretation Section (A.P.I.S.) which was controlled by the Intelligence Branch at G.H.Q. This close co-operation between Survey and A.P.I.S. at all the major formation headquarters in all theatres was a necessary and important feature. It concerned not only the revision of topographical detail on the face of the map, but also the preparation of defence overprints, the fixation of enemy gun positions and other defence works, and other items which required expert interpretation and treatment by technical survey methods for determining position with reference to the map grid.)

East Africa.

The East African Survey Company, the West African Survey Company, and the Southern Rhodesian Survey Company were organized as the East African Survey Group. There was also a detachment of reproduction tradesmen with printing equipment from 512 Field Survey Company R.E. The West African Survey Company was at this time under orders to return to West Africa.

Palestine, etc.

The 2/1 Australian (Corps) Field Survey Company was operating in Palestine, though not under command of the British Military H.Q. there.

No. 9 Field Survey Depot, which had been in Greece and had lost many of its numbers, was reforming, mainly from personnel enlisted locally.

Western Desert.

514 (Corps) Field Survey Company R.E. (less detachments) was at Matruh carrying out large scale surveys. One printing section and details of 514 Field Survey Company, plus one printing and drawing section of 517 Field Survey Company, were at the Alexandria drawing office. Two topographical sections of the mobile echelon of 512 Field Survey Company were in the El Alamein area engaged in topographical surveys of that area. The sections were later transferred to 517 Field Survey Company to make the latter up to strength for its move to Palestine.

The following units were notified as being ready to leave the United Kingdom for the Middle East, but were delayed owing to convoy space being limited:—

13 (Corps) Field Survey Company R.E.

519 (Corps) Field Survey Company R.E.

19 Field Survey Company R.E. (Recently in Iceland.)

(519 Field Survey Company never went to the Middle East. It remained in the United Kingdom until operation "Overlord," when it crossed over to France with Second Army.)

At the time of the Greek campaign, there was a great shortage of survey units. It was necessary, therefore, to form civil establishments, using locally recruited personnel, and equipped with locally purchased or constructed plant. The following organizations were therefore set up, and were capable of rapid drawing and the production of wet plate negatives. They were mainly of use for the reproduction in colours of captured maps or record copies. The number of nationalities represented amongst the personnel was so varied that notices had sometimes to be written up in nine or ten different languages!

Choubra (Cairo). This was supervised by an Austrian, with an Armenian deputy assisted by British personnel from 512 Field Survey Company.

Alexandria drawing office. Supervised by 514 Field Survey Company under the control of A.D. Survey Desert Force. Printing was carried out by detachments from 514 and 517 Field Survey Companies.

(c) MAP DISTRIBUTION

The holding and issuing of maps was carried out by a number of dispersed map depots organized and controlled as under:—

(a) *Under G.H.Q. control and manned by personnel of No. 2 Field Survey Depot:—*

Base Map Depot at Abbassia (Cairo). This carried stocks of all maps in use in the theatre. It took delivery of all maps printed under G.H.Q. arrangements, and distributed in bulk to sub-depots. Detailed issues were made to G.H.Q. troops.

G.H.Q. sub-depot. This carried small stocks for issue to branches and staffs at G.H.Q.

Moascar (Canal) sub-depot. This split the stocks with the Base Map Depot as well as providing for troops in the Canal Area.

Alexandria sub-depot. For holding reserve stocks of the Western Desert and Delta areas for the Desert Force and B.T.E.

(b) *Under control of A.D. Survey Western Desert.*

(i) El Daba sub-depot, which held the main stocks for the Desert Force.

(ii) Forward Map Depots at Bagush and Matruh.

(iii) Mobile map distribution unit operating with forward troops.

(c) Under control of D.D. Survey Palestine and Trans-Jordan.

- (i) Main Depot at Jerusalem.
- (ii) Sub-depots at Gaza and Tel Aviv.
- (iii) Forward Map Depot at Nazareth, which later moved into Syria.

Arrival of South African Survey Company from East Africa (See also Chapter XIII, Section 3.)

A valuable addition to the Survey strength during July was the arrival of the South African Survey Company from East Africa. It was assigned to G.H.Q. Survey Troops, and many of its field sections were detached for duty elsewhere. One section was sent to the Western Desert for the survey of forward desert tracks, one was employed on surveys of the defences in the Delta area, and two sections went to the El Alamein area to carry out 1/50,000 mapping. In view of the decisive battle which took place there at a later date, the Director of Survey's decision to undertake this work proved to be a particularly happy example of intelligent forecasting.

Arrival of 60 Squadron South African Air Force

Another important arrival in July, 1941, was No. 60 Squadron of the South African Air Force (S.A.A.F.) which also came from East Africa, and was to play such a valuable role in the production of air photographs for mapping purposes. On arrival, it was equipped with a small number of Glen Martin Aircraft. This unit was to form part of the Air Survey Photographic unit for the Middle East theatre, the remainder of the unit being provided by the R.A.F. Shortage of suitable aircraft, cameras and other equipment necessary for the production of the special photography required for mapping purposes was to hamper their activities for a long time and seriously affect the mapping programmes.

Survey units in Palestine

517 Field Survey Company, after being re-equipped and made up to strength, was transferred to Palestine during July, 1941. Policy agreement had now been reached regarding the status of the Australian Survey Company. Although corps troops, it was agreed that the unit would come under the control of the D.D. Survey in Palestine subject to the requirements of the Australian Corps having priority.

Mapping projects in the summer of 1941

Map production and printing was continuing with ever-increasing momentum, and included series covering Egypt, the Western Desert, Cyrenaica, Palestine and Syria, Turkey, Iraq, Persia, Cyprus, Trans-Jordan, and East Africa. Ground and control surveys were in progress for checking existing triangulations and trig lists, and for providing new control for air survey mapping in the Western Desert, Palestine, Sinai, Syria, the El Alamein area, and the Delta.

Increases in Survey organization

In August, the G.H.Q. Directorate establishment was increased by five officers, including one D.A.D. Survey (Major). A new Corps Survey Directorate arrived from the United Kingdom for duty with 10 Corps, and one officer

was appointed as Survey representative on the Commission of Control in Syria. Also during this month the advanced party of 13 (Corps) Field Survey Company with the unit transport arrived from the United Kingdom, the remainder of this unit not reaching Egypt until a year later. The 36th New Zealand Survey Battery R.A., which was strong in trained surveyors, was loaned from R.A. control for topographical work under D. Survey G.H.Q.

Survey Directorates for Eighth and Ninth Armies

Important changes took place in the organization of the Middle East Forces during September, 1941. The Western Desert Force became Eighth Army, and a modified Army Survey Directorate of one A.D. Survey (Lieutenant-Colonel H. S. Francis), one D.A.D. Survey and one Captain was assigned to Army H.Q. There was no Survey representation with H.Q. 13 Corps in Eighth Army. In Palestine, the Survey Directorate of the Palestine and Trans-Jordan Force H.Q. was transferred intact to Ninth Army with Colonel A. Prain as D.D. Survey. 10 Corps moved to Palestine without a Survey Directorate, the personnel having been transferred to H.Q. B.T.E. These changes conformed to the newly accepted policy that where a field force was operating under an Army H.Q., Survey representation in the form of directorates and units would normally be concentrated at army level, and not decentralized to corps.

Further additions to Survey units

Drawing strength with 512 Field Survey Company was augmented by the addition of 50 Indian draughtsmen in September, and a further increase in strength occurred with the arrival of 19 Field Survey Company, though its transport and equipment were delayed. Work in the Tura caves to make them ready for the installation of printing machines and depot stores was progressing, and three machines were erected during September. Most of No. 2 Depot's stores had also been installed there by the end of the month.

Survey stores problems

The situation regarding the supply of printing paper and the many and various technical stores required for map production and printing, was a source of much anxiety. Very little was being obtained through the normal Ordnance channels, and D. Survey was not able to obtain authority to effect his own local purchases of items that might have been available. Attempts were being made to obtain essential monthly supplies of these stores from Eastern Group in India, and also direct from the United States through the British Military Mission in Washington, but so far without success. Future map printing programmes were in danger of being held up as a consequence, and urgent representations were made to the War Office for assistance.

For a fuller account of the Survey stores activities *see* Chapter XIV, Section 9.

Second British offensive in Western Desert (November, 1941)

The second British offensive in the Western Desert started on 18th November, 1941, a quick advance of 50 miles into Cyrenaica being made. To cover the big map issues for this operation, over 800,000 maps had been taken forward to Matruh from the Base Depot, a distance of 300 miles, between 19th October

and the end of the month. They were moved in 3-ton lorries by the South African Survey Company, a very creditable performance.

In addition to 514 Field Survey Company, A.D. Survey Eighth Army had under his control for this operation ten detachments from the South African Survey Company. These were attached to the headquarters of divisions and infantry brigades for duty as navigation parties, for the preparation of special maps, and to assist in the distribution of maps to lower formations. This was the forerunner of the map distribution policy which was subsequently adopted, whereby, in order to ensure that the fighting troops really did get their maps, Survey assumed responsibility for distribution down to divisions. Establishment action was being taken to raise the strength of the Field Survey Depot in both personnel and transport so as to regularize this increased responsibility. For this operation, however, it was necessary to borrow personnel from other units as described above. By the end of December units of Eighth Army had reached the coast near Benghazi, though the town itself was not to fall till nearly a month later.

Survey work in Syria and Palestine

Other detachments from the South African Survey Company were placed at the disposal of D.D. Survey Ninth Army for topographical work along the Turkish-Syrian frontier and elsewhere. The German offensive in southern Russia was causing anxiety in view of the possibility of a future German move southwards through Turkey into Syria and Palestine, and this work on the frontier and in connection with 1/25,000 mapping of selected defence areas in Syria and Palestine was given high priority.

The occupation of Syria had opened up a further potential source of mapping as the French Service Géographique had a mapping installation at Beirut and arrangements were made with them for certain revision work to be undertaken on their own 1/200,000 maps of Syria.

Improvement in Survey stores situation

The stores situation improved considerably during December, and was better than it had been for a long time. This was owing to vigorous action on the part of the Survey Directorate at the War Office, who arranged for a scheme of long-term maintenance provision through Washington. To cover the period until regular monthly consignments would be forthcoming, D. Survey Middle East was authorized to order direct on the United States for stores which were essential to meet urgent operational requirements. As a second resource War Office arranged also for monthly supplies from the United Kingdom to bridge the gap period. Paper supplies from India were also more encouraging.

Preliminary mapping work for Tunisia and Italy

The map production and printing programme was always a pointer to probable future happenings, though, of course, full security cover was at all times introduced into the programmes so as not to draw attention to the real objective. The mapping work now taking place included maps of Tunisia and Italy and, with Russia still stubbornly resisting German aggression, there was a steady demand for maps of Russia and the Caucasus as wall maps for general study.

Special survey tasks in the Desert

During the Eighth Army operations a great deal of work was done to assist the troops to locate themselves in almost featureless country. Trig points and minor topographical features which were marked on the maps were labelled with their names and map references. Artificial marks were erected and labelled in areas where no natural features existed. Tracks, marked on the ground by barrels, were surveyed so that they could be shown on future reprints by a special symbol.

Japan enters the war. Survey Conference in India

December, 1941, was one of the critical turning points of the war. The Japanese attack at Pearl Harbour brought the United States into the war. It was followed, on 8th December, by the landing of Japanese troops in Thailand and north-eastern Malaya, at Hong Kong on the 19th, and the Philippines on the 22nd. A state of emergency now arose in Malaya, Burma, India and the whole of the East Indies. Australia was threatened. In view of the possibility that the Middle East might be called upon to assist in map production for operations based on Malaya or India, the Director of Survey flew to India for consultations.

One result of the new situation in the Far East was that the Australian Field Survey Company was withdrawn from Palestine and returned to Australia for duty in the Pacific Area.

Eighth Army retreats from Benghazi

Benghazi was reoccupied by Eighth Army on 24th December, and by 17th January, 1942, Halfaya, the last remaining German pocket still holding out in the back areas, surrendered. Success was, however, to be short-lived. Rommel staged a counter-offensive and retook Agedabia on 23rd January. A map depot had been established in Benghazi on 15th January but, with the German offensive against Agedabia, it was withdrawn to Derna on the 24th and thence back to Tobruk. By the end of January, the enemy had recaptured Benghazi and Eighth Army was retreating to defensive areas further east in Cyrenaica.

Before Rommel's counter-offensive, and in anticipation of a further British advance towards Tripoli, all the resources of 514 Field Survey Company were employed on the production of a 1/250,000 map of the Agheila area from photographs taken by 60 Squadron S.A.A.F. This had to be put into cold storage until a later date, when Eighth Army would be passing through once more on its final victorious advance to Tripoli and Tunis. The topographical sections of 514 Company were increasingly employed on the fixation of astronomical control points in the desert. 770 miles of car and compass traverse were completed by them.

Air photography

The situation at this time regarding air photography for mapping purposes was bad. At the beginning of January, 1942, 60 Squadron S.A.A.F., operating with Eighth Army, had only one serviceable camera, and no aircraft for survey photography were available with Ninth Army during the month. The photographs were required both urgently and in large numbers, and the failure in

supply had a serious effect on the preparation of 1/25,000 and other maps which were required for operations in progress or planned to take place very shortly.

Changes in Survey organization (early 1942)

A redistribution of command responsibilities early in 1942 affected survey plans for map supply and distribution. As Ninth Army was now fully engaged in cleaning up and occupational duties in Syria, zones of responsibility between it and the Palestine Base and L. of C. areas were laid down, and G.H.Q. took over responsibility for map distribution in Palestine and Trans-Jordan. Middle East also took over command of Tenth Army in Persia and Iraq, and thereby became responsible for supplying to them their maps and survey stores. The Survey Directorate with Tenth Army was headed by Colonel G. F. Heaney as D.D. Survey.

The appointment of Director of Survey, Middle East, was upgraded to Brigadier in January and the establishment of the G.H.Q. Directorate was increased during February, 1942, by the addition of a D.D. Survey, the appointment being filled by Colonel R. E. Fryer. The newly raised No. 13 Field Survey Depot, mainly staffed by Palestinians, completed its move to Eighth Army in March, thereby releasing most of the detachments of No. 2 Field Survey Depot which became available for other tasks. At this time also the South African Survey Company was reorganized. It was divided into two units, No. 45 (Type A), and No. 46 (Type B). The former returned to the Union in April, leaving No. 46 Survey Company for duty with Eighth Army. A Royal Marine Survey Group, which arrived from the United Kingdom, was placed by G.H.Q. at the disposal of D.D. Survey Ninth Army, and carried out field surveys in the Tripoli-Mina area in Syria.

Survey tasks in the Western Desert and in Syria (Spring, 1942)

In Cyrenaica the topographical sections of 514 and 512 Field Survey Companies did some ground surveys for map revision, much of which was in the patrol areas of the desert between the British and German forces. They were assisted by armoured car patrols, but strong enemy elements made the work difficult and both units suffered minor casualties in wounded and missing. A survey party was also employed on the reconstruction and maintenance of desert beacons which had been erected for survey and identification purposes. Many of these had been tampered with by our own troops and it was necessary to have an Army Order published forbidding unauthorized interference with survey marks and beacons. During these spring months of 1942, the survey units with Ninth Army in Syria were engaged mainly on work connected with the production of 1/50,000 sheets in the Turkish frontier region, and the provision of control for maps of important defence areas in Palestine, and around Damascus, Tripoli and Ras Baalbek. Air photography for mapping continued slowly, depending upon the availability of aircraft and cameras in the Agheila and Agedabia areas of Eighth Army and along the Turkish frontier in Syria.

With Tenth Army in Iraq and Persia. (See Chapter VII.)

Survey activities with Tenth Army in Iraq and Persia were complicated by political troubles between the Persian Government and the Kurds. It was desired to send survey parties from Iraq into Kurdistan, and this was arranged after some difficult and protracted negotiations. The 2nd and 4th Indian

Field Survey Companies therefore began triangulation work and ground surveys for $\frac{1}{4}$ inch and 1/100,000 mapping. Further difficulty was encountered owing to the Russian refusal to permit the entry of British survey parties into their zone in north-western Persia to carry through their triangulation programme. A mobile Reproduction Section was sent to Tenth Army overland *via* Baghdad during June to join No. 4 Indian Field Survey Company at Hamadan. This entailed the supply from Middle East of an overland convoy of reproduction stores, thus giving Tenth Army about six months' reserve stocks of these essential stores.

Eighth Army retreats into Egypt

June, 1942, was a black month for Eighth Army. It was forced back from Cyrenaica into Egypt and by the beginning of July, Rommel and his Afrika Korps had thrust deep towards Alexandria, being held up in the El Alamein area. This led to a reorganization of map supply arrangements involving the move back of considerable quantities of maps by the Eighth Army depots, and the destruction of certain stocks which could not be transported. During the retreat, when divisional headquarters were frequently moving, locations given by them were often out of date by the time that the map lorry reached the spot, and deliveries were, for the most part, made only to Corps H.Q.s. A consignment of 1/50,000 maps was sent to Tobruk by ship on the night that the fortress fell.

514 Field Survey Company was very heavily engaged on map printing with its mobile equipment. It had to move five times, but even so, the number of impressions printed for use during the retreat was about 1,000,000. On reaching the Alexandria area towards the end of the month this unit reverted to G.H.Q. control.

Owing to the potentially dangerous situation caused by the German advance into Egypt, it was decided to move a portion of the survey stores and equipment from the Tura Caves to safer places. As a first measure 20 tons of these, including theodolites which were so difficult to obtain at that time, were moved over to the east side of the Canal. Later it was decided to send about 25 per cent of the Tura stocks of paper and survey stores to Palestine and the Basra Base area in Iraq, and another consignment to the Sudan. By the end of July over 100 tons had been removed to Palestine. The building up of bulk map stocks in Palestine was another important item during July. Sections of several field survey companies were used for these map distribution duties, and depots for holding about 1,000,000 maps were opened up. The existing depots at Gaza and Jerusalem were increased in importance and size.

524 Field Survey Company, a new unit made up of Palestinian personnel, was in process of formation, and survey resources in Iraq and Persia were increased during the month by sending 19 Field Survey Company to Ahwaz *via* Baghdad. The headquarters of the mobile echelon and three topographical sections of 512 Company were trained in small scale plane-tableing to fit them for 1/100,000 survey work in Persia.

Changes in Higher Command

August was relatively quiet on the critical front of Eighth Army, and there were no active operations on the fronts of other armies in the Middle East Command. It was, however, a month of momentous changes in the Higher

Command. General (later Field-Marshal) Alexander became Commander in-Chief, and General (later Field-Marshal) Montgomery took over command of Eighth Army. At the end of August it was decided to form a separate command to control operations in Persia and Iraq. This splitting of the Middle East into two commands, though not increasing the geographical survey commitment, undoubtedly added to the work very considerably, as more troops would be moving into the area, and more and better maps would be required of areas for which the existing map coverage was poor.

Ground surveys in the El Alamein area

Important control and ground surveys were carried out in the El Alamein area during August, including work for R.A. surveys owing to the lack of sufficient R.A. Survey units. Track surveys and desert beaconing continued to be an important item of field work done by 514 Company, extending eastwards from the El Alamein area, and southwards for about 50 miles.

Organizational changes in G.H.Q. Survey Directorate (Autumn, 1942)

An organizational change affecting the G.H.Q. Directorate was the formation of a new unit known as 525 (G.H.Q.) Field Survey Company. Up till then the Survey Directorate had consisted only partly of personnel engaged on purely survey staff work. Many were employed on technical productive work, including, for example, computing, drawing and map production for local needs, all of which were essential at G.H.Q. The necessity for technical survey personnel at Headquarters was not always readily apparent to Establishment Committees who were naturally concerned with keeping down the size of staff branches at all headquarters, and who, somewhat naturally, insisted frequently that the survey staff was top-heavy, assuming that all the personnel were engaged on staff work proper. The transfer of the production personnel to the new G.H.Q. Company helped to remove this difficulty. The unit was largely formed out of the personnel of the Survey Directorate, which was thereby considerably reduced in numbers. Its functions included computing, map distribution and production and, by the nature and purpose of its work, it was necessary for it to work in conjunction with the Survey Directorate. In September three U.S. survey officers arrived in Cairo and were located alongside the G.H.Q. Directorate. This was the first official contact between the British and U.S. Survey organizations in the Middle East.

Unsatisfactory situation regarding air photography (Autumn, 1942)

The situation regarding air photography for mapping purposes continued to be unsatisfactory, very little photography being possible owing to lack of aircraft. A programme was planned to cover the large area of the Qattara Depression-Faiyum-Bahariya Oasis, but little progress was made. In view of the operations which were shortly to take place this fact was of particular significance, and points once again to the essential need to provide an adequate number of the right type of aircraft in time to ensure the provision of survey photographs for the mapping of vital areas.

Block-plots

It was during this preparatory period leading up to the battle of El Alamein that the "block-plot" was introduced. The enemy was building up enormous

strength in defences and gun positions, and it was important that our artillery should hammer these and endeavour to knock them out before our forces were committed to the assault. To effect this, it was vital that the co-ordinate positions of the enemy guns and defences should be determined with reference to the surveyed positions of our own guns, so that the guns could be laid accurately on to their targets. The Artillery counter-battery officers were asking for these co-ordinates with urgency. The block-plot was compiled by drawing the map grid on a large scale, and on this grid were plotted the principal points (or centres) of the photographs which covered the area in the form of strips of overlapping photographs. Having located on newly taken reconnaissance photographs the positions of the enemy guns and defence works, their positions with reference to the map grid were determined on the block-plot by a process of graphical intersections from the principal points of the photographs already plotted on the grid. The use of these block-plots met with very great success, and was undoubtedly a great aid to the effective artillery preparation for the battle itself. Between 27th October and 2nd November, 215 new enemy gun positions were located, and a very large proportion of these were destroyed. Map sheets on 1/25,000 scale were also prepared to cover selected areas of the battle-front, on which the enemy defences were overprinted from large scale air photos. All this work was done from whatever photographs could be obtained at the time. It could have been done very much quicker and with much greater accuracy if proper survey photos had been available.

Opening of British offensive at El Alamein

On the night of 23rd/24th October, 1942, the British offensive at El Alamein was launched. Shortly before that date Colonel V. E. H. Sanceau assumed duty as D.D. Survey with Eighth Army, and remained with it right through to the later stages of the campaign in Italy. His Survey Directorate was augmented so as to include one A.D. Survey, one D.A.D. Survey, and Survey Liaison officers (Captains) at the rate of one for each corps under the Army command. Map distribution for the battle was extensive, no fewer than 630,000 maps having been issued from the army map depots during October. For the battle itself, a fifth edition of the 1/50,000 map of the battle area was published showing enemy defences plotted from last-minute air photos. The Survey units operating with Eighth Army were 46 (South African) Survey Company and 517 Field Survey Company R.E. The field section personnel were trained in resection methods by night from fixed vertical searchlights, the idea being to determine the position of units moving forward during the battle in desert country where there were very few landmarks to aid the normal methods of identification of position. Survey parties accompanied the leading infantry brigades on the opening night attack, but the method outlined above did not meet with much success as the searchlights were far back, and the formations to whom the survey parties were attached did not seem to know how best to make use of these skilled surveyors. The clouds of dust and sand which arose as the result of gun-blasts and shell explosions soon enveloped the whole battle area in such a thick fog that it is doubtful whether the vertical beams could have been seen even if the searchlights had been placed very much further forward. As the battle developed, the sections of 46 Survey Company were employed on beaconing areas behind the forward positions, fixing start lines, and marking lines of advance.

The advance through Libya

The rapid advance of Eighth Army in November introduced many difficulties in map distribution. 13 Field Survey Map Depot, which was serving Eighth Army, moved its main depot by rail from Ikingi to Matruh on 21st November, and then on by road to Tobruk on the 29th. A railhead depot had previously been formed, which moved forward with railhead, and further west still was the forward map dump, functioning as an advanced depot detachment and feeding the formation map lorries which accompanied the headquarters of corps and divisions.

During December the battle moved so far westwards that the forward survey troops of 46 (South African) Survey Company were, by the end of the month, over 1,000 miles away from base. With such long lines of communication, bulk stocks of maps and survey stores were sent by sea to Benghazi. Air and road transport was also used. 13 Field Survey Depot moved forward from Tobruk to Benghazi.

As soon as the success of the operation had been assured, thoughts were directed to the future link-up between Eighth Army and the allied forces fighting their way eastwards into Tunisia in North West Africa. An exchange of signals and map material between the respective survey organizations was effected during December, and this contact continued and expanded during the subsequent months, involving much co-ordination of map production work in preparation for the final operations for driving the enemy out of Africa.

The formation of new Palestinian units continued during December. 14 Field Survey Depot completed formation and was sent to join Paiforce, and two more depots were being raised. The formation of 524 Field Survey Company with Palestinian personnel was nearing completion, and part of it was employed on productive work under A.D. Survey B.T.E.

The lack of good maps covering the battle area at Agheila necessitated the hasty production of new maps in the field. This was done by plotting from air photos, using newly fixed ground control, all this work being done by 46 (South African) Survey Company. Much difficulty was experienced owing to the minefields which were encountered on most of the vantage points selected for surveying the ground control, and there were several casualties. Enemy opposition, bad weather, and shortage of aircraft hampered the production of survey photographs required for the work.

Amongst other tasks, 517 Field Survey Company undertook the survey of the wrecked ships in Tobruk harbour, in conjunction with the Fleet Hydrographic officer. This unit also did a re-survey of part of the Egypt-Libya frontier, where the existing 1/50,000 maps were little better than rough sketch maps.

Survey organization in the Middle East at the end of 1942

The Survey organization in the Middle East at the end of December, 1942, was as follows:—

G.H.Q. (D. Survey—Brigadier R. Ll. Brown).

Survey Directorate.

525 (G.H.Q.) Field Survey Company R.E.

512 Field Survey Company R.E. (less detachments).

524 Field Survey Company R.E. (less detachments).

2 Field Survey (Map) Depot R.E. (less detachments).
11 Field Survey (Stores) Depot R.E. (less detachments).
Base Survey Drawing and Photo Process Office.

Eighth Army

Survey Directorate.
46 (South African) Survey Company S.A.E.C.
517 (Corps) Field Survey Company R.E.
13 Field Survey (Map) Depot R.E.

B.T.E.

Survey Directorate.
Detachment of 512 Field Survey Company R.E.
Detachment of 524 Field Survey Company (Palestinian).

Palestine Base and L. of C. Area

Survey Directorate.
Detachments of 2 Field Survey (Map) Depot R.E.
Detachments of 512 Field Survey Company R.E.
Detachments of 11 Field Survey (Stores) Depot R.E.
514 Field Survey Company R.E. (less detachments).
15 and 16 (Palestinian) Field Survey Map Depots.

Ninth Army

Survey Directorate.
13 (Corps) Field Survey Company R.E.
Detachments of 514 Field Survey Company R.E.
Detachments of 512 Field Survey Company R.E.
Royal Marine Survey Group.
9 Field Survey (Map) Depot R.E.
Service Géographique (French) at Beirut.

Paiforce

Survey Directorate.
19 Field Survey Company R.E.
14 Field Survey Map Depot (Palestinian).
10 Indian Field Survey H.Q.
1 Indian Field Survey Company I.E.
12 Indian Drawing Section.
14 Indian Computation Section.
88 Indian Survey Park Section.

Tenth Army

Survey Directorate.
2 Indian Field Survey Company I.E.
4 Indian Field Survey Company I.E.
13 Indian Drawing Section.

Survey activities in Tripolitania

The capture of Tripoli towards the end of January, 1943, considerably eased the difficulties of supplying maps and survey stores to Eighth Army, as consignments could be despatched there by sea. The Advanced Map Depot moved to a site just outside Tripoli at the end of January, where it was shortly joined by the Main Depot which now changed its title from No. 13 to No. 20.

Until the fall of Tripoli it was expected that the enemy would stand and fight at Buerat, and considerable survey preparations were made for such a

battle. 1/50,000 maps were published with enemy defences overprinted, and 46 (South African) Survey Company established ground control for the artillery and for air-photo programmes in the Buerat and surrounding areas. Much of this work was wasted effort as the air photographs did not materialize. 60 Squadron S.A.A.F., whose aircraft had nearly reached the end of their operational life, made two gallant efforts to obtain photographs of the strong enemy positions further to the west at Mareth, but one of these resulted in a crash on the homeward journey involving the death of the pilot, and the squadron was grounded while awaiting further aircraft. Towards the end of February two Mosquito aircraft were allocated to the Squadron for survey photography, and the installation of survey cameras was put in hand. As these were the only two Mosquitoes in Middle East it was a welcome indication that the importance of survey photography was at last being recognized.

Mapping and survey for operations in Tunisia

The G.H.Q. Computation Section was now engaged on an extensive programme of work for the preparation of trig lists of Tunisia, including many points which were urgently wanted by Eighth Army for the Mareth area, which was reached early in March. During February the survey units had concentrated most of their efforts on the production of new 1/50,000 maps in the Gabes, Mareth, and Medenine areas as this part of Tunisia had been only spasmodically mapped by the French. To assist in this field-mapping programme, No. 7 General Survey Section R.E. was formed by G.H.Q. and sent to Eighth Army.

The alteration in the general strategical situation in North Africa produced many changes in the programmes of work that were in hand with G.H.Q. Survey units at Cairo. The Tunisian programmes for new and revised maps on all scales were completed, and kodak film negatives for 1/100,000 and 1/50,000 maps and for town plans were supplied to Eighth Army so that they could be printed in the field on their mobile equipment. New mapping programmes were now taken up for Sardinia, Corsica and Italy, based on War Office material which was sent out to the Middle East. The mapping of Greece, Crete and the Dodecanese and Aegean Islands was based on War Office material or captured maps, with revision from air photographs and other information obtained locally. Trig list preparation for these areas was also undertaken.

With the advance of Eighth Army into Tunisia, survey duties in Cyrenaica, including map distribution, were taken over by the Survey Directorate B.T.E. In the Trans-Jordan Desert the survey units of Ninth Army continued to do much useful work with Paiforce. Paiforce had lost at this time No. 2 Indian Field Survey Company which returned to India, and approval was given for the formation of a Polish Artillery Survey Regiment, a Polish (Corps) Field Survey Company, and a Map Depot.

March and April, 1943, were busy months of intensive survey preparation for all possible future operations in which the Middle East might be involved. A quantity of new mapping, much of it from air photographs, was done and, to provide an increase of drawing power, 13 Field Survey Company, 514 Field Survey Company and the drawing sections of 19 Field Survey Company were concentrated at the old survey camp at Abbassia, 19 Company having returned to Middle East Command from Paiforce during April.

During May the final operations in Tunisia cleared all enemy forces from

Africa and the stage was therefore set for the next phase. With the accomplished junction between Eighth Army and the allied forces operating from North West Africa, changes took place in the higher direction of survey activities. Brigadier Brown was transferred to become Director of Survey at Allied Force Headquarters (A.F.H.Q.) in Algiers, and he was succeeded at G.H.Q. Middle East by Brigadier R. E. Fryer.

A.F.H.Q. takes over control

Operational control in the Mediterranean now switched across to A.F.H.Q., and the Middle East survey organization became an extremely active and important map production agency for all operations based in the Mediterranean and surrounding areas. June was probably one of the busiest months that Middle East Survey had as yet experienced. As "D"-day for the operations in Sicily approached, the main activities tended to shift from map production to distribution. Coding and bundling under the strictest security conditions was an arduous task for all those concerned.

Two changes occurred in the air-photo supply organization during June; firstly, 1434 Flight R.A.F. which, with its Maryland and Baltimore aircraft, had done such useful work in Syria and Persia, was now disbanded as, owing to lack of suitable aircraft, it was unable to undertake tasks outside non-operational areas; secondly with the shift of operational activity to the west, 60 Squadron S.A.A.F. was placed under the operational control of A.F.H.Q.

There were changes also in the map distribution organization. No. 20 Field Survey Depot was reorganized on a new war establishment as 20 (Army) Field Survey Depot including extra transport and further British and Palestinian personnel. The newly raised No. 18 (Palestinian) Field Survey Depot operating with Paiforce took over the map depots at Baghdad and Kirkuk, and a detachment of No. 14 (Palestinian) Field Survey Depot took over the depot at Tehran.

11 (Polish) Field Survey Company and the Polish Map Depot were now in commission and undergoing training. Pending the arrival of demy size printing equipment from the United Kingdom they were supplied with one double-demy printing trailer and ancillary equipment so that they could start productive work.

The invasion of Sicily ("Husky")

Operation "Husky" was launched on 10th July, 1943. A full account of the survey action connected therewith is given in Chapter XII, Section 4, but it is well to record here the part taken by the Middle East Survey Directorate and units in planning and preparation. The invading force consisted of the British Eighth Army and the U.S. Seventh Army forming together 15 Army Group, under the higher command and control of General Eisenhower at A.F.H.Q.

Towards the end of February, 1943, while First and Eighth Armies were still heavily committed in Tunisia, G.H.Q. Middle East held an exercise designed to study the probable requirements for an assault on the Sicilian coast. A planning staff (Force 545) was then assembled in Cairo to carry out planning for British participation in the operation. Long-term mapping preparations had for some time been in progress in London and Washington, and the War Office was asked for full details of the mapping programmes for Sicily and Italy and the islands in the vicinity. This information was made available during the first week in March.

The Director of Survey, Middle East was kept fully in the picture by the Cairo planners, but it was clearly necessary that a survey planning officer should be appointed to work with the rest of the planning staff to study and make arrangements for all the mapping and survey requirements.

At that early date it was not known which headquarters would eventually conduct the British element of the assault and, in any case, D.D. Survey, Eighth Army was in Tunisia where First and Eighth Armies were fighting the closing battles to clear the enemy out of North Africa. Those operations did not, in fact, end till 12th May, and as the target date for "Husky" was originally a date in June, later postponed till 10th July, it is a matter for conjecture whether D.D. Survey, Eighth Army could or should have been spared from his Army H.Q. in Tunisia in order to conduct the early survey planning in Cairo which started in March.

In the event D. Survey, Middle East appointed one of his own officers to act as D.D. Survey (Planning) for "Husky" and the survey preparations went vigorously ahead. It was not until the end of April, by which time it had been settled that Eighth Army would take part in the assault, that Colonel Sanceau (D.D. Survey, Eighth Army) was sent across from Tunisia to Cairo to take over responsibility for survey planning.

There were many difficulties in co-ordinating the work of various map production authorities which were as far apart as London, Washington, Algiers and Cairo, but the final result, with regard to map supply and distribution for the British force, must have given much satisfaction to all those who shared the immense labour of preparation.

The survey units available in Cairo for map preparation were 13, 512, 514, and 524 Field Survey Companies R.E. The first of these was scheduled to take part in the operation, and it was known that it would be withdrawn for training and other duties some time during the planning stage.

The following survey units, hitherto belonging to Middle East Command, accompanied Eighth Army to Sicily:—

- Survey Directorate, Eighth Army.
- 13 and 517 Field Survey Companies R.E.
- 7 General Field Survey Section R.E.
- 20 (Army) Field Survey Map Depot R.E.

Summary of survey activities in the Middle East (July, 1943 to August, 1945)

Once the successful assault into Sicily had been accomplished the interests and activities of the Survey Directorate, Middle East, then shifted, to a large extent, to possible future developments, which were not easy to predict. With this end in view some preparatory regrouping of survey resources and personnel was undertaken.

In order to provide a central organization to direct and check air photographic work on large revision projects, a small Air Survey Group was formed as part of the Survey Directorate at G.H.Q. The ever-increasing amount of work connected with map stocks had made it necessary to attach technical survey tradesmen to do map depot duties, which was obviously a wasteful use of skilled personnel. During August, therefore, the war establishment of 2 Field Survey (Map) Depot was amended, and the unit was then composed almost entirely of Palestinian and Jewish personnel. The Tripoli Base now became

Tripoli District, and the responsibilities of 20 Field Survey (Map) Depot, when it moved over to Sicily, were taken over by 16 (Palestinian) Map Depot.

Paiforce had many changes of units during July, the following leaving the Command:—

- 1 Indian Field Survey Company I.E.
- 4 Indian Field Survey Company I.E.
- 10 Indian Field Survey H.Q.
- 21 Survey Park Section I.E.
- 51 and 52 Drawing Sections.
- 14 Computation Section.

Since their arrival in the Command in 1941, the above units had done great work. Over 200,000 square miles in Iraq and Persia had been resurveyed or revised at scales of 1/100,000 or $\frac{1}{4}$ inch, and about 4,500 square miles of new mapping from air photographs at 1/25,000 and 1/50,000 scale had been accomplished. Over 2,500 miles of triangulation had been completed for plane table control. The country in which they had worked varied from the plains of Iraq to the mountains of Persia, where the surveyors had often to operate at altitudes exceeding 10,000 feet, and in temperatures varying from 0° to 127° Fahrenheit.

To take the place of the departing units the following were formed in Paiforce mainly by drawing men from Nos. 1 and 4 Indian Field Survey Companies:—

- 81 General Section I.E.
- 82 Ground Survey Section I.E.
- 83 Reproduction Group I.E.

Early in September the Polish Survey units left Paiforce on transfer to Ninth Army in Palestine.

After the above moves the Survey organization in Paiforce consisted of:—

- Survey Directorate (Lieutenant-Colonel L. de V. Carey, R.E.).
- 81 General Section I.E.
- 82 Ground Survey Section I.E.
- 83 Reproduction Group I.E.
- 14 (Palestinian) Field Survey Map Depot R.E.
- 18 (Palestinian) Field Survey Map Depot R.E.

With the departure of Eighth Army from Middle East Command, 46 (South African) Survey Company was mobilized as a general service unit to be available for service anywhere. The outstanding performances of this unit since its arrival from East Africa, and its exploits from El Alamein to Tunis, were deserving of the highest praise. The unit later moved to Tripoli (Libya) by road on 6th September *en route* for service elsewhere.

The autumn months of 1943 were, for Middle East Survey, relatively quiet operationally. The map production, revision, and computing personnel were, however, engaged at high pressure on work mainly for A.F.H.Q. operations in Italy, and also in preparation for other possible emergencies in the Balkans, south-eastern Europe, or Turkey. The Survey Directorate was also responsible for the preparation and equipment of survey units which were sent to join the allied forces in the Central Mediterranean. Survey representation at H.Q.

B.T.E. was withdrawn during January, 1944, and G.H.Q. took over all survey duties for British troops who remained in Egypt.

Relatively static conditions continued throughout the whole of 1944, but heavy fighting continued in Italy. In western Europe operation "Overlord" was gradually but surely destroying the German Armies in France and Belgium. Middle East Survey turned out record quantities of maps on an agency basis for A.F.H.Q., and opportunity was taken to improve the triangulation connections in Tripolitania and along the boundaries between Syria, Palestine and Trans-Jordan. Observations were also carried out to effect a junction between Syria and Cyprus.

There were a certain number of unit movements during the year. Mention should be made of the Basuto personnel who were employed with 19 Field Survey Company, and who added to their battle honours by going to Italy when that unit was transferred to the Central Mediterranean Force. 49 (South African) Survey Company, which came up from South Africa, also went to Italy. In June, 14 Field Survey (Map) Depot was transferred to Italy and 15 (Palestinian) Field Survey Depot assumed duty at G.H.Q., thus releasing British personnel for other duties. Later, in September, 524 (Palestinian) Field Survey Company was also sent to Italy.

There was a change in the Survey command during April, 1944. Brigadier R. E. Fryer was posted to the United Kingdom and was succeeded, as Director of Survey, Middle East, by Brigadier K. M. Papworth on transfer from Paiforce.

The scheme for repatriation of personnel who had completed long periods of service abroad involved numerous changes during 1944. The successful prosecution of the war in western Europe, with its inevitable effect of diminishing the probability of further serious operations in the Middle East, brought about a consideration of establishment reductions affecting both survey staffs and units. During February, 1945 the Persia-Iraq Command ceased to function separately, and was amalgamated once more with Middle East Command.

The German surrender in Italy and the rest of western Europe put an end to the urgency of operational mapping programmes for A.F.H.Q. Unfortunately, the cease-fire in Europe was celebrated in Palestine and Syria by political disturbances involving the intervention of British troops and the inevitable rush requirements for maps. At the end of June, 1945, the Survey Directorate Ninth Army was closed down and Colonel R. P. Wheeler succeeded Colonel E. B. Elkington as D.D. Survey, Military Forces in Palestine, taking over also the responsibility for the survey requirements of Ninth Army.

In August, 1945, Brigadier Fryer once more assumed duty as Director of Survey, Middle East, relieving Brigadier Papworth who returned to the United Kingdom. Although active operations against the Axis Powers were over, the survey activities of G.H.Q. continued at high pressure, and embraced wide areas of responsibility. The state of unrest which continued to prevail over a large part of the area constituting the Middle East Command was greatly felt by the Survey Directorate. Maps of areas which had been considered operationally inactive were suddenly demanded in large numbers. After the cessation of hostilities with Japan, there was a natural feeling of relief, and an inclination to ease the strain of continuous high pressure, but this had to be repressed, as the survey responsibilities under the conditions of troubled peace which persisted were almost as vital as during active hostilities. The situation was complicated

and rendered more difficult by the operation of the repatriation and demobilization schemes.

Big programmes of post-war air-survey photography over selected areas in Persia, Iraq, Syria and the Levant were put in hand, involving much work for field surveyors in the production of the necessary control.

This historical summary may well close at this stage. The more technical aspects of the work undertaken are dealt with in other sections of this chapter. It will be clear, however, that, under the control of successive Directors of Survey, the organization set up by Brigadier R. L. Brown and his staff early in 1940 played an important and not inconsiderable part in the successful operations in East and North Africa, in Persia, Iraq, and Syria, in Sicily and Italy, from the first offensive in December, 1940, against the Italians in Libya, until the final German surrender in May, 1945.

SECTION 2. MAPS AND MAP PRODUCTION

Pre-war mapping arrangements

In 1937 the War Office considered the problem of providing maps for British troops in Egypt in anticipation of a possible war emergency. At that time there was no possibility of sending out a survey unit to do any survey or mapping work in Egypt as no such units were in existence. There was, however, a Survey Department with headquarters in Cairo which was an Egyptian Government organization. It was a purely civil department with no military connection. The Surveyor General was an Egyptian, the remaining senior officials in charge of the various sub-departments being British.

An officer was therefore sent out to Egypt from the Geographical Section General Staff (M.I. 4) during 1937 to examine the situation with special reference to map coverage for the Western Desert, and to consider the question of air photography for mapping purposes over the same area.

As a result of this visit the following decisions were taken and implemented:—

- (a) Mobilization stocks of maps for the Western Desert area were printed in Egypt and stored there.
- (b) Air photography by the R.A.F. was begun in the coastal zone with a view to extending the surveyed area southward to the Qattara Depression.
- (c) Black impressions of these mobilization maps were obtained from Egypt. One set was held by the War Office and one set by the Survey Department of India, so that production could be undertaken in either place if the Survey Department in Egypt were put out of action before military map printing resources were available there.
- (d) Black impressions of certain War Office map series were sent to the Survey Departments in India and Egypt so that they could undertake reproduction and printing of such maps if so required.

Air photography proceeded very slowly and was stopped altogether in 1939, as by that time the Survey Department of Egypt had produced by normal ground methods all the maps which it was then considered would be required by the British troops. Amongst their other tasks the R.A.F. photographed a small area round Mersa Matruh.

With regard to Palestine, maps of that country for training and other

purposes were customarily provided on an agency basis by the Palestine Survey Department. The agreement was that as soon as the maps had been provided the War Office held themselves responsible for replacing the paper used. As there was always a considerable delay in effecting this replacement a dangerous situation frequently arose when the Survey Department was almost completely devoid of paper stocks. This happened during the crisis period in 1938 and though at that time it was not considered likely that Palestine would become a theatre of operations, the following action was taken:—

- (a) The War Office arranged for a reserve stock of paper to be held by the Palestine Survey Department.
- (b) Plates of the Palestine 1/100,000, 1/250,000 and 1/500,000 maps were obtained and held by the War Office.
- (c) Black impressions of the 1/100,000 series were sent to the Survey of India for reproduction action if so required.

Mapping situation on mobilization

As one of its principal tasks during peace-time M.I. 4 (Geographical Section, General Staff) was responsible for keeping a record of all known maps produced in foreign countries, and for obtaining record copies of them where possible for the War Office Map Library. For those areas over which it was considered that British troops would most probably operate in the event of war, it was the responsibility of M.I. 4, on receipt of instructions from the General Staff, to reproduce the appropriate maps either by facsimile copying from the national maps or by new drawing and compilation, to bring the maps up to date by revision from any material that could be obtained, and to ensure that printed stocks would be available on mobilization. The area of operational interest in the Middle East was a very extensive one, including Egypt and the Sudan, Libya, Palestine and Trans-Jordan, Syria, Iraq, Turkey, Persia, Greece, the Dodecanese Islands and the Balkans generally. In addition there were the British and Italian East African possessions including Abyssinia.

In view of Germany's aggressive attitude, involving extensive mapping programmes for a probable European war, it was clearly impossible at the same time to reproduce and print operational stocks for vast areas of south-eastern Europe and western Asia which were only possible and not probable war theatres.

For the Middle East, therefore, the War Office arranged, as indicated above, for mobilization stocks of maps covering Egypt and the Western Desert to be printed by the Survey of Egypt, and held at British Military Headquarters in Cairo. There were a number of War Office (G.S.G.S.) editions of maps covering large areas of south-eastern Europe, western Asia and Africa of which small stocks were available in the United Kingdom, and for which reproduction material could be prepared quickly.

It should be realized that, under peace conditions, the War Office normally has no means of carrying out its own surveys over foreign territory in order to produce maps for possible operational purposes. It is entirely dependent, during peace, on making use of the national maps which the Survey Departments of foreign countries produce for their own use, and on obtaining any other information or material which will serve to bring those maps up to date, especially with regard to road and rail communications and other essential features of military importance. Having collected copies of all such maps the

Geographical Section, or its military Survey organizations overseas, can reproduce those required either by recompilation and new drawing, or by direct copying and reproduction by photo-lithographic processes. Whatever methods are used, but more especially when new drawing and extensive revision is entailed, the preparation of an extensive map series is a slow and laborious undertaking, and requires very early consideration by the General Staff when planning for possible future operations.

During the winter of 1939-40 Colonel R. Ll. Brown, who at that time was serving with the B.E.F. in France, was appointed Director of Survey for the Middle East. He returned to the United Kingdom to be briefed for his task and to collect his Survey Directorate staff. While waiting to go to Egypt he visited Paris to consult with the French Service Géographique on various subjects concerning cartography and triangulation for those areas in the Middle East in which the French had a special interest, and for which they possessed technical survey and mapping material.

In the survey dossier handed to Colonel Brown he was given details of the existing mapping situation covering the Middle East theatre, embracing parts of Europe, Asia and Africa. The cartographic information which this placed at his disposal included the following:—

- (a) A brief summary of all the known map series on various scales which existed for the various countries. This summary gave the scale, approximate date of each series, the area covered, the number of sheets, whether coloured or in black only, details of the map projection used, and remarks on the contouring or other method of showing hill features and heights.
- (b) A list of mapping material which was being handed over to him.
- (c) A list of special maps and town plans which had been ordered by Headquarters, Middle East and which were in production at the War Office.
- (d) Notes on the G.S.G.S. map series which were available for the area in question.
- (e) Information regarding the stock of printed maps which were being supplied to the Survey Directorate in the following two categories:—
 - (i) From home sources. This category consisted of limited stocks of G.S.G.S. map series of the area as well as small stocks of outline maps for staff use. This stock from home sources was intended for strategical and staff purposes only, and there were not sufficient quantities available either for a fighting or training issue.
 - (ii) Already held in Egypt. These, as referred to previously, were the stocks printed by the Survey of Egypt and held out there, so as to allow British forces to undertake operations without delay if the emergency should arise.
- (f) List of G.S.G.S. maps for which black impressions were held by the Survey Departments of Egypt and India. From this list D. Survey would be in a position to order reproduction of any particular map for which he considered there was urgent need.

The strategic requirements in small scale maps for the planning and operational staffs were met by the G.S.G.S. series on the 1/M and 1/2M scales. With the entry of Italy into the war it was obvious that the priority areas for tactical maps were those covering the Western Desert and Libya, and those adjacent to and including the Italian East African colonies and Abyssinia.

Egypt and the Western Desert were covered by an Egyptian series at 1/100,000 scale. This was made up of the following:—

- (a) Normal series covering an area from El Daba in the west to the east side of the Suez Canal, and the whole of the Nile Valley to Wadi Halfa.
- (b) North Coast series extending from the western limit of the normal series to the Libyan frontier.
- (c) Western Desert series extending the North Coast series southwards.
- (d) Northern and Southern Sinai series, covering the whole peninsula except for a small central area.
- (e) Eastern Desert series. This covered a small part only of the area between the Nile and the Red Sea.

On the 1/25,000 scale the Survey of Egypt had concentrated mainly on the cultivated areas. The following were covered by maps on this scale:—

- (a) The whole of the Delta extending from Alexandria up to and including the Canal.
- (b) The Nile southwards to Beni Suef.
- (c) A stretch of the Nile from Asyut southwards.
- (d) Another stretch from Aswan northwards.
- (e) Matruh area.
- (f) Daba area.

The Egyptian Survey Department had also published a four-sheet series covering Egypt on a scale of 1/500,000.

Subsequent to these mapping and stock arrangements which had been made by the War Office, the initiative for further mapping programmes and production in the Middle East lay with the Director of Survey, Middle East.

Map printing resources

To enable D. Survey to be more or less independent with regard to map production and printing, 512 (Army) Field Survey Company R.E. was sent out to Cairo early in 1940. From the map printing aspect this was a static unit equipped with fast running double-demy litho printing machines, cameras, and ancillary plant. It also had a number of small drawing sections, and these were increased in numbers very shortly after arrival, when D. Survey recognized that the programme for new mapping and revision was going to be a very heavy one. Throughout the entire war in the Middle East this unit played a predominant part in the immense task of map production which was undertaken, not only for those operations which came under the direct or indirect control of G.H.Q. Middle East, but later, on an agency basis, for the operations in Sicily and Italy which were under A.F.H.Q. control.

Further map printing resources were provided by the mobile printing sections of the field survey companies which, arriving at intervals in the Middle East, were employed in various parts of the theatre, and accompanied the armies in the field during operations. In addition there were the civil survey departments in Egypt and Palestine and, at a later stage, the French Service Géographique at Beirut. In Greece also there was a national Survey Department which gave a great deal of assistance during a critical time.

Early operational mapping activities

On arrival in Cairo during February, 1940, D. Survey took over the mobilization map stocks which had been assembled there, and obtained all available information from the planning and operational staffs at G.H.Q. of future intentions and probabilities.

The grid systems adopted for the various zones within the theatre are referred to briefly below (see Diagram 2 on page 112):—

- (a) *Egypt.* H.Q. B.T.E., in conjunction with the local Survey Department, had established two Transverse Mercator grid belts for Egypt. One of these, known as the Red Grid, extended from longitude 29° (E.) to the eastern frontier. The other, known as the Purple Grid, extended from longitude 29° (E.) to the Libyan frontier. These were accepted by the War Office.
H.Q. B.T.E. had also introduced its own system of map referencing, which was at variance with the accepted British system of letters and numbers.
- (b) *Palestine.* A Transverse Mercator grid covered Palestine and Trans-Jordan. This extended from the eastern limit of the Egyptian Red belt to its junction with the Iraq grid in the east, and northward to its junction with the Levant grid just north of Haifa.
- (c) *Levant.* The Levant Grid covered Syria and the Lebanon and a small area of Turkey in Asia. It was bounded by the Palestinian belt in the south, the Iraq and Caucasus zones in the east, and the Mediterranean zone in the north and north-west.
- (d) *Cyprus* was covered by its own grid.
- (e) *Turkey in Asia* was covered by the Mediterranean Grid Zone which extended eastward to its junction with the Caucasus Zone.
- (f) *Libya.* It was decided to cover Libya by a Lambert Grid which extended westwards from its junction with the Egyptian Purple Grid. Its western and southern limits had not been defined in 1941, but a junction with the N.W. African Grid was later effected. With the almost certain probability that operations would be conducted over long distances east and west, and limited distances north and south, the Lambert projection was very suitable technically for military purposes.
- (g) *Crete.* This island was covered by its own grid.
- (h) *Greece* was covered by the western end of the Mediterranean Zone Grid which included also both European and Asiatic Turkey.

The political situation regarding Turkey in 1940 was obscure but, with the possibility of establishing air bases in that country and of having perhaps to operate through Turkey to meet a potential threat from the north, it was essential to provide mapping cover. Sheets of the 1/200,000 Turkish maps of western Asia Minor were therefore taken up for reproduction in colour and were gridded (Plate 6), and a few 1/50,000 sheets were produced by enlargement from smaller scales. "Tank Going" maps were also prepared by adaptation of 1/250,000 sheets, and several town plans and other special maps were produced. The reproduction of the Turkish 1/800,000 series was later undertaken and completed during the summer of 1941 together with other maps to which later reference will be made.

With the 1/M International series as basic material, 40 sheets were adapted for special use as aviation maps covering the Balkans and the Middle East.

After the preparation of grid overprints, and the use of printing plates of the standard Egyptian sheets supplied by the Survey of Egypt, stocks of gridded 1/100,000 maps were printed, extending over the Western Desert as far as the Libyan boundary. The War Office mapping preparations for Cyrenaica and Tripolitania consisted of reproductions of a certain number of Italian sheets on medium and small scales belonging to the following series. Only a limited number of sheets in the series was available, several being missing.

(a) *Cyrenaica*

1/100,000. A narrow coastal strip extending from Benghazi to the Egyptian frontier.

1/400,000. Coastal block.

1/50,000. Coastal strip from Benghazi to Derna.

(b) *Tripolitania*

1/400,000. Coastal block.

1/100,000. Coastal strip from the French frontier to Misurata.

1/25,000. Town of Tripoli and surroundings.

(c) *Libya*

1/400,000. Central area extending from the coast well inland.

The Survey Directorate undertook the reproduction, including gridding, of the available sheets from reproduction material supplied by the War Office, and stocks were assembled for the concentration of the Western Desert Force and for the opening of the first British offensive. During the short period before the offensive, the mapping situation around the railhead area of Mersa Matruh was improved by the production of several sheets on 1/25,000 scale, the work being done from air photographs and ground check by sections of 512 Field Survey Company.

There were some points of technical interest concerning the above maps, one of which especially should be recorded, as it gave a good deal of trouble, and added to the difficulties of production. Owing to a break between the triangulations of Egypt and Cyrenaica, the topography of the Egyptian and Italian Surveys did not join up properly. This break resulted in a discrepancy in longitude which was sufficient to affect artillery shooting quite considerably. Its effect on the topographical sheets was also noticeable and, when reproducing the frontier sheets of the Italian 1/100,000 maps in the Sollum area, the War Office had adjusted the Italian detail to fit corresponding detail on the Egyptian sheets without inserting any note on the map to indicate that this had been done. The sheets concerned were therefore reproduced afresh in Cairo from original Italian material, due allowance being made in the gridding for the discrepancy in longitude between the two countries.

The British offensive opened in December, 1940, and rapid advances were made. One of the principal objectives of survey parties operating with the Desert Force was to obtain copies of captured Italian maps, and they were fortunate in this respect. Some of the hitherto missing 1/100,000 sheets were found, and some more up-to-date editions of available sheets were also captured. As there was no survey unit with mobile printing equipment then in the field, the maps were sent back to Cairo where they were rapidly reproduced in one colour and flown up to the front. Later the entire 1/100,000 series, with reorganized sheet lines across the frontier, was redrawn for reproduction in colour.

It was also found that there was a considerable amount of fairly recent Italian 1/50,000 mapping in Cyrenaica, and of special importance was a 1/50,000 sheet of Tobruk, which town was at that time just about to be attacked. This map was reproduced with the British grid, and was flown forward in time for the actual assault. Of particular interest and value was the fact that enemy defence works and gun positions were incorporated in the form of an overprint, thus enabling the artillery to concentrate successfully on these features. At a later stage, some 1/25,000 maps of Tobruk were captured, and it was noticed that these had been produced by the Italians by enlargement from the 1/50,000 map, not from the original Italian material, but from the British reproduction of the captured map.

When reproducing these Italian maps, 512 Field Survey Company added new detail and revision from all available sources, including air photographs when the latter could be obtained. Work was also begun to re-compile the Italian 1/400,000 series into a new British 1/500,000 series covering the operational area.

The British offensive reached its extreme western limit in February, 1941, when El Agheila was occupied. Difficulties of supply over long lines of communication, and a reduction in available resources of personnel and equipment, owing largely to the necessity for sending an Expeditionary Force to Greece, made a retirement inevitable. Benghazi was evacuated early in April, and the Desert Force was back across the Egyptian frontier in the Sollum area by the end of that month.

Anxiety about the Greek mapping situation had been felt in the autumn of 1940 when the Italians crossed the Albanian frontier into northern Greece. The mapping work which was undertaken for the campaign, which opened in early April, is described in Chapter XII, Section 3.

Maps of Crete were reproduced in the Middle East and were available for distribution before the German invasion of that island. They included the following:—

- (a) A 1/300,000 map of the island, which was a reprint of GSGS 1896 incorporating some road revision. It was first printed in August, 1940. During the battle in Crete in May, 1941, when it looked as though existing stocks might not be sufficient, a second printing was carried out.
- (b) A 1/100,000 map in five colours covering the Heraklion area. This was printed in Palestine from black pulls of an original Greek map dated 1936, a name trace giving transliterated names, notes for the margins, and data from which to plot and incorporate the Crete grid. A small advanced stock was flown to the island, the remainder following by sea.
- (c) A 1/50,000 gridded series of 16 sheets covering most of the island exclusive of that portion covered by (b). This was a transliterated edition of the original Greek maps and was produced by a combination of redrawing on enamel plates and duffing out on the negative. An all-black edition was available in Crete for the initial fighting, and a final four-colour edition was produced by 17th May but, owing to the lack of both sea and air transport, very small stocks only of the latter reached Crete.

Maps of Cyprus were prepared as under:—

- (a) A $\frac{1}{4}$ -inch map (GSGS 3974) was printed in May, 1941, from War Office reproduction material, with layers, grid, and revised roads.

- (b) Maps on 1/25,000 scale were produced by enlargement from the existing $\frac{1}{2}$ -inch to 1 mile map. H.Q. British troops in Cyprus selected certain sheets and these were printed during May and June, 1941.
- (c) 1/50,000. To accelerate the production of a medium scale tactical map, it was decided to cover the island on 1/50,000 scale rather than on 1/25,000. 16 provisional sheets covering the whole island were produced in June, 1941, in black only. These were later replaced by a fully coloured edition.

The following maps of Palestine, published by the Palestine Survey Department, were in existence at the beginning of the war:—

- (a) 1/20,000 covering the coastal areas and the Plain of Esdraelon.
- (b) 1/100,000 covering all Palestine north of Lat. $31^{\circ} 20'$.
- (c) 1/100,000 (new large sheet series) in course of production, extending from Lat. 31° northwards and overlapping the lower sheets of (b).
- (d) 1/250,000 covering all Palestine.

The above were printed in one colour and were gridded. The preparation of revised sheets on 1/25,000 scale was put in hand at an early date, and this applied also to the 1/100,000 series. As a result of surveys carried out by the Australian Field Survey Company a 1/100,000 edition covering Transjordan was completed and published.

Before the start of hostilities in Syria the following maps of that country were in existence:—

- (a) 1/50,000. A coloured, hill shaded series which was in course of production by the French Service Géographique, covering the south coastal area, Damascus, Homs and Aleppo.
- (b) 1/100,000 series covering the coastal area. This was an enlarged, transliterated edition of the Turkish 1/200,000 series and was not kept up to date.
- (c) 1/500,000 series covering Syria and the Lebanon. This, again, was based on the Turkish 1/200,000.
- (d) 1/200,000 series covering the whole of Syria except for the north-central area. This map was based on proper surveys where available, the remainder being compiled from route surveys.

The principal early work on the maps of Syria which was initiated by the Survey Directorate was as under:—

- (a) Three sheets of a road diagram on 1/500,000 scale were produced in June, 1941, to cover the coastal belt.
- (b) A redrawn edition of the French 1/200,000 series west of longitude 40° was published in five colours. The remaining sheets were at first printed in black only, with coloured grid numbers. It was decided that, east of longitude 40° the sheets of this 1/200,000 series would be replaced eventually by the Survey of India $\frac{1}{2}$ -inch sheets.
- (c) Reproduction of the French 1/50,000 series was begun by redrawing for a four-colour edition. After ten sheets had been completed the remaining 30 were reproduced as a provisional edition in two colours only, slate-blue detail with red road filling and grid, in order to expedite completion. They were later revised from air photographs and other material and were redrawn for reproduction in four colours.

Fuller details of the mapping situation in Iraq and Persia will be found in Chapter VII. Early production in the Middle East included the following:—

- (a) The 1/500,000 Iraq Desert series was reprinted in Cairo from War Office plates.
- (b) 20 sheets of the $\frac{1}{4}$ -inch series covering the area from Mosul to Basra were printed from black pulls supplied by the Survey of India during the Iraqi revolt. Ten more sheets covering the area west of the Tigris into Syria were subsequently reproduced from Indian basic material.

The above brief summary gives a general idea of the mapping situation which presented itself to the Director of Survey, Middle East when he assumed responsibility for the area, and the work which he initiated to develop and improve it during the early months of the campaign. Further notes will deal with the principal mapping programmes which were later undertaken for operations directly controlled by G.H.Q., Middle East, for other potential operational areas, and for A.F.H.Q., on an agency basis in connection with the fighting in North Africa, Sicily and Italy, and for the operations in southern France in 1944.

Temporary civilian mapping organizations

Reference has already been made to the map production and printing resources available with the Survey Departments in Egypt and Palestine. Later on, after the cessation of Vichy French resistance in Syria, the Service Géographique de l'Armée at Beirut was available to augment these resources to a limited extent. In the early days, however, when there was a shortage of survey units in the theatre, temporary civil establishments were formed in Cairo and Alexandria from locally hired personnel and equipped with locally purchased or constructed plant. Both were capable of rapid drawing on enamel plates and the production of wet plate negatives. Their special use was for the reproduction in colours of captured or record maps.

The Tura Caves

As 512 Field Survey Company was the principal map production unit at the disposal of the Director of Survey, it was essential that it should be accommodated in a good and safe place. The first location, on the edge of the Heliopolis airfield, was considered too vulnerable. Arrangements were therefore made for the unit to be moved to some caves at Tura, about six miles to the south-east of Cairo, where their work would be carried out within the safety of the caves themselves. The task of preparation and improvement took a long time, and it was some months before the unit was working to full capacity at Tura. It remained there throughout the whole war period, suffering periodical inconveniences and delays due to roof falls, dust and other factors incidental to the conditions prevailing there.

Revision Group

With the prospect of large revision programmes having to be undertaken, a special Revision Group was formed in 512 Company. This worked in close touch with the R.A.F. Photo Reconnaissance unit and the Air Photo Interpretation unit. In the early days the group was fully occupied with the revision of maps required for urgent reprints but, as soon as arrears had been

overtaken, it was organized to work on a continuous revision basis, and for new map compilation. Arrangements were made also with the various commands of the Middle East to decentralize to them responsibility for the revision of certain map series and a system was evolved for the interchange of air photographs and other revision material.

The mapping situation in the autumn and winter of 1941

Germany attacked Russia in June, 1941, and their rapid move eastward towards the Caucasus caused considerable strategic apprehension in the Middle East. This was aggravated by subversive activities in Iraq and Persia, German successes in the Balkans, and the British retirement from Libya back into Egypt. Uncertainty about Japan's future actions, and their possible repercussions on Middle East strategy, completed this somewhat gloomy picture. One bright spot on the credit side was the defeat of the Italian forces in Abyssinia and Eritrea, which removed the threat to the Sudan.

The effect of all this on the mapping policy of the Director of Survey, Middle East was considerable. The potential areas of possible operations had been widened, reinforcements which were arriving in the theatre in increasing numbers required to be mapped up, and plans were afoot for a new British offensive in the Western Desert. The latter started on 18th November, and was followed by a rapid advance into Cyrenaica and the reoccupation of Benghazi in December. This success was somewhat offset by the entry of Japan into the war, the invasion of Malaya and the fall of Singapore.

It would serve no useful purpose to enumerate in detail all the mapping work that was carried out to meet the actual or potential situations that arose or might have arisen as a result of the above happenings. As in all other theatres the work of the Survey Service included not only the revision and reprinting of existing standard map series, but also the preparation of new ones, and the production and printing of innumerable special maps, charts, diagrams and sketches required by various branches of the staff and services, and by field headquarters and formations. Reference will be made, therefore, only to the more important tasks which were handled by the Survey Directorates and units, with special notes, where applicable, on any special activities in the mapping sphere that were undertaken in connection with particular operations.

Second British offensive into Libya (November, 1941)

In anticipation of this offensive, and for training purposes in Egypt, much new mapping and revision was carried out covering both Egypt and Cyrenaica. Big printing programmes were undertaken so as to build up large operational stocks. After the offensive had been launched, and while our troops were in occupation of Cyrenaica, much further mapping work was undertaken, both in the field and at G.H.Q.

The Normal and Western Desert 1/100,000 series of Egypt continued to be the principal tactical maps, and were reprinted with revisions. An important new project was the production of 1/50,000 maps from ground surveys in two areas of the desert. One of these, known as the Daba-Alexandria series, covered the important defensive area around El Alamein, just east of Daba, extending from the coast to the Qattara Depression (Plate 7). At the time that this work was proposed by the Director of Survey, the offensive westwards was proceeding so satisfactorily that there was some inclination on the part of the

General Staff to consider it unnecessary and a somewhat wasteful use of survey resources. The survey was, however, undertaken and, as subsequent events proved, the resulting maps were invaluable when the British Eighth Army was thrown back on the defensive and then turned to win the battle of El Alamein. The other area covered was further to the west in the Matruh-Daba area. Much of the ground survey was done by the South African Survey Company.

A new small scale series at 1/250,000 scale was taken up by G.H.Q. to cover northern Egypt and Cyrenaica, some of the sheets being compiled by survey units and others being done by the Egyptian Survey Department (Plate 8).

Large scale (1/25,000) sheets of the Egyptian Normal series were revised and reprinted for important areas such as the Delta, and further new sheets were produced by the Survey of Egypt. The 1/25,000 maps of the Matruh area (Plate 9), which had previously been compiled from air photographs, were revised on the ground by field survey units, and the Matruh defences were covered by a special defence map at 1/12,500 scale. In addition, numerous selected areas were surveyed and mapped at even larger scales for the development of camp sites, etc.

The entire 1/100,000 series of Cyrenaica was redrawn for reproduction in colour, and was published with recast sheet lines across the Egyptian frontier (Plate 10). Where revision material was available in the form of air photos or other material, it was incorporated. For Tripolitania the existing 1/100,000 sheets were reprinted with grid letter overprints.

Two special sheets on 1/50,000 scale covering the important frontier area between Egypt and Cyrenaica were produced, and were overprinted with information interpreted from air photographs. With an eye to the future, a pilot sheet for a 1/50,000 map of the Tripolitania area was put in hand during September, 1941, and several sheets were printed by December, so as to provide basic maps for overprints when the operations should reach there. The 1/50,000 maps of the Tobruk area which had been previously issued, were recast in three new sheets during October with defence overprints added. During March, 1942, it was decided to cover Cyrenaica by a standard 1/50,000 series, each sheet to be one quarter of the new 1/100,000 sheets. They were to be compiled from ground surveys and air photographs by the survey units serving with Eighth Army. Important tactical areas were, of course, given priority, such as Tobruk, Gazala, and other localities where fighting was in progress or anticipated.

On the smaller scales, sheets of the new 1/250,000 series covering Libya were in production at G.H.Q. in October, 1941, as also were some revised sheets on the 1/500,000 scale. On these latter special "Going" overprints were issued as an aid to the movement and operations of armoured units (Plate 11). When Eighth Army had, for the second time, reached El Agheila, all the resources of 514 Field Survey Company in the field were put on to the preparation of three 1/250,000 sheets in that area from photographs taken by 60 Squadron S.A.A.F., using control established by 514 Company.

Preparation of 1/25,000 maps of the Tripoli series started in September, 1941. Many special strip maps and mosaics from air photographs were prepared to meet urgent operational requirements, and defence overprints, revised at frequent intervals, were an almost daily requirement during critical periods of the fighting.

The survey unit available with Eighth Army at that time was 514 Field Survey Company R.E. which had attached to it a drawing section of 512 Field

Survey Company. The unit was equipped with mobile lorry-borne map printing equipment.

Mapping work in Palestine and Trans-Jordan

During the period leading up to the clash with the Vichy French in Syria, the priority areas of Palestine from the mapping point of view were in the north, immediately south of the Syrian border, and in the eastern defence area along the Jordan valley running north from the Dead Sea. The existing 1/20,000 maps of these parts of Palestine, after reduction to the standard of 1/25,000 scale, were revised and printed. They were followed by further blocks of sheets along the coast, and in selected defence areas (Plate 14).

The survey resources at the disposal of the D.D. Survey, Military Forces in Palestine, during 1941 included 517 Field Survey Company R.E. with its mobile demy size reproduction equipment, and 2/1 Australian (Corps) Field Survey Company R.A.E. which was equipped with double-demy size machines mounted in trailers. In addition a detachment of the South African Survey Company was working in Sinai under the control of D.D. Survey, the 36 New Zealand Survey Battery R.A. was doing topographical survey work in Trans-Jordan under G.H.Q. control with a detachment in Cyprus, and a Royal Marine Survey Section became available late in 1941. Later on 13 Field Survey Company R.E. increased the survey resources with Ninth Army in Palestine. The Palestine Survey Department was available on an agency basis for carrying out limited programmes of map production and printing.

Field parties of the above units completed extensive ground surveys to establish control for new air-photo mapping for the revision of existing maps, and for plane-table surveys.

The existing 1/100,000 series of Palestine was periodically revised and, as a result of the combined resources of military survey units and the local Survey Department, a newly drawn series on this scale was begun, with recast sheet lines, the detail being compiled from a combination of ground survey and air photographs (Plate 12).

On the 1/250,000 scale two demy-size sheets covering Trans-Jordan were produced in August, 1941. These overlapped the Palestine series and, during the summer of 1942, a new series on this scale was produced covering both countries in five sheets of a size suitable for printing on the mobile demy machines of the field survey companies.

Syria

Syria came within the responsibility of the D.D. Survey Ninth Army after its occupation, and the somewhat limited resources of the French Service Géographique at Beirut were at his disposal in addition to the survey units mentioned in the preceding paragraph.

When the Germans thrust deep into Russia towards the Caucasus, Syria assumed considerable importance strategically as an outer bastion of the Middle East theatre. As Turkey continued to remain neutral, the frontier between Syria and Turkey became one of great survey importance, and much ground survey and new mapping work was put in hand both along the above frontier and in various selected defensive areas which guarded the approaches from Iraq and Trans-Jordan.

On the tactical scales this work included 1/50,000 and 1/25,000 maps covering

the so-called fortress areas of the Jordan, Damascus, Ras Baalbek, Tripoli and Haifa, and also along the Turkish frontier. On the smaller scales the original Syrian 1/200,000 series, which had been reproduced in revised form, was partly replaced in 1942 by a new "Levant" series on the same scale. This carried bilingual names, and new 1/250,000 sheets of South Levant were completed in August, 1943. The 1/500,000 maps of the country were republished in a revised bilingual edition during 1942.

The map series that were eventually maintained for this area, apart from the large scale 1/25,000 of special areas, were:—

1/50,000	Levant (Plate 13).
1/50,000	South Levant.
1/100,000	South Levant.
1/200,000	Levant.
1/250,000	South Levant.

Turkey

Although it became increasingly likely that Turkey would maintain her neutrality, that country still remained an area of great strategical importance in so far as maps were concerned. Possible action by Germany, as a result of operational successes in South Russia, might have involved the employment of British forces from the Middle East in the defence of Turkey against aggression, and it was therefore essential that maps should be available in case of need.

At the end of 1941 the Turkish 1/800,000 series had been reproduced in colour to form a small scale strategical map. Reproduction of the Turkish 1/200,000 series continued during 1941 and 1942, and sheets were revised as new detail material became available.

A few new 1/100,000 sheets covering Turkey in Europe were produced during 1943–44 as an extension of the Greek maps on the same scale. On the 1/25,000 scale the important areas of Istanbul and the Dardanelles were covered by colour separated reproductions from Turkish large scale maps. Names were transliterated and revision was incorporated.

The Caucasus

This, being the frontier region between Russia, Iraq and Persia, became an area of great strategical significance when the German armies swept through towards the Caspian Sea. It was covered by a War Office 1/500,000 series which, in turn, was overlapped in the south by a ¼-inch series produced by the Survey of India. Reproduction of both these series was effected by Middle East Survey from material supplied by the two respective sources of origin.

Malaya

At the beginning of 1942, following the Japanese invasion of Malaya, the Australian Corps was transferred from Middle East to the Far East, and had to be mapped up to meet possible contingencies. The following maps were reproduced and printed from material supplied:—

Malaya

1/250,000	North and south sheets of Johore and Singapore, first in a quick monochrome edition, followed by a coloured edition.
1 inch to 1 mile	Selected sheets.
Motor Map	(12 miles to 1 inch).

Sumatra

1/750,000	Selected sheets.
1/250,000	Selected sheets.
1/100,000	Selected sheets.
1/50,000	Selected sheets.

Borneo

1/200,000	Selected sheets.
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Java

1/100,000	Selected sheets.
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Further miscellaneous mapping during 1942

Aden. A limited amount of new mapping was done. Ground control for Aden and its hinterland had been established between the two wars under War Office arrangements, and air photographs were taken during 1942. One sheet at 1/50,000 and two at 1/25,000 were produced by Middle East Survey.

Crete. During October and November, 1942, several of the existing sheets on scales of 1/400,000, 1/100,000 and 1/50,000 were revised from air photographs. Further work for this island was undertaken later in 1943.

Cyprus. The provisional 1/50,000 series in black only was replaced by a second edition in four colours. As there were many areas in the island where no contouring had been done, a survey party was sent to do this work so that the map series could be completed.

Further 1/25,000 sheets were taken up for production during 1942, and a revised edition of the existing $\frac{1}{4}$ -inch map was begun.

Malta and Gozo. The maps of the island at 2 inches to 1 mile were reprinted using War Office reproduction material.

East Africa. Although the operations against the Italians were over, there was quite a big programme of new mapping being done by the East African Survey Group, and G.H.Q. Middle East took a share in the preparation of several of the new 1/500,000 sheets.

Dodecanese and Aegean Islands. These were still in enemy hands during 1942, but, in view of their considerable nuisance value in the Mediterranean, action to dislodge the enemy from them was being planned. A revised edition of Rhodes at 1/100,000 was taken up in November, 1942, also a new sheet to cover Scarpanto. Later, in 1943-44, the Dodecanese were covered by a newly compiled 1/25,000 series.

The original maps of the Aegean Islands, which were direct reproductions from record copies, were now being replaced by newly compiled maps from air photographs at a scale of 1/50,000.

Italy. Thoughts were directed to the mapping of Italy at an early stage, and pilot sheets at various scales had been prepared by G.H.Q., Middle East, during 1941 and early 1942.

The extensive programmes of Italian mapping which were taken up in conjunction with A.F.H.Q. during 1943 will be dealt with later.

The Battle of El Alamein and the final Eighth Army offensive into Libya and Tunisia (Winter of 1942-43)

In January, 1942, Rommel and his Afrika Korps retook Agedabia, the extreme westerly limit of the British offensive in the autumn of 1941 and, after occupying Benghazi, thrust Eighth Army well back into Cyrenaica. There

followed a period of relative inactivity until May, 1942, when he launched his offensive, advanced to Bir Hakeim, and forced Eighth Army to withdraw into Egypt. By the beginning of July the enemy had passed Mersa Matruh and was thrusting forward towards Alexandria. By 6th July, however, the drive to the Nile had been stopped in the El Alamein area, and both sides were concerned with building up their strength and resources.

The survey units with Eighth Army were almost continually on the move during this period of withdrawal, and the mobile printing equipment of 514 Company was kept busy day and night turning out enormous quantities of maps, defence overprints and other requirements of that nature to meet the day to day operational needs of the force.

It is of interest to note that at a critical period when Eighth Army was on the defensive in the El Alamein area, the enemy planned a final stroke to thrust their armour through to Alexandria and the Nile delta. A faked "Going" map was prepared and deliberately allowed to fall into enemy hands. The map showed patches of "bad going" for armour along what was in fact the most favourable line for his advance, and "good going" along a route which would lead his armour towards concealed British defences where it could be adequately dealt with. According to prisoners' statements it seems probable that he fell for this ruse. In the event his force was so badly mauled during the battle of Alam Halfa in the first week of September, 1942, that it proved to be his last offensive action in that area.

In mid-August came the changes in the Higher Command when General Montgomery took over command of Eighth Army. From that moment all energies were devoted to preparations for an offensive which was to drive the enemy out of Africa. It was to be timed to take place more or less concurrently with the landing of Allied Forces in North West Africa.

Mapping preparations for this offensive were considerable and widespread. As the German threat to the Middle East through the south of Russia was still a real one the development of the mapping programmes for Palestine, Syria and Turkey had to continue unchecked.

514 Field Survey Company was withdrawn from Eighth Army to G.H.Q. control at the conclusion of the British retreat and was employed on track surveys and desert beaconing behind the El Alamein position and towards the south, the results of their work being incorporated in all relevant maps of the area.

Most of the map production work for the offensive was done by 512 Field Survey Company, which was the base production unit at the Tura Caves, and 46 South African Survey Company, to which a drawing section of 514 Company was attached, principally for work in connection with the location and plotting of enemy battery positions on block plots at 1/25,000 scale. These were specially prepared for the El Alamein battle and were used successfully by the counter-battery organization for concentrating artillery fire on to enemy gun positions and defence works before and during the battle.

It will be remembered that the Daba-Alexandria series of maps at 1/50,000 which covered the battle area had been produced from ground surveys some months previously. During the build-up period before the battle some further sheets were published, and overprints were prepared showing all known enemy positions, gun areas and other important detail. Between the beginning of August and the battle itself five editions were issued, each one bringing the information known about the enemy more up to date. These maps were distributed down to platoon commanders.

A special edition of three 1/25,000 sheets showed enemy defences in the area lying south-west of Tel-el-Eisa. The defences had been located on photographs taken with a 36-inch lens, and were positioned on the block-plots which covered the whole front. The positional accuracy of the detail was reckoned to be about ± 20 metres.

Special air observer maps were issued which showed only the main topographical details. Day bombers used the 1/250,000 scale, and the Photo Reconnaissance units and the Tactical and Strategic Reconnaissance squadrons used the 1/500,000 scale.

Apart from the above-mentioned and many other special maps which were prepared for planning and for the battle itself, large stocks of the standard series of maps covering the Western Desert and Libya were reprinted in revised editions for distribution and for assembly in the various map depots. Principal field survey units which were assigned to Eighth Army were the 46 South African Survey Company and 517 Field Survey Company R.E., each of which was equipped with mobile demy size printing equipment.

The standard maps took the Eighth Army through Libya as far as Agheila during its rapid advance. In anticipation of a battle there, demands for survey increased, and 46 South African Survey Company moved up near Army H.Q. and printed copies of the 1/50,000 sketch maps of Agheila and Agedabia which had been prepared during the previous offensive. They were the only maps of that area available on a scale larger than 1/250,000 but were unsatisfactory, being based on very limited ground control of dubious quality. The previous withdrawal of the British forces had prevented the completion of proper control surveys, and there was a considerable divergence of detail relative to the grid between the 1/50,000 and 1/250,000 maps. This caused a good deal of confusion and lack of confidence. It also pointed to the need for clear-cut action on the part of Survey regarding the control and gridding of maps at varying scales to ensure that the best available control material is used, and that the grid incidence of detail on maps of the same area at different scales is consistent.

Very little enemy map material was captured during the early stages of the offensive. One of the most useful finds was an index diagram of the Italian 1/100,000 series which indicated that, anyway as far west as Benghazi, no Italian sheets of this series were in existence which had not already been used in the preparation of the British map series.

As Eighth Army continued its advance into Tripolitania, the division of the map reproduction work between 46 Company and 517 Company became very unequal. 517 Company was back at Bardia and had little printing to do, as map stocks of Eastern Cyrenaica were adequate. 46 Company, however, was overwhelmed with repeated demands for overprints of enemy defences, etc. 517 Company was therefore moved forward to the Sirte area to assist 46 Company, and to prepare the 1/100,000 series of Tripolitania for printing on the mobile demy machines. At this time G.H.Q. supplied reproduction material to Eighth Army, in the form of kodelines, of four map series of Tripolitania, so that they could be self-contained and independent with regard to map printing. This became more and more essential as the lines of communication grew longer and longer.

By 23rd January, 1943, Eighth Army had captured Tripoli, and on 29th January, entered Tunisia. In anticipation of this the Army had assumed responsibility for printing in the field over 40 sheets of the 1/200,000 series of Tunisia in five colours. At the same time G.H.Q. Survey concentrated much

of its resources on Tunisian map production during January, work on Cyrenaica and the Levant being placed in abeyance.

During early January, 1943, one of the principal mapping tasks with Eighth Army was the production of 1/50,000 defence overprints of the Buerat area, and second editions of sheets which had been compiled from imperfectly controlled air photographs were issued before the attack on 15th January.

In addition to the Tunisian 1/200,000 series there was one at 1/100,000 but it was considered unsuitable for battle owing to its lack of clarity and the discrepancy in detail which was apparent between it and the 1/200,000 series. During February, therefore, Eighth Army survey units undertook the production of new 1/50,000 maps in the Gabes, Mareth and Medenine areas (Plates 15 and 16). These were considered necessary because the southern part of Tunisia had been only spasmodically mapped by the French at medium scale, their 1/50,000 series ending about the latitude of Sfax. It was, in any case, inconvenient to use the French native sheet lines as they were too big for the mobile demy machines.

By mid-March Eighth Army was on the Mareth Line. There was a demand for new 1/25,000 maps of the Mareth Line proper but, owing to pressure of work and insufficient resources, this could not be met. As a compromise, certain portions of the 1/50,000 maps were enlarged to 1/25,000. For the battle itself a special 1/12,500 sketch map was made up and, for the New Zealanders' turning movement round the Matmata Hills, a special edition of the 1/100,000 sheets was issued. During the ensuing fighting through southern Tunisia the survey units turned out new maps from air photographs wherever it seemed likely that the enemy would stand.

For the last phase of the operations between Sfax and Cape Bon, Eighth Army was using principally the Tunisian maps at 1/50,000 scale. These were printed in the field from kodelines supplied by G.H.Q., and air-photo revision was incorporated where obtainable. Enlargements to 1/25,000 of the French 1/50,000 sheets were also used, with the British (North African) grid overprinted. The infantry liked to have the larger scale map as it gave them more space for inserting local detail and notes.

Hostilities ceased in Tunisia on 12th May, 1943, and the long and arduous struggle to keep Eighth Army supplied with maps for their African campaign came to an end.

G.H.Q. mapping in the early part of 1943

The strategic outlook in the Middle East underwent a considerable change during January and February, 1943. There were firm indications that the days of the Axis forces in Africa were numbered as a result of Eighth Army's victorious advance from Egypt to Tunisia and the eastward drive of the British and U.S. Allied Force in North West Africa.

In Russia, Stalingrad had been relieved at the end of November, 1942, and the tide definitely turned about the end of February when Russian armies began to drive the Germans westwards.

These events materially affected strategical mapping policy and G.H.Q. Survey then took up urgent mapping programmes for future operational areas. As the advance of Eighth Army proceeded further and further to the west, there arose demands for maps covering areas well outside the original geographical boundaries of the theatre. The next move, after clearing the enemy out of Africa, was to pave the way to a landing on the

mainland of southern Europe by eliminating, one by one, the obstacles that lay in the way. Map production for Sicily, Sardinia and Corsica was put in hand using War Office reproduction material. Greece, Crete, and the Aegean and Dodecanese Islands were also taken up. Some of this work was reproduced from War Office material, some was new mapping from air photos. Mapping of Italy itself was included, and these programmes were co-ordinated with the Survey Directorate at A.F.H.Q. which would be responsible for the conduct and control of the operations. Owing to the immense scope of the task the maps were at first prepared for one-colour printing wherever possible, with the intention of clarifying them by the use of colours and adding further revision as opportunity offered later.

G.H.Q. Survey concentrated 13 and 514 Field Survey Companies and drawing sections from 19 Field Survey Company at Abbassia to contend with the increased work. On the printing side May, 1943, provided a record with an output of over 2,000,000 maps. This record was, however, well beaten during June when the monthly output soared to 4,000,000.

The invasion of Sicily ("Husky")

The general arrangements and organization set up by D. Survey, Middle East to plan and execute the mapping preparations for this operation have been described in Section 1. Further details regarding the survey side of the operation will be found in Chapter XII, Section 4.

The Allied force which took part in the assault was under A.F.H.Q. command, and various portions of it were mounted respectively in the United Kingdom, the United States, North West Africa and the Middle East. Maps had therefore to be printed and distributed in all the above mounting areas.

These notes refer to the actual mapping work which was undertaken in the Middle East itself. The maps which were required and the material from which they were reproduced were as under:—

1/M International Series.	Material already in Middle East.
1/M Plotting Series for Air Navigation.	" " " "
1/500,000 air map in colour.	Black pulls of all colours from the War Office.
1/250,000 in colour.	Kodalines of all colours from the War Office.
1/100,000 in colour.	(a) Black pulls, all colours. (b) Kodalines, all colours, from the War Office.
1/50,000 "Griblet" style.	Kodalines for the basic map and grid from the War Office Black pulls for red and blue overprints from the War Office.
1/25,000 "Griblet" style.	As for the 1/50,000, except that the grid was on the basic map.
Town plans.	

The kodalines and black pulls were sent out from London by air as they became available. Some of this material arrived somewhat late during the production period. It was found that a combination of black pulls and

kodalines for any one map proved most difficult to assimilate. Many methods were tried by the survey units engaged on the work but, in the case of this mixed material, the quickest practical method was found to be to redraw the red and blue detail. In the case of the 1/25,000, time and resources did not allow of this being done for the blue detail, so they were therefore printed in brown and red only.

The black pulls of the 1/100,000 series were uneven in size, so printing was held up till the kodalines arrived. These were found satisfactory, as also were those for the 1/250,000 series.

The general recommendation as a result of experience on this job was that for any future operational planning of a similar nature, all reproduction material should be supplied in kodak form if the necessary amount of film is available. With modern improvements in the manufacture of low-distortion film, and the introduction of improved methods for film duplication, there seems little doubt that this recommendation was a correct one.

For the 1/500,000 series, which was a comparatively coarse map for air use only, the black pulls were found to be satisfactory.

It was intended that for the 1/250,000 and larger scales, the sheets should be of demy size. In most cases the demy sheets, as sent out from the War Office in the form of kodalines, were arranged in pairs on the film so as to enable printing to be done directly on double-demy machines. This was a good arrangement, allowing full and direct use of the machines available in the Middle East.

In spite of the difficult climatic conditions prevailing, it was found that, over a long period, the small (demy) machines belonging to the field survey companies could turn out 500,000 impressions a month, and the larger (double-demy) machines could reach an output of 700,000 impressions. At peak periods as many as 30,000 impressions a machine each day were obtained.

When planning for "Husky" first started it was comparatively easy to introduce some form of mapping "cover" as a security measure, as at that time Middle East was engaged on the mapping of areas such as Greece, Crete and elsewhere. Later on, however, it became more difficult. There were delays due to the late arrival of mapping material from London, the need for local revision of the maps from air photos which came in much too late, and the shortage of labour and printing paper. During the last few weeks before "D"-day the survey "cover plan" practically ceased to operate, as all available men and machines had to be concentrated on the Sicily maps to the exclusion of all other work. This was probably unavoidable and no doubt occurred in other theatres during urgent last-minute spasms before a specific operation, but it does not affect the general principle that, wherever possible, security must be guarded to the utmost extent by having concurrent work in progress for other areas. And yet, so far as is known, there were no lapses of security on the part of the survey personnel employed on this mapping work.

At the last moment there was an urgent demand for the printing of chart maps for the Royal Navy. These were to have been supplied originally in bulk by the Admiralty. Owing to a hitch in the supply channels, however, they were despatched to the Middle East too late, but fortunately the Director of Survey at the War Office had foreseen the emergency and had sent out by air the necessary reproduction material which enabled stocks of the chart maps to be printed locally and supplied to the Navy in time for the operation.

Early planning indicated that there would be a requirement for a series of defence overprint maps on 1/25,000 scale all round the coast from Catania to Licata. The standard 1/25,000 sheets were of demy size and, as there were approximately 60 of them, for which 18,000 copies of each were required, this represented a formidable printing project. They were therefore made up into 18 double-demy sheets, thus effecting a considerable saving in printing time. Three planning editions of these defence overprints were published between 1st May and 4th June, and the fourth (final) edition for the operation itself was issued on about 1st July. This latter edition gave the latest possible information about enemy defences in Sicily.

There were some interesting and useful lessons to be learnt from the arrangements made for the production of these overprints. The "defences" information was compiled in the form of two traces by officers of the Middle East Interpretation Unit (M.E.I.U.), who examined the air photographs of the area and interpreted the detail. One of these traces showed topographical information which was not already indicated on the base map itself, and included such general annotations as "Vineyards," "Olive Groves," etc. The other showed details of the enemy defences. These two traces for each map sheet were prepared by different officers, who were often not in contact with each other. The result was that, when they were superimposed for printing, the detail on one fouled that on the other. Another defective arrangement was the fact that the basic maps supplied to the interpretation officers, from which they made their overprint traces, were of slightly different size from the final printed copies. This caused much wasted time due to faulty register, and could have been avoided by more careful survey supervision of the job as a whole. It is essential that, if they do not do the work themselves, Survey should issue clear technical instructions to units such as M.E.I.U., or other similar interpretation organization, who may be undertaking the preparation of defence or similar overprints for which Survey will be responsible for subsequent printing.

The overprint information was printed in two colours, except in the case of the final edition where three colours were used. The arrangement was:—

- (a) *Green*, for the topographical overprint which consisted mainly of topographical annotations such as "Vineyards," etc.
- (b) *Dark blue*, for enemy defences.
- (c) *Black*, for last-minute additions to either of the above.

It seems probable that most of the green notes were superfluous. Those that were considered to be of vital importance could probably just as well have been included in the "blue" overprint. The last-minute additions might also have been included in the "blue" printing, and this would have been less confusing to the user. The saving in colours would have cut down the printing time by a considerable amount.

Special maps, showing such things as airfields, water resources, "going" conditions, etc., were asked for in considerable numbers and variety. These demands came in late and had to be cut a great deal as practically all the survey printing resources were required for the defence overprints.

During the initial preparation of the mapping material, the War Office had carried out a certain amount of revision, but this could only be made up to 1st April, 1943, in view of the fact that the reproduction material had to be distributed over a wide area to the overseas survey organizations sufficiently far in advance for them to reproduce and print the maps. By that date there was

only a limited quantity of air-photo cover available, so the amount of revision possible by the War Office was somewhat scanty. Subsequent to 1st April some further air-photo cover became available to A.F.H.Q. and Middle East, and revision was put in hand locally in both places.

The survey photo supply situation for the revision of the maps for "Husky" afforded many useful lessons. With a force the size of that employed on this operation, the map printing programme was extensive and took a long time to complete. When preparing for a big operation it is desirable that, at the earliest possible stage, a decision shall be reached by the planning staff of the areas over which new mapping from air photos or revision will be required, and arrangements made, and implemented, for survey photography to be undertaken without delay. The photographs should be in the hands of Survey sufficiently far in advance of the date of the operation to enable the best use to be made of them. Where the mapping material is being initially provided by a central body such as the War Office, the ideal to aim at is that the photographs shall be in the hands of that central body early enough for them to incorporate the revision before they distribute the reproduction material. In the case of "Husky" much of the photography was undertaken too late for any useful work to be done.

The final phase (August, 1943–May, 1945)

After the invasion of Sicily until the end of the war in Europe, mapping activities in the Middle East were concerned principally with the following:—

- (a) Map production and printing on an agency basis for A.F.H.Q.
- (b) Continuing the mapping programmes for Turkey, Palestine, Syria, the Lebanon, and Trans-Jordan.
- (c) Map preparation for all other possible operational areas within the theatre, *e.g.*, the Greek Islands and the Dodecanese, Greece, Crete and the Balkans.
- (d) Local map production for training and defence purposes and for staff use.

Air revision work for A.F.H.Q. was held up during July owing to a breakdown in the arrangements for supply of air photographs, but the situation improved in August. The general principle at that date was that Middle East Survey prepared revision models conforming to a specification laid down by A.F.H.Q., the latter undertaking the actual production of the revised sheets. In September, however, it was decided to revert to a system whereby Middle East prepared the revised kodalines for all sheets on which important revision was necessary.

This large scale revision programme had to be drastically cut when, in preparation for operations in the Dodecanese, all available mapping resources were concentrated on this new operational area.

In November, 1943, the bulk printing programme of the 1/M and 1/250,000 maps of Italy was accelerated, and printing of all the 1/100,000 sheets of Greece was undertaken. By January, 1944, the Dodecanese operations being over, resources could again be concentrated on printing and air revision for A.F.H.Q., including the preparation of maps for possible use in the Balkans, south-eastern Europe generally, and Turkey.

It may be of interest here to quote the system on which the large scale

maps of Italy and southern France were classified for revision purposes by the Air Survey Group in Middle East:—

Class "A." Very important revision required.

This was used for sheets containing areas of unsound planimetry.

New control was supplied by the Air Survey Group.

Class "B." Normal revision required.

"Normal" implied that the planimetry was sound, but revision of military importance was needed.

Class "C." No revision required.

In this case photos showed only minor differences from the map.

An example from areas in northern Italy and southern France will show how this worked out in practice:—

	<i>No. of Sheets</i>	<i>Classification</i>		
		<i>A</i>	<i>B</i>	<i>C</i>
1/25,000 Italy (North)	44	—	17	27
1/25,000 France (South)	63	—	14	49

In March, 1944, when A.F.H.Q. was planning for the assault landing operation ("Anvil") in the south of France, they asked Middle East to assist in the printing of cushion stocks involving over 30,000,000 impressions. Middle East offered to print about 13,000,000 for them and, during this intensive programme, 512 Field Survey Company on one occasion exceeded half a million impressions in a 24-hour period. 512 Company and 17 Map Reproduction Section between them turned out over 11,000,000 impressions in 30 days' work.

The maps of France required by A.F.H.Q. included:—

1/25,000, based on the French 1/20,000 where they existed, otherwise new mapping from air photographs.

1/50,000, reproduced from the modern series at that scale which the French had published along their eastern frontier areas.

1/100,000 sheets which had been newly produced by the War Office and the Army Map Service (A.M.S.) Washington.

Maps of the Balkans

Before the shape of the final operations in Europe was clearly determined there was a possibility that Allied forces from the Mediterranean theatre might operate through the Balkans into Germany. For the purpose of this history, the Balkans will be taken to comprise Greece (including Crete and the islands of the Aegean), Albania, European Turkey, Bulgaria, Roumania, Yugoslavia and Hungary.

The mapping responsibilities of the Directors of Survey at A.F.H.Q. and the Middle East included between them, therefore, those areas of the above territories which it was considered might become potential operational zones. The Director of Survey at the War Office, with his comprehensive strategic mapping responsibilities, had undertaken with his resources in the United Kingdom the preparation and publication of certain Balkan series, A.F.H.Q. and Middle East supplementing these by local publications, and revising them. The War Office publication "Notes on Maps of the Balkans (July, 1944)" describes the G.S.G.S. series of that area which were available together with

some of those published by A.F.H.Q. and Middle East. Most of the map series so described were reproduced identically in the United Kingdom, at A.F.H.Q. and in the Middle East. This was made possible by the distribution by air of kodak films for each colour plate. Thus forces which might be despatched from widely separated bases could be identically mapped up.

All the principal British-produced maps of the Balkans at scales of 1/500,000 and larger carried the British Military Grid. There were certain provisional series which, being direct copies of foreign originals, were not so gridded. In selected areas the Admiralty Hydrographic Department produced charts carrying the British grid which were thus in sympathy with the army maps in that respect.

The Mediterranean and Balkan areas were covered by the following grid zones (see Diagram 2, page 112):—

- (a) *Mediterranean Zone*, covering Greece, most of Albania, the extreme south-east of Yugoslavia, Turkey, southern Bulgaria, the Greek Islands and the Dodecanese.
- (b) *Danube Zone*, covering eastern Yugoslavia, northern Bulgaria, Roumania, eastern Hungary, eastern Czechoslovakia, and the extreme northern tip of Albania.
- (c) *South Italy Zone*, covering southern Italy.
- (d) *North Italy Zone*, covering northern Italy, north-western Yugoslavia, and parts of southern Austria and western Hungary.
- (e) *Nord de Guerre*, covering the northern part of Austria and north-western Hungary.
- (f) *Crete*, covering only the island itself.

The principle of retaining local name-forms on maps was accepted for the preparation of all British- and American-produced maps. This had, amongst other advantages, the merit of affording consistent treatment as between maps redrawn *ab initio* and those reproduced by direct photographic methods from foreign originals. There are always, however, large numbers of foreign topographical terms, or abbreviations of them, on foreign maps, with which the average map user is not acquainted, and this was perhaps more in evidence in the Balkans than elsewhere in Europe on account of the diversity of languages. Many of the Balkan map series, therefore, carried brief marginal glossaries of the most commonly occurring abbreviations and topographical terms. Fuller glossaries were prepared for most of the Balkan countries by the Permanent Committee on Geographical Names (P.C.G.N.), assisted in some cases by the War Office.

For the principal Balkan countries gazetteers were prepared and published, mostly by the Survey Directorate in Middle East, one or two, however, being the work of the P.C.G.N. or the War Office. These gazetteers gave grid references except in the case of those of Greece and Albania in which the references were generally given in geographical co-ordinates.

One important requirement in the case of 1/250,000 maps, and those tactical maps on a larger scale which may be used for road movement purposes, is the classification of roads into width and surface categories. There is, unfortunately, no standard military datum by which to refer to these road qualities. A basic datum which applies to one zone of operations is probably not suitable for another, where the ground conditions and possibly the character of the operations themselves may be different. In any case the available data are often

entirely dependent on the information given on the local foreign maps themselves which makes it almost essential to adopt the same system or something very like it.

As a result the road classifications shown on the various map series of the Balkans varied from series to series. The details of these categories and the symbols by which they were shown were, of course, given in the marginal footnotes and conventional signs, and they were clearly illustrated in the "Notes on the Maps of the Balkans."

Most of the systems of width and surface classification were generalizations of, and were based on, local information and experience, and this inevitably resulted in some errors. For example, the system used for Hungary was based on a combination of intelligence reports, personal experience of individual roads, information from ground photographs, articles in technical journals, etc. All these data had to be collated into terms of the local system of classification appearing on the original maps of Hungary so that width and surface values could be allotted.

As a general principle, classifications given on military maps should wherever possible be checked by reconnaissance, and should never be regarded as more than a general guide. In the case of map series published by the War Office, most of the road classification systems were formulated by M.I. 10(c), the War Office Section concerned with such information. The Greek and Turkish systems were formulated by Military Intelligence (Topographic) in Middle East.

No attempt will be made to describe in detail all the series that were prepared or published to cover the Balkans. It will suffice to indicate in general terms some of the more important. They are grouped according to scale:—

(a) *Small Scale* 1/1,000,000.

- (i) GSGS 2758. Based on the International 1/M Series with standard sheet lines. This map was mainly for topographical "form at a glance" and for use as an air map. For this latter purpose it became standard practice during the latter part of the war to print the layer tints in shades of purple instead of the normal browns and greens, so that they would show up better under the special lighting conditions within the aircraft.
- (ii) MDR 1. This was a special 1/M series produced by the Survey Directorate in Middle East covering the Balkans with slightly different sheet lines from GSGS 2758. Towards the end of the war in Europe the GSGS series in its revised form was adopted for general use.
- (iii) GSGS 4257 (Russia). This was reproduced from a fairly modern Russian map and was layered similar to GSGS 2758. It overlapped the latter over Roumania and Hungary. This was a War Office series and was not published in Middle East, though small stocks were available both at A.F.H.Q. and in Cairo for wall map and other study purposes.

(b) 1/500,000.

- (i) Europe (Air) GSGS 4072. This was the standard "Air" series designed specifically for navigational use. It covered nearly the whole of Europe, and was the only homogeneous series which embraced the whole of the Balkans. The detail being very generalized, limited its scope for military use.

- (ii) MDR 580. This was not published as a War Office series and was a local Middle East production made up by direct reproduction from the original drawings for the 1/M series (MDR 1) referred to above. It was replaced by the standard series GSGS 4072 for all sheets except a very few covering Turkey in Asia.
- (c) 1/250,000.

Except for Turkey, for which a 1/200,000 series was used, there were five principal series covering the Balkans at the 1/250,000 scale. All these were designed to join up with each other so as to provide continuous map coverage of the whole area suitable for strategical use and as road maps. Moreover the four series covering Greece, Bulgaria, Roumania and Yugoslavia were finally produced in identical style which showed topographical information as under:—

Black. Towns, place names, railways, and grid.

Red. Roads.

Blue. Rivers and river names.

Green. Woods.

Brown. Contours.

The shape and size of the sheets were such that the sheet lines were closely related to those of the larger scale basic map material of each country, a fact of obvious value and convenience.

These 1/250,000 Balkan series extended northwards to the 47° N. parallel where, like the 1/100,000 series, they joined up with the standard series on both those scales covering Central Europe which were in use by the Allied Expeditionary Force engaged on operation "Overlord."

They were all published in Army/Air style with purple layers, accentuated railways, and strong water colouring. From the military point of view, the maximum amount of detail consistent with clarity at this small scale was shown on the maps. Names were transliterated in the case of Greece, Bulgaria and southern Yugoslavia. All were gridded with the British Military Grid.

Except in the case of Greece, few air photographs were available for checking or revising topographical detail during the initial stages of preparation from the foreign maps. It was therefore to be expected that when such photos did become available, a thorough inspection would reveal considerable alterations to roads, railways and woods.

The individual 1/250,000 series and a few features regarding their preparation are now given.

Greece. MDR 630/GSGS 4410.

Part of Greece was originally covered by a War Office series (GSGS 4088) which was issued for the Greek operations in 1941 (see Chapter XII, Section 3) and was found unsatisfactory. This new series, except for the War Office sheets of Crete, was produced in the Middle East, and was compiled from the latest available Greek 1/100,000 maps and various large scale maps of the Dodecanese and Aegean Islands, Italian maps of southern Albania, and the Yugoslav 1/100,000 series. It was subsequently republished by Middle East after revision from air photos and other information.

Bulgaria. MDR 633/GSGS 4412.

Compiled and published by the War Office, principally from Bulgarian 1/40,000 and 1/126,000 material.

Roumania. MDR 635/GSGS 4375.

Compiled and published by the War Office from the Roumanian 1/100,000 maps, Bulgarian maps, and the Yugoslav 1/100,000 series.

Yugoslavia. MDR 634/GSGS 4413.

Compiled and published by the War Office using Yugoslav 1/100,000 maps as basic material. In the north this series covered Hungary, for which part Hungarian 1/200,000 and 1/75,000 originals were used.

Italy. MDR 300/GSGS 4230.

Though Italy was not included in the Balkans area, a part of this series covered the north-western tip of Yugoslavia. Middle East did a lot of work in connection with the revision and reproduction of this series.

Hungary. The southern half was covered by the Yugoslav series (see above). The northern half lay within GSGS 4346, the Central Europe series published by the War Office (see below).

Central Europe. GSGS 4346.

This series was prepared for operations in Europe in connection with operation "Overlord." For that part which included northern Hungary and northern Roumania it was produced by colour separation from the relevant Hungarian and Roumanian 1/200,000 originals and was not redrawn.

(d) 1/200,000.

The principal map on the 1/200,000 scale in the Balkan area was that of Turkey, viz. MDR 3/GSGS 4193. This was originally published by Middle East direct from Turkish originals on the same scale.

The War Office produced a two sheet map on this scale covering the whole of Albania.

(e) 1/100,000.

The entire mainland area of the Balkans, as far north as Lat. 47°, was planned to be covered by four principal 1/100,000 series, viz. the Greek, Yugoslav, Bulgarian and Roumanian. To the north of Lat. 47°, Hungary and Roumania were included in the Central European 1/100,000 series. The War Office policy was first of all to reproduce by colour separation method from record copies of the foreign series without alteration, in order to provide provisional map cover, and then to follow up with a revision of those areas specifically required. There were no Bulgarian 1/100,000 original maps available as basic originals.

Crete and the Aegean Islands were not included in this 1/100,000 project.

The principal 1/100,000 series were as under:—

Greece. MDR 356 & 610/GSGS 4439.

MDR 356 was first produced by Middle East by direct reproduction from Greek maps, the only alteration being that the place names were transliterated. A newly drawn series (MDR 610) with detail revised from air photos was then produced by Middle East on

the same sheet lines. These two series replaced the original War Office publication (GSGS 4087) of northern Greece which had been issued in 1940-41.

Bulgaria. 1/126,000. MDR 650.

Though not at 1/100,000 scale, this map is included within this category as it was produced by Middle East as a "stop gap" until something better could be prepared. It was a one-colour direct copy of the Bulgarian sheets and was ungridded.

Bulgaria. MDR 654/GSGS 4444.

This was in production at the War Office and was a newly compiled redrawn map based on Bulgarian 1/40,000 and 1/126,000 material where such was available. A certain amount of intelligence information was incorporated as revision, but only a few sheets were actually published.

Roumania. MDR 627/GSGS 4417.

Middle East originally published a monochrome edition by reproduction from the Roumanian 1/100,000 maps. The War Office then took up direct colour separation reproduction from the Roumanian sheets. They carried no revision.

Yugoslavia. MDR 621/GSGS 4396.

A monochrome reproduction (MDR 604) of the Yugoslav 1/100,000 series was completed by Middle East during the winter of 1942-43. The War Office meanwhile undertook colour separation and the distribution of reproduction material for full colour printing. Responsibility for maintenance of the series was delegated to Middle East. The latter subsequently carried out revision and improvement work for A.F.H.Q.

Hungary.

This was partly covered by the Yugoslav, and partly by the Central Europe 1/100,000 series.

Central Europe. GSGS 4416/AMS.M 671.

The southern portion of this series covered the northern parts of Hungary and Roumania, and for those areas was based on Hungarian 1/75,000 and Roumanian 1/100,000 material. It was a newly drawn map compiled by A.M.S., Washington.

Rhodes. MDR 341/GSGS 4161.

Scarpanto. MDR 341/GSGS 4168.

These two sheets were compiled in Middle East using as a basis the 1/25,000 sheets covering the islands. They were brought up to date from air photos.

European Turkey. MDR 626/GSGS 4467.

These sheets were produced as an extension of the Greek 1/100,000 series referred to above. The basic material was the old Russian-Bulgarian 1/126,000 map, supplemented by 1/25,000 maps for the Dardanelles and Istanbul.

Italy. 1/100,000 MDR 540/GSGS 4164.

As in the case of the Italy 1/250,000 series, the only reason for including this in the Balkan area is because it covered the extreme north-western tip of Yugoslavia.

(f) 1/50,000 and larger scales.

As described above, the Balkan area was primarily covered by a uniform homogeneous series, country by country, on the 1/250,000 scale, with a heterogeneous collection of 1/100,000 series for most of the area. Consideration will now be given of the principal topographical maps on larger scales, some of which were supplementary to the 1/100,000 series, and some to fill gaps where no 1/100,000 maps existed.

Crete 1/50,000. MDR 612/GSGS 4426.

This was originally produced by Middle East from Greek maps and covered all but the eastern end of the island. Names were transliterated but it carried no revision. Subsequently Middle East published a revised edition from air photos including new sheets for the eastern end of the island compiled from a German 1/100,000 sheet and air photographs.

Aegean Islands 1/50,000. MDR 611/GSGS 4468.

This series, which covered nearly all the Greek Islands of the Aegean, consisted of sheets newly compiled in Middle East from air photos where such were available. They were contoured, and carried a red road classification overprint. Where no photos were at first obtainable, local charts were used, the result being of doubtful accuracy. They were later replaced by maps systematically compiled from air photographs.

Albania 1/50,000. MDR 639/GSGS 4477.

This Middle East publication covering the whole country was initially a direct copy of the Italian 1/50,000 originals. A revised and gridded monochrome edition of certain sheets was subsequently published early in 1944 using air-photo cover which then became available.

Bulgaria 1/50,000. MDR 657/GSGS 4449.

This was a War Office production obtained by colour separation from the modern Bulgarian 1/50,000 series with names transliterated. Only a very few sheets reached publication stage. As a "stop gap," Middle East reproduced direct from the Bulgarian 1/40,000 series. It was an unreliable map, especially with regard to communications, but was better than the 1/126,000 series which Middle East had also reproduced as a "stop gap" issue.

Yugoslavia 1/50,000. MDR 638.

A few isolated sheets were prepared by Middle East by direct enlargement from the 1/100,000 sheets.

Istanbul 1/25,000. MDR 629/GSGS 4470.

A block of old Turkish 1/25,000 maps was reproduced by Middle East by colour separation, the names being transliterated.

Dardanelles 1/25,000. MDR 624.

Over 60 Turkish maps were copied by Middle East to cover this area, and revision was incorporated.

Yugoslavia 1/25,000 (Med. 1).

The sheets of this series, which cover the Dalmatian Islands between Split and Dubrovnik, were prepared by A.F.H.Q. They were newly drawn, and were based on Yugoslav 1/100,000 originals,

which were enlarged and extensively revised during the course of drawing.

(g) *Town Plans.*

As in all other operational theatres there was a big demand for town plans, which are of special value for administrative purposes after occupation. Many of these were produced for the Balkan area, some by the War Office and others by Middle East, from a variety of basic material. Some were direct facsimile copies of existing plans, some were redrawn from the best material available, others were new compilations from air photos. In addition to those which were actually printed and published, record copies of plans for many other towns were held so that they could quickly be reproduced if the necessity should arise.

(h) *Through-way Town Plans.*

These special volumes were prepared by the War Office. They were intended to assist drivers to find their way quickly and directly through a town, and showed only the principal roads, buildings and other topographical features that would assist to this end.

They covered only Yugoslavia, Albania and Hungary. For the former the plans were prepared mainly from Yugoslav 1/100,000 maps, with added information from air photos. For Hungary the plans were produced from a Hungarian through-route publication and, where photos were obtainable, they were brought up to date and revised.

(j) *Miscellaneous.*

Communications Maps.

Several special maps were published either by the War Office or Middle East to show road, rail, and water communications. They were principally on a small scale varying from 1/2M to 1/400,000.

As part of a general European series the War Office prepared a communications map on a scale of 1/800,000 showing, on a brown topographical base, roads in red, railways in black, and navigable waterways in strong blue. The changes could be rung on the colour plates so as to present the required information either singly or in any combination.

Air Maps.

The maps available for the air forces in the Balkan area were the same as those in other theatres:—

- (i) The standard army maps, or the army/air style, for the tactical air forces operating in conjunction with the ground forces. This comprised the 1/M Army/Air, the 1/250,000 series, and, in some cases, even larger scales such as the 1/100,000 or 1/50,000.
- (ii) Air maps proper, which included the Europe (Air) series at a scale of 1/500,000 (GSGS 4072) which covered nearly the whole of Europe; the Middle East 1/500,000 series, which was eventually superseded by GSGS 4072; and Europe (Air) 1/250,000 (GSGS 3982). This latter covered only small areas of Yugoslavia, Hungary and Albania; over the rest of the Balkans there was no special air map at 1/250,000 scale, and the standard army/air map was used.

Maps for special navigational use were published by the War Office for the Balkans as for other operational areas. These included

the 1/2M and 1/M Plotting Charts. There were also the Lattice Maps on which "lattice" curves were overprinted for use in connection with radar aids to navigation.

Finally there were "Target" maps, which were prepared in special design and colouring for night bombing use, usually on a scale of 1 inch to the mile.

- (iii) Geological Maps, which were obtained from copies of foreign geological maps held by the Geological Survey in London from which the War Office prepared facsimile reproduced copies for Albania, Roumania, Yugoslavia, Hungary, the Central Balkans and the Middle Danube. Geological maps are of great value during the planning stage for an operation, when considering such things as water supply and suitability of terrain for airfield construction.

SECTION 3. AIR SURVEY PHOTOGRAPHY

At the beginning of the Middle East campaign there was no provision for supplying air survey photographs but at a later stage, mainly as a result of the work of a squadron of the South African Air Force, and 1434 Flight R.A.F., large numbers of photographs were taken for and used by Survey for mapping, revision and other purposes. The R.A.F. were so preoccupied with their primary operational tasks for which they had insufficient resources, that they could do little about survey photography.

Much credit is due to the pilots of 60 Squadron S.A.A.F., 1434 Flight R.A.F., and other units who "delivered the goods" in spite of all handicaps, difficulties and hazards. Much of the photography was obtained by using aircraft of a type quite unsuitable for survey photography in operational areas against enemy opposition and which, owing to the small number available, could not be grounded sufficiently for proper maintenance.

The earlier that survey photography could be undertaken, before the enemy had built up his fighter opposition and anti-aircraft defences, the easier and quicker could it be obtained.

Experience in many theatres showed that this aspect of the problem was not fully appreciated in spite of constant representation by the General Staff and Directors of Survey. It is, of course, for the R.A.F. to say what type of aircraft is capable of carrying out operational photography for survey purposes, but it may be well to outline the general requirements for the Middle East:—

- (a) Aircraft whose performance would give a good prospect of survival in long straight flights over enemy territory.
- (b) Long serviceable endurance.
- (c) Minimum crew of two.
- (d) Cameras giving a large-size picture and having between-lens or louvre shutters.
- (e) Focal length of lens suitable to give a scale of about 1/30,000 at the selected flying height.
- (f) Vertical photography, with tilts not exceeding 2 degrees off the vertical.
- (g) Unbroken stereoscopic overlaps and no crabbing.

It was only during the final stages in the Middle East operations that really suitable aircraft were provided in the shape of two Mosquitoes. These were excellent for survey photography but two machines were insufficient.

During the period from March, 1940 to June, 1941, which included the first British offensive into Libya and subsequent retirement back to Egypt, there was no properly flown survey photography. Obliques taken with tilts up to 15 degrees off the vertical were taken by fighter aircraft and, after rectification, were used for revision and for making up gridded mosaics such as were used for the attack on Bardia. They were unsuitable for new map compilation. In Syria No. 2 Photo Reconnaissance Unit (P.R.U.), a bomber squadron based in Palestine, produced some photography over parts of Syria which was used for revision purposes.

The next period, from July, 1941 to December, 1941 included the completion of hostilities in Syria, the strengthening of British forces in the Middle East, and the build-up of German formations in Libya. In November, the second British offensive into Libya was launched, Benghazi being reoccupied at the end of December. During August, British and Indian forces had entered Persia.

Of chief importance during this phase was the arrival of No. 60 Squadron S.A.A.F. from East Africa in July, 1941. An R.A.F. Flight (No. 1434) was formed in conjunction with 60 Squadron and one aircraft and crew moved over to Palestine to photograph selected defence areas in Syria where large scale maps were needed. This was the first action taken in the Middle East to provide a unit whose principal task was air survey photography, and 60 Squadron S.A.A.F., together with 1434 Flight R.A.F. continued to give invaluable assistance to Survey during the rest of the campaign in spite of the limited and inadequate resources at their disposal. The South African units operated in Egypt and the Western Desert, and 1434 Flight alternated between Palestine, Syria, Iraq and Persia. There were periodical attempts, during the campaign, to take 60 Squadron off survey photographic tasks and switch it over to general reconnaissance duties.

Besides the survey photos provided by 60 Squadron, use was also made of verticals and obliques taken by Hurricanes on reconnaissance sorties. Large areas in Syria were thus dealt with, and in the absence of survey photographs, 1/50,000 sheets on the Cyrenaican frontier area were revised and amplified from rectified obliques.

Between July and October, 1434 Flight photographed over 8,000 square miles in Palestine, Syria, Trans-Jordan and Egypt. 60 Squadron was not ready for operations till the end of August and did not move out to the Western Desert until early October, the delay being due to unserviceable aircraft. Among its first tasks was the photography of 600 square miles in the Gialo area, and a 90-mile strip from Sidi Omar to Bir Hakeim. Enemy opposition was strong, the weather was bad, and the camera shutters started to freeze at over 25,000 ft. altitude. Block flying was not allowed as the aircraft had not a sufficiently good performance in the face of enemy opposition.

During November, 1941, 60 Squadron had an average of only two aircraft available for operational photography in the Western Desert, but it completed over 400 miles of strip flying, and covered 4,500 square miles in Libya. The Western Desert strips were plotted as strip maps or mosaics which were annotated for topographical and military detail. 1434 Flight, after completing its task along the Syrian-Turkish frontier during November, moved over to Mosul for work in Iraq. From the Syrian photos the South African Survey Company

plotted 1/25,000 and 1/50,000 maps of northern Syria, and they also produced a 1/50,000 sheet covering the Maan-Aqaba road in Palestine.

Weather during December, both in the Western Desert and Iraq, was bad, and only on about nine days was it possible for survey flying in the former area. No survey aircraft were available in Ninth Army area in Palestine during December.

While Eighth Army was at the extreme limit of its advance in the Agheila area a big programme of survey photography was required to provide new maps and improve the existing ones of that area. 60 Squadron had only one serviceable camera at the beginning of January, but this situation was remedied and over 8,000 square miles were photographed, after which photo coverage of the Agedabia district was started. Every effort was made to keep two aircraft in the air each day, and the work of the squadron during this period was exceptionally valuable. Meanwhile, during January and February, 1434 Flight continued its activities in Iraq and Persia and by the end of February had photographed a total of over 13,000 square miles. A further 1,600 square miles were covered during March.

In March, 1942, the weather in the Western Desert was very bad, with low cloud and dust storms; the aircraft were near the end of their serviceable life, and no replacements were available. On each of the rare fine days only one aircraft could be put in the air. However, about 30 sorties were flown during the month for use in connection with 1/250,000 mapping in the locality of Benghazi. Control was provided by astronomical observations and points fixed by car and compass traverses.

60 Squadron was refitted during April with reconditioned aircraft and engines, and became fully operational. A limited number of control strips were flown for 1/250,000 mapping in the Agheila and Agedabia areas where some parts of the desert were so featureless that plotting was very difficult. Work was also begun on some new 1/100,000 sheets from photos supplied by 60 Squadron and Photo Reconnaissance units. New F-8 cameras were supplied to the Survey Flights in May, and during the month 60 Squadron beat its previous record by covering 10,000 square miles.

July and August, 1942, were busy months. An area measuring about 140 by 30 miles was photographed south of Wadi Matruh and El Maghra to fill in a gap in the southern parts of the 1/250,000 sheets, Daba and Alexandria, and one flight moved to Beirut to photograph the coastal areas of Cyprus and the Levant. 1434 Flight moved to Tehran and began work in Persia, 3,000 square miles being photographed for the survey of defence positions in the mountain passes and the preparation of 1/25,000 maps.

In September, the aircraft situation with 60 Squadron again deteriorated and little work was possible, only one machine being serviceable. The Director of Survey represented to the Chief of Staff and to the Air Staff the serious situation arising from the shortage of machines, especially at such a critical time when preparations for the El Alamein offensive were reaching a climax. Survey was working at top pressure preparing maps of all sorts, enemy defence overprints, artillery block-plots, and the survey fixation of enemy battery positions. In this latter connection the positions of new targets after being located on daily reconnaissance photos, were transferred to survey photos, and their positions determined on the block plots. Owing to the lack of sufficient aircraft to do the survey part of the work well in advance, the survey photo cover had to be obtained during the last few difficult weeks in face of heavy enemy opposition.

It cannot be sufficiently stressed how great is the importance of obtaining good quality vertical air-photo cover of possible combat areas before the requirement becomes pressingly urgent, and while the enemy opposition is either non-existent or, at any rate, not intense. It enables counter-battery methods to be put into operation more or less at a moment's notice, and it has, besides, a wider application for topographical mapping, intelligence purposes, and camouflage projects.

The period from October, 1942 to May, 1943 included the El Alamein battle, the pursuit through Libya into Tunisia, and the final phase culminating in the expulsion of all enemy forces from Africa.

Though only one aircraft was available with 60 Squadron during the greater part of October, the situation improved at the end of the month when three Marylands and two short-range Baltimores were allocated. Progress was made in the photography of an area south of the Qattara Depression. 1434 Flight which, during July, August and early September, had covered 3,000 square miles in Persia, was handicapped during October by a serious shortage of suitable and serviceable aircraft. The weather deteriorated rapidly in Persia during October and November, and the Flight was ordered to return to Syria.

60 Squadron was given four new long-range Baltimores in November which added greatly to its operational value over the battle area. With the rapid advance of Eighth Army new programmes were undertaken further and further to the west and in January, 1943, two Mosquitoes became available and were allotted to the squadron, whose work was now recognized as being of such tactical importance to the progress of operations. The first task was to complete the photography of the Mareth defences for large scale map production, and the value of these high-performance aircraft for this class of work became very clear.

During the early part of 1943, photography was undertaken by 2 P.R.U. for the mapping of Rhodes and other islands in the Eastern Mediterranean. 1434 Flight returned to Ninth Army in Syria during January, and started on a big programme extending over 10,000 square miles. As it was equipped with old and almost worn out Blenheims, 1434 Flight could only be used for photography over non-operational areas.

In March, 1943, the Survey Flights were issued with Fairchild K-17 cameras, with 6-inch and 12-inch lenses similar to those being used in Europe for the photography of northern France. Pressure of work in Tunisia during March was very great and the two Mosquitoes could not keep pace with the demand. Amongst other items a block of over 1,000 square miles was photographed in the Gabes area.

April and May saw the closing stages of the operations in Africa. 60 Squadron covered the Pont du Fahs and Enfidaville areas and also the Bon peninsula, but progress was slow owing to bad weather and lack of sufficient aircraft.

From June, 1943, onwards 60 Squadron operated under A.F.H.Q. control in connection with the Sicily and Italian campaigns. 1434 Flight, which was unable to take on tasks outside non-operational areas owing to its unsuitable aircraft, was disbanded in June. Photo squadrons of the U.S. Army Air Force were now arriving in the Middle East, and they undertook various tasks including the photography of coastal areas and localities in the Persian Gulf, the results being used for the revision of the quarter-inch maps. There

was also photography over Greece, Crete, and other Mediterranean areas with K-17 6-inch cameras and this was used for Multiplex compilation of new maps on 1/50,000 and 1/100,000 scale. There was also a project for covering the northern parts of Palestine at 1/15,000 scale for the production of mosaics and enlargements at 1/5,000 of selected towns and villages.

The lessons to be learnt regarding air survey photography during the Middle East campaigns were, generally speaking, similar to those in other theatres. It is impossible to forecast what the survey conditions and requirements are likely to be for any future war, but it seems safe to predict that, whatever may be available in the way of mapping material for any operational theatre, there will always be a requirement for early and complete survey photography for revision purposes and for new map compilation. The dangers and difficulties which may result from a lack of sound policy on the subject and inadequate resources will be obvious from the above brief summary.

SECTION 4. TRIANGULATION AND FIELD SURVEYS

Early Investigations

In anticipation of possible operations in Egypt, Palestine and Syria the War Office had no cause to be unduly anxious regarding triangulation data. In the two former countries British military forces were already in occupation before the war started in accordance with treaty rights and mandate responsibilities respectively, and there was a close liaison with the local survey departments. France, being the mandatory Power for Syria, controlled the local survey organization, and held much in the way of records and data which would be placed at our disposal.

Little useful information was available before the war regarding Italian triangulation work in their African Colonies, and this lack of data was to remain unsatisfied until documents were captured during the first British advance into Libya in 1940.

Little knowledge was available with regard to survey data in Turkey until the Middle East Survey Directorate made contact with the Turkish Survey Department in 1940.

With regard to the Balkans, the geodetic information held by the Geographical Section General Staff at the War Office before the war was sketchy and incomplete. When, therefore, the B.E.F. was in France during 1939-40, advantage was taken of the fact that the G.H.Q. Survey Directorate was in close touch with the French Service Géographique de l'Armée (S.G.A.). Colonel Hotine, then serving with the G.H.Q. Directorate, visited Paris in December, 1939 and, after discussions with the French geodetic experts, and a study of the available records, he prepared a summary of the triangulation situation in the Balkans, and made certain recommendations regarding future policy in connection therewith.

Subsequently, early in 1940, when Colonel R. L. Brown had been appointed Director of Survey for the Middle East, he and Captain E. H. Thompson visited Paris for a more detailed consultation with the Service Géographique, and to draw up an agreement concerning the preparation and ultimate use of survey data for the Balkans and other areas in the Middle East in which the French had a special interest and for which they held important records.

Military factors affecting triangulation systems within a war theatre

An important principle of surveying is to avoid local discontinuities. This is achieved in any given area by the laying down of a "primary" triangulation of high precision, which should be adjusted within itself before the less precise "secondary" and lower class work is based on it. Unfortunately, this counsel of perfection is not always followed by national survey departments, and the resultant discordances are a source of much inconvenience.

In modern war the need for consistency in a survey framework is of considerable importance now that survey plays such an important role in connection with artillery action, radar chains, etc. An error of a few metres in the *absolute* position of a point is not of great importance, provided that other points in the vicinity have comparable errors. It is the *relative* accuracy of position between neighbouring points that matters. Positions of points provided by the Survey Service for artillery use should have a relative accuracy which will enable bearings to be calculated from them to within about two minutes of arc. Assuming that points will not be used which are closer together than about one kilometre, this requires a relative accuracy in position of about 0.5 metre.

In any well conducted modern national survey, it should not be difficult to achieve this standard but, in many areas over which operations were conducted during the war a confusion between old and new survey systems, faulty methods of adjustment, and errors of printing and typescript in the preparation of trig lists, produced relative errors of displacement which exceeded this allowable toleration.

Discrepancies are often found along the junctions between national triangulation systems in frontier areas. Each system is probably based on its own origin for absolute position, its own base measurement which affects the scale, and its own determined azimuth or bearing along the basic side or sides of the triangulation. Very often also the so-called "common points" between two systems are not strictly common. It sometimes happens that both countries select the same hill-top on one side or other of the frontier on which to establish a triangulation station and, for some reason or other, do not both use the same identical point. The two points may be some metres apart. In the trig data of the two countries these points, although they bear the same name, will carry values which are not sympathetic.

Operations frequently take place on or across an international frontier, and it is not wise to accept the independent triangulation values of adjacent countries in the hope that they will be sufficiently in agreement to enable them to be used without further ado. Relative discrepancies of as little as five to ten metres will cause large angular errors between points lying close together but belonging to different national surveys, and these points may fall within a battle area and be required for use by the artillery in connection with fire control and predicted shooting.

It was for this reason, therefore, that it was necessary to decide what action should be taken with regard to the numerous separate survey systems which existed in the Balkans, where Austrian survey influence had been strong. As a result of the discussions in Paris, it was agreed to reduce all the various primary triangulations to one homogeneous system which would be known as the Balkan Homogeneous System, and as, at that time, more triangulation data was possessed for Austria than for any of the Balkan countries, the new homogeneous system was to be based on, and adjusted to, the Austrian triangulation. The computations for this work were to be carried out by the

French Service Géographique. As will be seen subsequently, pressure of events early in 1941 at the time of the Greek crisis and the acquisition of much new Greek data made it undesirable and uneconomical to adjust the Greek triangulation to this proposed Balkan system and, as a consequence, most of the Balkan area was eventually assimilated to the Greek triangulation instead of into the old Austro-Hungarian network as had originally been proposed.

While considering the action that was initially proposed it may be well to summarize briefly the various national triangulations that were at that time known to be in existence in the Balkan area. The work that was undertaken will then be more clearly appreciated. Triangulation problems affecting the remainder of the Middle East Theatre will be dealt with in later paragraphs.

Triangulation systems in the Balkans

- (a) *Austria, Hungary.* The largest single self-consistent block of triangulation was that of the old Austro-Hungarian Empire. There were several points of this system in northern Yugoslavia, and a coastal chain ran down the Adriatic shore as far as the Greek border. It was originally intended to use this triangulation as the basic network to which all the others would be adjusted. As it had been computed on the Bessel spheroid, it was decided to adopt "Bessel" for all the Balkan computations.
- (b) *Yugoslavia.* The available data initially consisted of the adjusted angles and logarithmic sides of a meridian chain having common points with the Austrian system in the north and the Greek triangulation in the south.

In the north there was a difference in scale of one part in 20,000 in the lengths of common sides between Yugoslav and Austrian systems. About 50 miles to the south of this junction, however, there was a Yugoslav measured base, and the length of the primary side computed from this base was held fixed, and the scale difference was smoothed out by a rigorous adjustment between that fixed side and the connection with the Austro-Hungarian system.

Using the Austrian geographical values as starting elements, the co-ordinates of all points in the Yugoslav chain were computed on the Bessel spheroid and, as the original Yugoslav computations had been on the Hayford spheroid, the adjusted angles of the chain had to be modified by the small differences in spheroidal excess between the Hayford and Bessel figures.

- (c) *Greece.* The national triangulation of Greece had been computed on the Bessel spheroid, and was based for origin on a geodetic pillar near the Athens observatory. The published Greek values for latitude and longitude had been based on a value for the Athens origin of:—

Lat. 37° 58' 20.10"
Long. 00° 00' 00.00"

The above latitude value was the result of a determination made in 1889 and, though a more recent astronomical determination in 1927 gave a new value of 37° 58' 18.68", this latter had not been used in any computations affecting either the triangulation or mapping of the country.

In 1927 also, a provisional longitude of the Athens Pillar referred to above had been published. This gave a value of 23° 42' 58.5" (E.)

from Greenwich, and it was adopted, by British and French agreement, as the fundamental longitude of the new proposed Balkan system.

The Greek triangulation itself dated from four periods, the first dating back to 1889, and the fourth being work carried out subsequent to 1930, which included the connection with the Bulgarian system and a few triangles in the Aegean and Ionian archipelagos. Amongst the Greek work was an arc of meridian which extended the Yugoslav meridian chain southwards to Crete.

At the time when the computations were being done for the Yugoslav meridian chain referred to above, the modern observed angles of the Greek chain were not available. The Adriatic triangulation in Greece connecting Athens with the Austrian coastal chain did not appear to be of first quality, and it was therefore decided to fix the position of Athens in the Austrian system by the method described below.

A point on the Adriatic coast (Pandokrator) was known to be common with the Austrian coastal chain, and another point (Kaimak Calan) was known to be common with the Yugoslav chain. Together with the Athens Pillar these points formed a well-conditioned triangle whose angles could be computed from the published Greek geographical co-ordinates. The azimuth and length of the side Pandokrator-Kaimak Calan were obtained from the Austrian co-ordinates, and from these values the following co-ordinates were calculated for the Athens Pillar:—

Lat. $37^{\circ} 58' 20.441''$
Long. $41^{\circ} 23' 11.290''$ E. of Ferro.

As stated previously it had been agreed that the value $23^{\circ} 42' 58.5''$ (E. of Greenwich) would be adopted for the longitude of the Athens Pillar and that all longitudes would be modified by an amount necessary to give Athens that value. The difference of $17^{\circ} 40' 12.790''$ was therefore subtracted from all Austrian values to convert from Ferro to Greenwich.

It will also be remembered that a recent astronomical determination for the latitude of the Athens Pillar gave a value of $37^{\circ} 58' 18.68''$. The difference between this and the value deduced from the Austrian system *viz.* $1.761''$ represented a linear displacement of 56 metres. It had been agreed that, should this difference be less than 50 metres, the Austrian value would be accepted for Athens but that, should it be greater, the new astronomical value would be adopted and the Austrian values adjusted accordingly. As the difference did exceed the stipulated 50 metres the latter course was followed. Correction graphs were then prepared by which the Greek-published geographical co-ordinates could be transformed to the homogeneous Balkan system. The scale of the graphs was selected so that the distance between two lines representing $0.1''$ difference in latitude or longitude amounted to about two centimetres on paper. When interpolating, therefore, an interval of approximately 2 mm. was equivalent to the selected limit of $0.01''$. The transformation of longitudes consisted first in adding $23^{\circ} 42' 58.5''$ (the accepted longitude of the Athens Pillar referred to Greenwich) to the published longitudes measured from Athens and then adding a small correction from the graph.

- (d) *Bulgaria.* The Service Géographique in Paris had amongst their records some annual reports on Bulgarian surveys for a few isolated years between 1922 and 1930. These contained actual angular measures executed during the year. The triangulation was a new one, apparently well observed and marked, but the records were incomplete, several years being missing. No geographical co-ordinates were given in these reports. It was learnt, however, that the Bessel spheroid was to have been used for the computations.

In the absence of full data at that early period to enable a connection to be made between Greece and Bulgaria the triangulation of the latter was computed separately as an isolated system. Later, when the necessary data became available, the Bulgarian points were adjusted to the values of the Greek common points in the homogeneous system.

- (e) *Turkey.* As a result of information supplied by the Turkish Survey Department to the Survey Directorate in Middle East in April, 1940, the available knowledge about the Turkish triangulation system was increased, but little useful data were obtained other than the geographical and rectangular co-ordinates and the measured angles of a chain of triangulation in Thrace common with Greece and Bulgaria.

Turkey had computed its triangulation on the Hayford spheroid, and had referred positions of points to an origin at Kandilli, near their observatory, whose value was:—

Lat. $41^{\circ} 03' 48.899''$

Long. $29^{\circ} 03' 55.200''$

The projection system used in Turkey was the Gauss-Kruger, indicative of German influence during the First World War.

An investigation was made by the Survey Directorate into the triangulation chain which had been observed by Greek and Turkish observers along their common frontier. The quality of the work appeared to be sound, and the maximum triangular misclosure in the chain was about two seconds. Taking the Turkish values for the co-ordinates of points lying in Turkey based on Kandilli as origin, and the Greek values for points lying in Greece based on the Athens Pillar as origin, the discordance between the two triangulations was determined. There was a considerable scale difference between the two, amounting to about one part in 3,700, the Turkish being the smaller.

In order to allow Turkish maps to be gridded, a provisional value was worked out for the co-ordinates of St. Sophia on the Balkan system. In the absence of triangulation data for Turkey, the formulae obtained from the investigation referred to in the previous paragraph were used, and by extrapolation a fair estimate was reached as to what difference there was between the Turkish and Greek values of St. Sophia. By subtracting these differences from the Turkish values the co-ordinates of St. Sophia on the Greek system were deduced and, by using the correction graphs, a further correction was obtained for transforming these values to the Balkan system.

- (f) *Roumania.* The only special publication concerning the Roumanian triangulation at the Service Géographique in Paris was an article of

general interest which indicated that there were probably three current systems, and that the whole country was not yet covered.

Grid Zones in the Balkans (See Diagram 2)

In any operational theatre it is obvious that the less often the projection and grid change the better. Taking as an axiom that an orthomorphic projection is the most generally suitable for military purposes, where direction and scale over limited areas are required to be as correct as possible, the actual choice of projection will depend largely on the general shape of the area. The Balkan area was as broad as it was long and the Lambert projection, being about the simplest of the orthomorphic family, appeared to be the obvious choice. The Service Géographique were considering an extension of the French Lambert II and III belts across to the Balkans on their existing parallels, and adding a similar Lambert IV belt to the south. One of their main reasons for suggesting this was because there were already in existence projection tables for Lambert II and III. As stated above, however, the Bessel spheroid was the obvious selection for the Balkans, and the French Lambert tables were based on the Clarke 1880 spheroid. In addition the French projection belts were narrow ones and, when starting with a clean slate, it would obviously be better to adopt wider belts which would give less grid changes within the battle area.

It was finally decided to cover the area with two Lambert grid zones, the Danube Zone in the north, and the Mediterranean Zone in the south, the junction between the two passing through the northern tip of Albania, south-eastern Yugoslavia, the middle of Bulgaria and the Black Sea.

The Danube Zone effected a junction on the west with the northern Italy and Nord de Guerre Zones, on the north with the various Russian belts, and on the east with the Caspian and Caucasian Zones.

The Mediterranean Zone had a junction on the west with the southern Italy Zone, on the south with the Libya Zone, and the Egyptian Purple and Red Belts, and on the east and south-east with the Caucasus and Levant Zones and the isolated Cyprus grid. The isolated Crete grid lay within the southern extremity of the Mediterranean Zone.

The final arrangement of triangulation in the Balkans

- (a) *The Greek System.* The original intention, as has been stated previously, was to compute all triangulation data on one homogeneous Balkan system based on the Austro-Hungarian triangulation. Until about November, 1940, there were more data available for Austria and Hungary than for any of the Balkan countries but, after the entry of Greece into the war against Italy, a very large amount of new Greek trig data were made available to G.H.Q. Middle East by the Greek General Staff and Survey Department, who proved most co-operative. These new data comprised values for all the Greek minor triangulation numbering some thousands of points, all of which were in sympathy with the Greek large scale maps which were also made available for the first time. The task of preparing trig lists, including the translation of descriptions of points into English, was a formidable one in itself and if the extra task of converting all these new points to the Balkan Homogeneous System had been attempted, it was clear that it could not have



been finished within a reasonable time. D. Survey, Middle East therefore decided to make a change of policy, accept the Greek system as the basic network, and to base on it all the other Balkan triangulations which, at that time, were of less importance.

This new homogeneous system had as its neighbours:—

- (i) The Italian geodetic triangulation.
- (ii) The French system, which was based on the old French triangulation.

(b) *Adjustment between triangulation datums.*

In each of the Greek, Italian and French Zones, all the triangulation work within each zone was adjusted to its own zone datum. From an investigation into discrepancies between the geographical co-ordinates of common points, a table of differences was obtained for use in the adjustment between triangulation data as under:—

	<i>Lat.</i>	<i>Long.</i>
Greek minus Italian	+ 1·549"	— 10·863"
Greek minus French	— 1·262"	— 18·921"
Italian minus French	— 2·811"	— 8·058"

(c) *Trig lists.* These were compiled by the Survey Directorate, Middle East, wherever possible based on sheets of the 1/100,000 series.

Where grid systems met, an overlap of at least 30' was provided, and trig lists gave co-ordinates on each of the adjoining grids.

Where triangulation datum areas joined, an overlap of at least 30' was provided and trig lists gave co-ordinates on each of the adjoining datums.

(d) *Adjustment and computation.*

Having decided to use the Greek system as the basic network, the triangulations lying to the north of it had to be adjusted to the Greek datum.

As time was limited, and in order to avoid the complication of readjusting the northern triangulations into terms of the Greek orientation, they were assimilated to the Greek datum by applying a constant correction derived from a comparison of values at three common points in the area of Boscop. These triangulations were then used as the basic network in the Balkans, and all other systems were brought into sympathy with it.

(e) *Use of contour graphs for triangulation adjustment.*

The adjustments, which were made graphically by means of correction graphs, dealt with:—

- (i) Change of spheroid.
- (ii) Scale differences.
- (iii) Errors in orientation and position due to the effect of deflection of the vertical at the point of origin of the survey.

Graphs were of two kinds:—

- (i) Those which gave corrections to rectangular co-ordinates.
- (ii) Those which gave corrections to geographical co-ordinates.

Although both types of graphs were used in the adjustment of the Balkans systems, it was generally considered preferable to adjust in terms of geographicals.

When triangulations were homogeneous, then a regular conformal correction graph could be drawn, based on differences at common points.

It was often found difficult to identify points which were, in fact, identical to two surveys, particularly when there were large differences in scale and orientation. Also when surveys had been made at different times, the old station mark had often disappeared and a new one established, possibly a metre or two away.

Trig data were sometimes received in the form of a list of geographical co-ordinates without any explanatory notes as to its origin. It was necessary to ensure that the values were homogeneous, and that the lists had not been compiled from different sets of original records which were not in sympathy with each other. This occurred in the case of the data received for the Serbian first order triangulation. It was found, fortunately, that discontinuities of this nature became obvious when the graphs were being drawn.

The Western Desert and Cyrenaica

The attitude of Italy as an Axis partner indicated that the Western Desert of Egypt and Cyrenaica were likely to become operational areas. When, therefore, G.H.Q. Middle East was formed early in 1940, these areas were treated with priority urgency with regard to mapping and triangulation data.

For the Western Desert the results of triangulation work carried out by the Survey of Egypt were available. For Cyrenaica there was very little known, before the first British offensive in December, 1940, regarding any Italian survey work which might have been completed.

For military purposes the triangulation and maps of Egypt, the Western Desert, and Cyrenaica were referred to three different grids, the Red and Purple Grids in Egypt, and one covering the whole of Libya known as the Libya Grid. (See Diagram 2.)

The Egyptian grids were based on the Transverse Mercator projection using the Helmert spheroid. The Red Belt extended eastwards from Long. 29° (about 50 miles west of Alexandria) to the middle of the Sinai peninsula where it met the Palestine Transverse Mercator Grid. The Purple Belt extended westwards from Long. 29° to its junction with the Libya Grid, about 100 miles west of the frontier between Egypt and Cyrenaica.

The Libya Grid was based on the Lambert Conical Orthomorphic projection, using the Clarke 1880 spheroid. It extended westwards to its junction with the North West Africa Grid at Long. 11° E. in the neighbourhood of the Tunisian frontier.

The Western Desert was considered as being that part of Egypt which lay between the cultivated area of the Nile Delta and the frontier at Sollum. As part of the Egyptian triangulation network there was a geodetic chain which extended along the coast from the Libyan frontier in the west as far as El Alamein, and then south-east to Cairo and along the Nile Valley. There was another chain running eastwards from Cairo to Suez. A second-order triangulation, adjusted to the geodetic chain, covered the whole of the cultivated area, and a third- and fourth-order triangulation had been completed and adjusted to the second order network. The Egyptian Survey Department maintained these triangulations up to date, and replaced any trig stations that might be destroyed or damaged.

The whole of the Western Desert area, from the coast as far south as about Lat. $28^{\circ} 31'$ was covered by a network of "desert points" which were controlled, on the north side only, by the geodetic and second-order triangulations. As a consequence the work had to be adjusted at various points to observed azimuths and chained base lines. Most of the sides of this desert network were short, about 10 kilometres in length, and although it could not be considered to be of first-class quality, it was adequate for mapping purposes and artillery use.

The geodetic and second order triangulations had been computed and adjusted using geographical co-ordinates on the Helmert spheroid, and their rectangular co-ordinates were obtained by second difference interpolation from the co-ordinates of a graticule which was computed for every $2' 24''$ in latitude and $3'$ in longitude.

The third- and fourth-order triangulations were computed on the plane and adjusted to fit the rectangular co-ordinates of the higher order points.

The co-ordinates of all trig stations in the Western Desert were compiled in trig lists conforming to the sheet lines of the Survey of Egypt 1/100,000 map series.

Descriptions of stations and trig diagrams were not available, but nearly all the points had been plotted on the 1/100,000 maps, which made their identification possible. As a rule, the geodetic stations were marked by an iron cylinder filled with concrete, and the desert points by iron posts covered by stone cairns.

As previously stated very little, if any, triangulation data were available for Cyrenaica before the war. It was, however, noticed that the incidence of topographical detail on Italian 1/100,000 maps in the neighbourhood of Sollum was not in sympathy with that on the corresponding Egyptian maps. For the purpose of gridding these maps it was essential, therefore, to determine a provisional correction to the printed Italian graticule in order to avoid an undesirable "cassure" in the frontier area. Unfortunately a firm triangulation connection had never been made before the war between the Egyptian and Italian triangulations in the frontier area.

While the Mobile Echelon of 512 (Army) Field Survey Company R.E. was working in the frontier area during 1940, opportunity was taken to carry out intersection observations on to the Italian Fort Capuzzo by forward rays from Egyptian triangulation stations. The Fort could be identified on air photographs and on the relevant sheet of an Italian 1/50,000 map of the area. The geographical co-ordinates were scaled from the map, converted to Egyptian Purple Grid co-ordinates, and compared with the values obtained from the field observations. The resulting difference in rectangular co-ordinates was then converted to a difference in latitude and longitude which gave a provisional correction to be applied to the Italian geographicals to bring them into line with the Egyptian system. This correction was:—

For latitude — $7.7''$.

For longitude — $13.6''$.

As a check only, a comparison was made between numerous points of detail which were common to the Egyptian and Italian maps, and these agreed so closely with the result obtained from the Fort Capuzzo observations that the latter was accepted as giving the provisional correction to be adopted. The Italian maps were therefore gridded, first of all by amending the Italian graticule by the above correction, and then converting the amended values to Purple Grid co-ordinates.

During the early days of the British offensive, Italian lists giving geographical co-ordinates of numerous triangulation stations were captured and these were hurriedly transformed to the Libya grid. The corresponding rectangular co-ordinates were derived by means of tables based on the Clarke 1880 spheroid, without any consideration being given to a possible difference in spheroid between that used for the British Libya grid tables (Clarke 1880) and the spheroid which might have formed the basis of computation of the Italian geographicals. The Italian spheroid of reference was, at that time, not definitely known, but several computations of "point to point" working on the Bessel figure had agreed very closely with the geographical co-ordinates, and it seemed safe to presume that the Bessel figure had been used. This was subsequently confirmed by a later captured document.

This mix-up of spheroids when transforming co-ordinates, resulted in a distortion of the triangulation and a considerable departure from the orthomorphism of the projection, not sufficiently great to be of much consequence for artillery use, but appreciable enough to affect any large extension which might be made from the existing network.

At a later stage in the offensive further lists giving geographical values were captured, and it was noticed that they were not in sympathy with the Italian co-ordinates from which previous lists had been prepared. It seemed evident that there were two distinct triangulation systems in Libya, and these were thereafter known as the Eastern and Western systems respectively. There appeared to be one common point only between these two. Examination of the 1/100,000 sheets showed also that the Italian 1/100,000 map series was not a homogeneous one, but was based on two independent triangulations which were not in sympathy. It was also apparent that the Italian 1/50,000 series covering the area from Derna to Benghazi was based on an early triangulation dating back to 1920, whereas the 1/100,000 maps of the same area were based on a more recent survey, and the geographical positions of map detail did not agree between the two series. Unfortunately these facts were not known when the maps had been first gridded by the Survey Directorate.

This confusion of basic control data made it impossible to correct the geographical co-ordinates in such a way that:—

- (a) the points would plot correctly on the Italian 1/50,000 and 1/100,000 Western sheets both from geographical and rectangular co-ordinates, and
- (b) the co-ordinates of the common point would agree in both systems.

In order to preserve the correct plotting of the points, it was thought best to keep the two systems independent. The procedure outlined below was therefore adopted.

The geographical co-ordinates of all points in the Western system were corrected first of all by an amount which the Italians had themselves applied to allow for the shift of graticule. A further correction was then applied to bring the points into sympathy with the Survey of Egypt.

This correction to the Western system values was:—

Latitudes.

Italian correction	+ 8.31"
Correction to bring into sympathy with Egypt	— 7.70"
	<hr/>
Total	+ 0.61"
	<hr/>

Longitudes.

Italian correction	+ 1' 12.45"
Correction to bring into sympathy with Egypt	- 0' 13.60"
	<hr/>
Total	+ 0' 58.85"
	<hr/>

The alternative procedure of correcting the Western system to agree with the Eastern was considered to be risky, since there was only the one known common point, and even if the values of this point were good, nothing was known about differences of scale and azimuth. The two systems were therefore kept separate and when field parties wanted to base new work on trig list values, they had to be very careful to use starting elements which were taken from either one system or the other, but never from a mixture of both.

When the Allied advance reached Benghazi, the Mobile Echelon of 512 Field Survey Company was able to carry out field observations in order to tie the Eastern and Western systems rigidly together. The adjustment was then effected by means of a contour correction graph, similar to those used for the Balkan adjustments and elsewhere. New trig lists were compiled for the newly adjusted co-ordinates. The result of this alteration of co-ordinates was that the existing gridded maps were no longer in sympathy with the new trig lists, and they therefore had to be redrawn and regrided. Attention has already been drawn to the break in continuity between the Egyptian and Italian triangulation systems at the frontier near Sollum, and to the provisional correction which was applied so as to bring the Italian Eastern system into closer agreement with the Egyptian network. This correction, it will be remembered, was obtained by scaling from a map in conjunction with intersection observations to Fort Capuzzo. At the first opportunity after crossing the frontier the Mobile Echelon of 512 Company effected junction between the two by means of field observations. The result was that the Italian values were found to be out of sympathy with the Egyptian values by an amount which was too great to be smoothed out. Since the Egyptian triangulation could not be altered, and it had been decided to keep the Italian Eastern system fixed, it was necessary to prepare duplicate trig lists for an overlap area between the two systems giving co-ordinate values in both systems.

It will be appreciated from the above that the different stages and processes of adjustment to which the Cyrenaican triangulation had to be subjected were considerably involved. For clarity, the main steps have been arranged in the form of a diagram (*see* Diagram 3) which it is hoped will make the situation easier to follow.

Syria and the Levant

Primary triangulation. The primary triangulation was the product of the following bodies:—

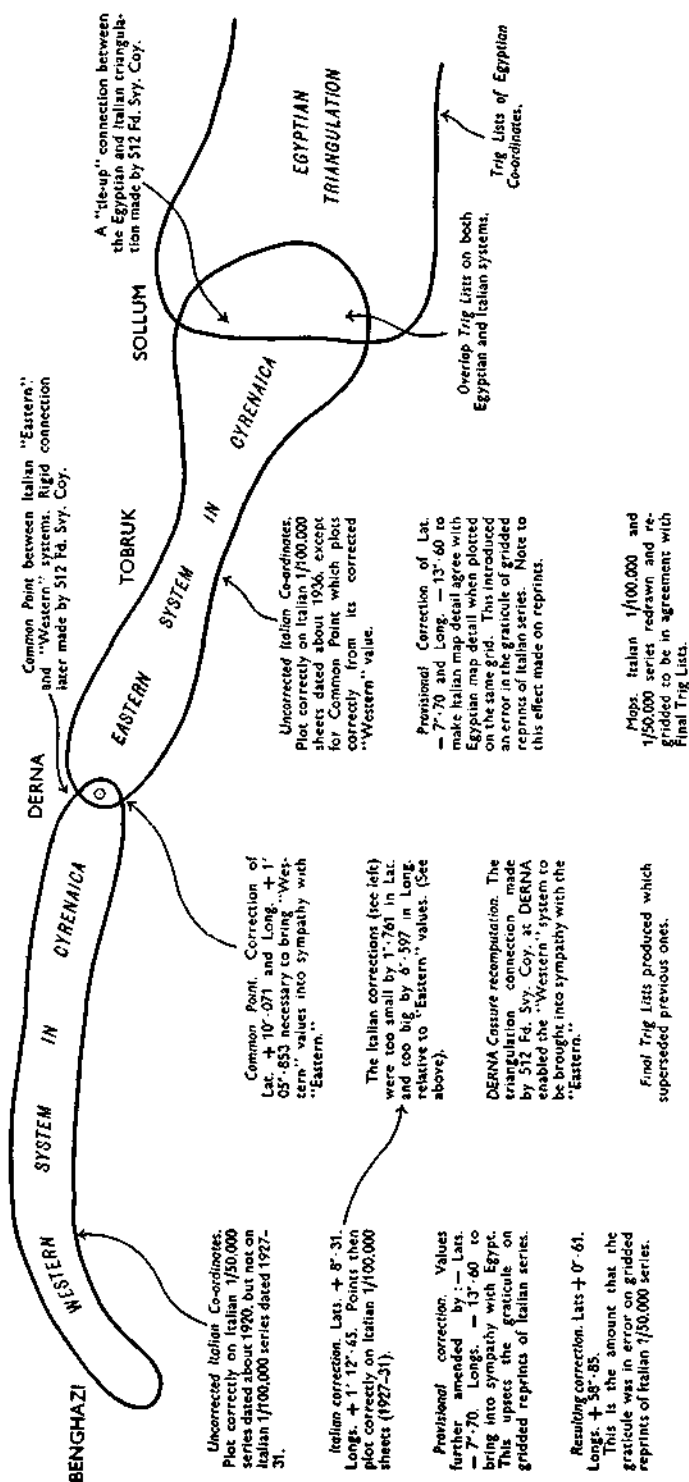
The Service Géographique de l'Armée Française (S.G.A.).

The Iraq Petroleum Company (I.P.C.), also known as the Syrian Petroleum Company (S.P.C.).

The Bureau de Cadastre (B.C.).

In addition, minor triangulation had been carried out by the Bureau Topographique des Troupes du Levant (B.T.).

DIAGRAM 3



Adjustments to the Triangulation Systems in Cyrenaica

The S.G.A. triangulation was the work of officers sent to Syria from Paris, and there was apparently little co-operation between them and the B.T., which was a local military organization under the command of the G.O.C. Levant. In a report published by the S.G.A., called the "Memorial du Service Géographique de L'Armée," the triangulation carried out by the S.G.A. between 1920 and 1929 was described, but few details of the work were available, only the results.

The Bureau de Cadastre was responsible for land registration, and all records of their work were available in their offices in Beirut.

The work of I.P.C. had been carried out in connection with geological prospecting and the delimitation of concessions. Their records were available in the offices of the company at Haifa, and also with the B.T. in Beirut.

The principal triangulations in Syria are described briefly below:—

SERIES A. ALEPPO MERIDIAN CHAIN AND THE COASTAL SERIES.

The division of this primary series into two parts was purely arbitrary, all the work being of the same high standard of accuracy. The Aleppo Chain was the backbone of the triangulation, the observations for which had been carried out by the S.G.A. between 1920 and 1929. The origin of the system for azimuth and latitude was the south terminal of a measured base at Bekaa. The fundamental longitude had been measured at the geodetic pillar at Ksara, and it was transferred through the triangulation to the origin at the Bekaa base terminal. A second base had been measured at Bab, and the scale of the triangulation was governed by the two bases. A check azimuth, latitude and longitude were measured at the Bab base. The triangulation was computed on the Clarke 1880 spheroid.

SERIES B. THE DJERABLOUS-MENNBIDGI SERIES.

This was observed by the S.G.A. with the same precision as the Aleppo chain, to which it was rigorously attached at four points. Starting elements of this series were used for the second-order Euphrates Valley Series.

SERIES C. THE EUPHRATES AND TURKISH FRONTIER PRIMARY SERIES.

This was observed between 1934 and 1937, and must not be confused with the second-order Euphrates Valley series mentioned above, with which it was not wholly in sympathy.

SERIES D. THE HASSETCHÉ SERIES.

Observed by the S.G.A. between 1932 and 1933. Provisional values of the co-ordinates were issued, based on astronomical values of the south base terminal of the Hassetché Base. These provisional values were used for a considerable amount of the B.T. minor work, and for all the original I.P.C. work in the area. But the co-ordinates of all primary points published in the G.H.Q. trig lists were based on the Bekaa system, though some of the minor points still remained based on the Hassetché system. This led to some confusion in the field. The Hassetché system was eventually connected to the Aleppo Chain through triangulation series B and C above and was re-computed, holding the Hassetché base fixed, but ignoring the astronomical observations at the Hassetché base terminal.

SERIES E. I.P.C.'S FRONTIER POINTS.

There was a gap along the Turkish frontier between series B and C which was filled by three points of the I.P.C. triangulation. The work was not in the geodetic class, but was up to good secondary classification.

SERIES F. CADASTRAL CENTRAL SERIES.

All the Cadastral primary work was of the highest standard, and it was on this work that series G (below) was based. The series was on the Bekaa system, and well tied to the surrounding S.G.A. work.

SERIES G. I.P.C. CENTRAL SERIES.

This, as in the case of series E, was a ruling triangulation with good second-order accuracy. It was tied into the Cadastral points of series F, and also along its northern boundary to series C. All points were on the Bekaa system.

SERIES H. ABOU KEMAL CADASTRAL SERIES.

This started from two stations of series C, and was a well-observed work. Though, for a primary triangulation, the sides were short, and it was without a check base, it was reliable.

Minor triangulation. Broadly speaking, all minor work to the west of Long. 40° E. was based on the Bekaa system, that to the east being on the Hassetché system.

The work as a whole can be divided into four main groups, each group consisting of a number of observation blocks. The points published in the G.H.Q. trig lists followed the French arrangement of compilation by sheets of the French 1/200,000 map series. In addition to the published points there were a great many minor cadastral points with a 1-km. density in the cultivated areas. Field surveyors had to be very careful in the identification of these points, applying check rays to make sure that they were using the correct one.

GROUP 1. THE EUPHRATES AND IRAQ-SYRIAN FRONTIER.

Blocks Nos. 30-34. Euphrates Valley. This was the work of the B.T. It was probably the only first-class work in this group, and it was based on the provisional values of Primary Series B.

Block No. 35. A rapid triangulation carried out for the Syria-Iraq Boundary Delimitation. It was of third-order accuracy only. Though attached to Block 34 (Euphrates Valley), it was not in sympathy with it, owing to the acceptance of an astronomical azimuth and a weak connection.

Block No. 36. Probably the weakest of the frontier series, and it was not quite clear how it was attached to the surrounding work, though there was evidence to show that it might have been attached to one side of Block 35.

Block No. 38. Another rapid triangulation, but reasonably good. It was tied into Primary Series C, but could not be said to be either on the Hassetché or the Bekaa system, as provisional field values in the former system were used as starting elements. The values were later converted to Bekaa terms, in view of the good connection with the primary points.

Block No. 49. Carried out by British surveys on the Iraq Boundary Commission. No points from it were included in the French lists from which the G.H.Q. lists were compiled. It overlapped Block 38 (above) and had one side in common with Block 36. Its starting elements were sides of the Iraq tertiary series which was not, at the time, attached to the Iraqi secondary work.

GROUP 2. THE HASSETCHÉ GROUP.

- Block No. 40. Turkish Frontier Boundary Commission.* The points belonging to this block were not included in the trig lists. It had its own starting elements, and though the names of some of its points were the same as those in Block 41, they were not common points.
- Block No. 41. Region Haute Jezireh, 1936.* A well-observed triangulation, properly attached to the primary network. Co-ordinates were in the Hassetché system.
- Block No. 42. Region Hassetché, 1937.* A good triangulation which was in sympathy with the Hassetché Primary.
- Block No. 43. Abdul El Aziz Sud, 1938.* Similar to No. 42.
- Block No. 47. I.P.C. Haute Jezireh, 1934.* Good work on the Hassetché system. It was re-computed on the Bekaa system.
- Block No. 48. Region El Rhana, 1938.*
Region Cheikh Mansour, 1937.
This was I.P.C. work based on Hassetché co-ordinates.
- Block No. 51. Bornes de Permis de Recherche de Pétrole de la Société des Pétroles et Asphaltes de Lattaquieh.* Unreliable work which was not used.

GROUP 3. THE JEBEL DRUSE-JEBEL TENF GROUP.

- Blocks No. 21 (BT 1939), No. 22 (BT 1937) and No. 23 (BT 1937).* Observed by the Bureau Topographique and not very reliable. Supposed to be attached to the primary triangulation in Bekaa elements and to each other, but the connections were not good. Useful for small scale mapping but not otherwise.
- Block No. 24. Triangulation Frontière 1932.* A good British-French boundary triangulation having its own starting elements and attached in the Jebel Druse area to No. 23. Its base was at Jebel Tenf, and the latitude, longitude and azimuth were measured by the British survey party.
- Boundary Triangulation. Jebel Tenf-Abou Kemal.*
A British triangulation which had not been allotted a French serial number. It was attached to Block 34 at Abou Kemal and to the origin at Jebel Tenf (*see* No. 24 above).

GROUP 4. THE CENTRAL GROUP.

- Block No. 25.* This was I.P.C. work and was computed from the values of points in Series H.
- Block No. 26. Bureau Topographique, Saba Biar, 1934.* A reliable triangulation attached to the Cadastral Primary. A few points of No. 24 were intersected from No. 26, but the two blocks were not adjusted together.

Palestine

Before the war, the ruling triangulation was established and maintained by the Survey of Palestine. Apart from minor extensions in Trans-Jordan, the

triangulation covered the area from the coast to the Jordan River Valley and from the Syrian frontier in the north as far south as Lat. 31° N. No permanent triangulation had been established between this parallel and the Egyptian frontier. The extent and general arrangement of the work is shown in Diagram 4.

The Palestine major triangulation consisted of about 100 stations with sides of average length 15 kms. There were approximately 1,100 secondary stations, and 20,000 third- and fourth-order points established within the major framework. The major work was well observed, rigorously computed, and of a high order.

The final results were recorded by the Survey of Palestine in the form of Cassini rectangulars, made up into lists conforming to the sheet lines of the Palestine 1/25,000 map series, which measured 10 kms. square.

As stated above, the Survey of Palestine rectangular co-ordinates were computed on the Cassini projection. As this was not conformable, it was unsuitable for military survey purposes and a Transverse Mercator grid was therefore established to replace Cassini. The origin was a point at Jerusalem with geographical co-ordinates:—

$$\begin{aligned}\text{Lat. } & 31^{\circ} 44' 02.749'' \\ \text{Long. } & 35^{\circ} 12' 39.290'' + 4.200''.\end{aligned}$$

The additional $4.200''$ to the longitude was in accordance with a 1928 decision to adopt the French value for the longitude of points of junction with the French triangulation in the north, and to correct all Palestine longitudes accordingly.

The true origin of the Cassini projection was retained and also the numerical values of the false origin so as to be able to retain the gazetteer and various maps which had already been prepared. The only amendment to the Survey of Palestine co-ordinates was the application of small corrections to the Cassini eastings in order to correct them to the Transverse Mercator values. The northings were the same for both projections, so no alterations to them were involved.

The limits of the Transverse Mercator Grid Zone were as under:—

East. 39° E. where it made junction with the Iraq and Muscat Zones.

West. The 70-km. easting line (Palestine Grid) where it made junction with the Egyptian Red Grid.

North. The junction with the Levant Grid along the 150-km. northing line of the latter.

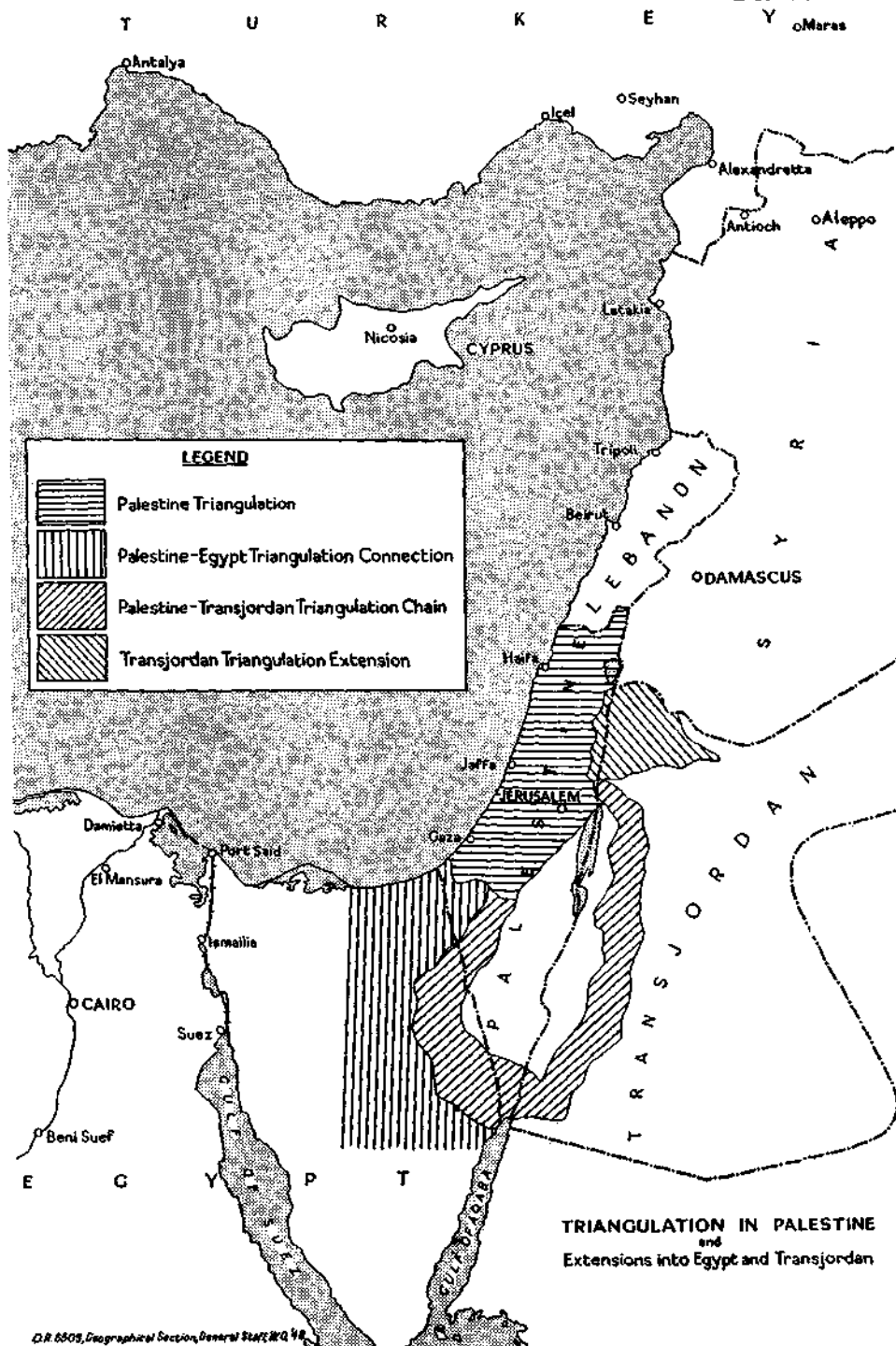
South. A Loxodrome passing down the middle of the Red Sea.

The Palestine Transverse Mercator co-ordinates were compiled in lists conforming to the Palestine 1/25,000 map series.

The area covered by the Trans-Jordan triangulation extension is shown in Diagram 4. The work was started some years before the war, but had only been observed and had not been finally adjusted. The original observations and data were obtained by the Survey Directorate, Middle East, and the necessary computations were done by 2/1 Australian Field Survey Company.

During the few years just before the war, a triangulation net had been extended southwards from the Palestine major triangulation to join the Egyptian geodetic chain which ended close to the Palestine border. The observations

DIAGRAM 4



were unreliable, and a junction had been made at one point only. It was therefore decided by the Survey Directorate to establish another connection and to extend it into Trans-Jordan at the Gulf of Aqaba. This work was undertaken by the South African Survey Company, who re-observed the old connection and established four new stations in order to expand the lengths of the triangulation sides up to those of the Egyptian Geodetic Survey.

At the same time the 36 New Zealand Survey Battery extended the Palestine triangulation down the eastern side of the Dead Sea in order to provide suitable mapping control points along the Palestine-Trans-Jordan border. This was eventually connected to the stations established by the South African Survey Company at the Gulf of Aqaba, and so completed a circuit of triangulation called the Palestine-Trans-Jordan Chain.

The Chain started from stations of the Palestine major network near Beer-sheba and connected up with four stations of the Egyptian geodetic system to the south-east of El Arish. It then ran along the Palestine border to the Gulf of Aqaba, thence passed through Trans-Jordan, and closed on the Palestine major network near Jericho. Where it passed along the Palestine southern boundary it included stations of the Egyptian third-order triangulation wherever possible.

Observations were made on to both luminous and opaque signals, and the results were within the limits of accuracy laid down for second-order work.

Each polygon or quadrilateral within the system was first of all treated separately for angle and side adjustment, then, with the co-ordinates of the Palestine major stations near Beersheba as starting elements, the chain was computed right through to its junction with the Palestine network near Jericho. The closing error was distributed through the chain by the method of contour graph adjustment.

Two bases were measured in Trans-Jordan by catenary method, but as there was difficulty in standardizing the tapes, the bases were used as a check only and did not govern the scale of the work.

Azimuth observations were made to Polaris at three stations. The results were consistent in themselves but differed from the azimuths as computed from the final co-ordinates. Possibly the Rift Valley was responsible for a deflection which would have affected the observed values. The results were used as a check only.

Several subsidiary stations were established in Trans-Jordan, mainly along the Maan-Aqaba road. They were fixed by intersections, resections, or subtense methods from the major stations and were suitably marked. In anticipation of air-photo mapping in Trans-Jordan several ground control points were fixed. These took the form of road intersections, prominent rocky outcrops, isolated buildings, and points in villages which it was thought would be recognizable on the photos.

Provisional values for the section of the chain in Trans-Jordan had been computed originally by starting from the Palestine major stations near Beer-sheba. The co-ordinates of the subsidiary and ground control points were computed in the same terms. To obtain final values, a contour correction graph was drawn based on differences for the major points between the provisional and final values, and from this graph corrections were obtained for converting the minor points to their final values.

As photographs were not available when the minor points were fixed, sketches showing form lines, and drawn to an approximate scale of 1/25,000,

were made at each point, showing enough detail to ensure the subsequent identification of the air survey control points on the photographs.

The triangulations of Palestine and Egypt had been computed on different spheroids, Palestine being on Clarke 1880, and Egypt on Helmert's figure. Quite apart from differences based on the fundamental origins of the two systems, this fact affected the values of points between one system and the other along the common frontier. To change from the Egyptian Red grid to the Palestine grid near the grid junction it was necessary for the triangulation to be calculated on the same spheroid and, for this purpose, the geographical co-ordinates of the origins of the two grids were defined as being on Clarke's 1880 figure.

As stated previously, the Palestine-Trans-Jordan Chain incorporated a certain number of Egyptian stations along the frontier zone so as to enable a comparison of co-ordinates to be made. These included four geodetic stations and four third-order points of the Egyptian network. The co-ordinates of common points differed roughly by 120 metres in eastings and 30 metres in northings, this being largely owing to an initial error in the longitude of the Egyptian origin.

Palestine Transverse Mercator co-ordinates of the common Egyptian points in the Chain were first converted to geographicals on Clarke 1880, and these were then converted to Egyptian Red grid Transverse Mercator co-ordinates using Clarke 1880 tables.

Differences were then taken out between the resulting values and the corresponding Red grid co-ordinates in terms of the Egyptian triangulation on Helmert's figure. A contour correction graph was drawn from these differences to enable the Egyptian third-order points lying to the east of meridian $33^{\circ} 30'$ E. to be converted to Red grid values in agreement with the Palestine network.

The co-ordinates of all Egyptian points lying to the east of the Palestine grid junction were converted to Palestine grid values after being first amended by the correction graph.

As the Egyptian triangulation was not in sympathy with the Palestine system it was necessary to provide overlap trig lists, and this was done for the area lying to the east of meridian $33^{\circ} 30'$ E.

Cyprus

A major triangulation of Cyprus was carried out between 1913-15, and subsequently a large number of third- and fourth-order stations were established, thus covering the island with a dense trig control. The records of the survey were kept by the Director of Land Registration and Surveys, who supplied all necessary data to the Director of Survey, Middle East.

The co-ordinates as originally supplied were in the form of rectangular Cassini co-ordinates in feet, computed on Clarke's 1880 spheroid, and referred to a true origin at Lat. $35^{\circ} 00'$ and Long. $33^{\circ} 19'$. For military purposes these were converted from feet to metres, and a false origin taken in order to make all co-ordinates positive. The amended values represented co-ordinates on the Cyprus (Cassini) grid system. This Cyprus grid is an isolated one covering just the island itself, and a suitable extent of sea all around, and made a junction with the Mediterranean Zone, the Levant Zone and the Egyptian Red Belt. (See Diagram 2.)

It was perhaps unfortunate that, when the Cassini co-ordinates were converted to metres, they were not also amended to values on a Transverse Mercator

projection with the same true origin, as the latter projection is orthomorphic, and calculations on it may be carried out more easily.

The major triangulation consisted of a network of well-shaped triangles with an average side length of 10 to 15 miles, covering most of the island. The adjustment of the net was by the method of least squares in a single block, including condition equations introduced by two measured bases at Famagusta and Ktima.

The major net was broken down into third- and fourth-order systems, the points of the latter being about one to two miles apart.

Rectangular Cassini co-ordinates of the major and third-order stations were converted to the Cyprus grid and made up into trig lists corresponding to the 1/50,000 map series of the island. The fourth-order points, of which there were over 6,000, were not so converted, nor made up into trig lists, but the data, including their heights, were available if required for mapping purposes.

Observations were made between Cyprus and the mainland to connect the triangulation systems of Cyprus and Syria. The work was carried out by a section of 512 Field Survey Company R.E. under the direction of D.D. Survey Ninth Army in July and August, 1944. This connection ultimately formed a part of the Mediterranean Chain which was computed from Cyprus through Palestine, Egypt and Libya as far as Tunis.

Aden

A record of the triangulation work carried out in the Aden Protectorate before 1932 is contained in a War Office Survey Paper entitled "The Triangulation of the Aden Protectorate 1876-1931." In 1927-28 an air survey of Aden was undertaken under War Office control, and further control points were fixed. In 1934 a Lambert conical orthomorphic projection was introduced in place of the Cassini previously in use.

Details of the projection and grid (Diagram 2) were as under:—

Spheroid.	Clarke 1880.
Projection.	Lambert conical orthomorphic.
True origin.	Lat. 15° 00' 00" N. Long. 45° 00' 00" E.
False origin.	1,500,000 m. west of true origin. 1,000,000 m. south of true origin.
Limits of grid.	<i>East.</i> 60° E. meridian. <i>North.</i> Junction with the Mecca-Muscat grid on 150-km. northing line of the latter. <i>West.</i> Junction with the East African 5° Belts along a loxodrome running down the middle of the Red Sea. <i>South.</i> A loxodrome in the Indian Ocean running more or less parallel with the coast of the Aden Protectorate and forming a junction with the East African 5° Belts.

For the re-triangulation of Aden in 1931 a base line was measured and an azimuth observed, but although sufficiently accurate for local purposes, the triangulation was not suitable for possible extensions inland owing to the small triangles and short base.

A number of points variously fixed were used to control the 1934 air-photo survey of Aden. During 1932 astronomical fixations, including wireless longitude observations, had been determined at five R.A.F. landing grounds

near Aden. Other control was provided by Survey of India triangulation points, and some were astrolabe points fixed by the Royal Navy.

As the 1931 triangulation was unsuitable as a basis for extension to the north, a new network was observed during 1942 by an officer of the New Zealand Artillery to provide control for an area of about 300 square miles which was to be mapped from air photos to meet certain artillery requirements. It depended for scale on a new base measured in catenary. From the base extension, figures were built up to cover the area consisting of two quadrilaterals with triangular sides of 12 to 14 miles. These were broken down so as to give triangles of four- to five-mile sides, and numerous air-photo control points were fixed by intersections and resections.

The stations were permanently marked by angle irons set in concrete, and the observations, mainly on to helios, resulted in a mean triangular misclosure for the control net of under three seconds, and for the whole network of under four seconds.

The Mediterranean Chain (See Diagram 5)

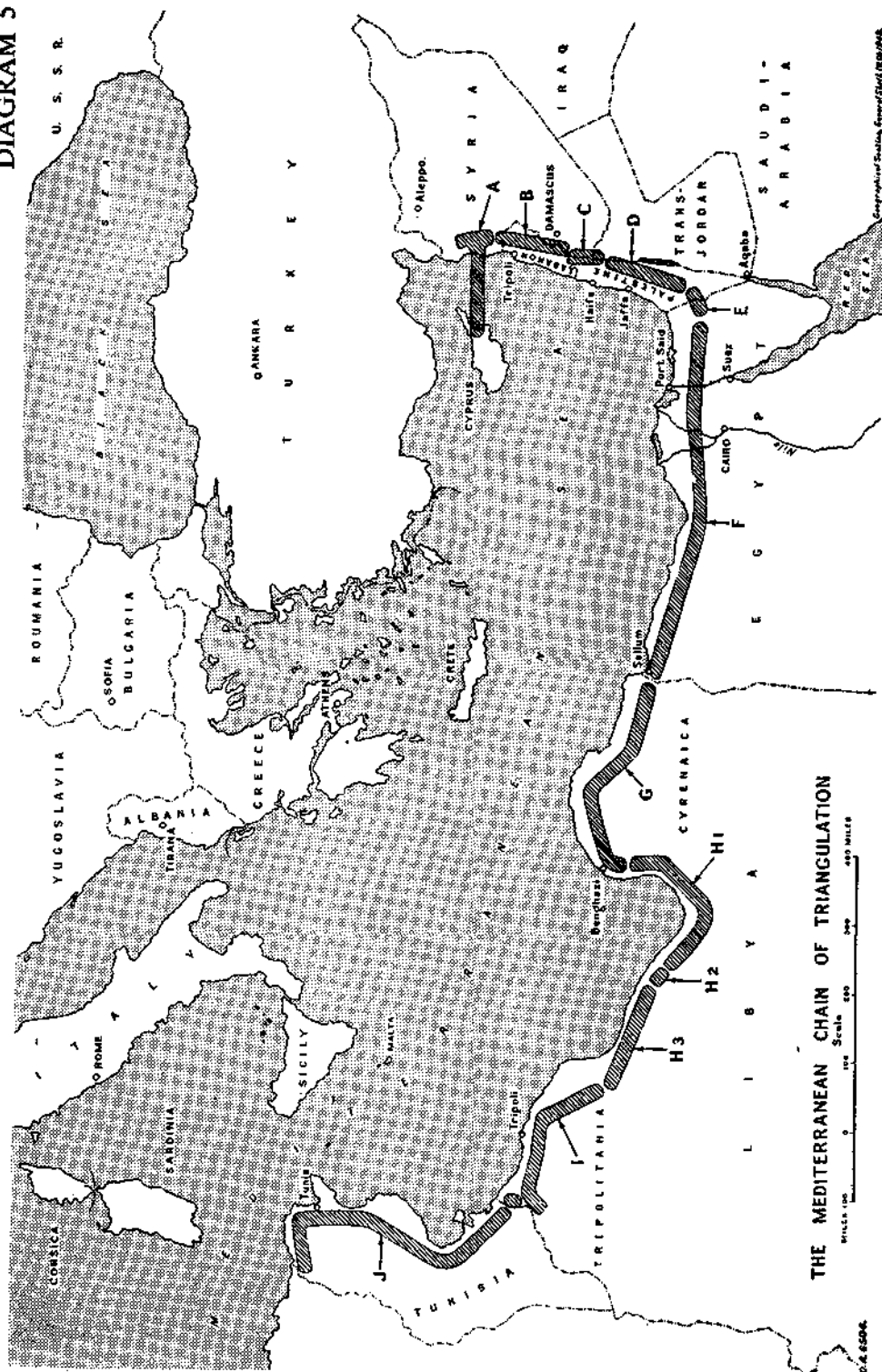
The Mediterranean Chain was the name given to the assembly of various networks of triangulation, both national and military, lying between Cyprus and Tunis which were connected together by the Survey Directorate, Middle East to form one continuous chain.

The fundamental origin adopted for the Chain was that of the Survey of Egypt at the Transit of Venus station on the Moqatta Hill at Cairo. Owing to local attraction in the prime vertical, the adopted longitude was corrected by $+ 3.45''$ throughout. Computations were based on the Hayford 1910 spheroid.

The complete Chain, which consisted partly of national triangulation networks and partly of work carried out by military survey units during the war, was subdivided into the following sections:—

- Section A. Cyprus-Syria connection.* The observations were carried out by a section of 512 Field Survey Company R.E. in 1944, between two points of the Syrian primary net and three points in Cyprus.
- Section B. Syrian Primary.* The triangulation used for the Chain was that part of the Syrian network known as the "Primary Meridional Chain," lying between Bonadi and the Palestine frontier.
- Section C. Palestine-Syria connection.* In 1944 a connection was observed between the Palestine and Syrian triangulations consisting of 27 points, including 13 Syrian primary points, and 6 primary stations of the Palestine survey.
- Section D. Palestine Primary.* A chain of quadrilaterals forming part of the primary triangulation of Palestine was used, the observed and adjusted angles being supplied by the Palestine Survey Department.
- Section E. Palestine-Egypt connection.* In 1941 observations by the South African Survey Company extended the Palestine major triangulation to connect with the Egyptian geodetic net.
- Section F. Egyptian geodetic triangulation.* The Survey of Egypt supplied geographical values for a chain of quadrilaterals extending from the Palestine border to the Cyrenaican frontier.

DIAGRAM 5



Section G. Italian triangulation in Cyrenaica. It will be remembered that two Italian triangulation systems (Eastern and Western) were found in Cyrenaica, which were eventually connected by observations carried out by 512 Field Survey Company R.E. Subsequently several first-order points of the western system were found, whose geographical co-ordinates were also given in terms of the eastern system, and these values were used for the computation and adjustment of the Mediterranean Chain in preference to the connection observed by 512 Field Survey Company.

Section H. This Section consisted of triangulation observed by military survey units to link up the Italian work in Cyrenaica with that in Tripolitania. It consisted of three sub-sections:—

H-1 observed by 46 South African Survey Company.

H-2 observed by 36 New Zealand Survey Battery.

H-3 observed by 517 Field Survey Company R.E.

In addition, a final connection between H-3 and Tripolitania was re-observed by 524 (Palestinian) Field Survey Company R.E., as the original connection was unsatisfactory.

Section I. Italian triangulation in Tripolitania. This Section extended as far as the Tunisian frontier, the final connection between the Italian and French systems being observed by 524 Field Survey Company in July, 1944.

Section J. French triangulation in Tunisia. Geographical values of stations were supplied by the S.G.A. in booklets corresponding to the 1/200,000 sheets. Only those following the coast from the Tripoli frontier to the area Tunis-Bizerta were used.

The general arrangement of the Chain is shown in Diagram 5 and the computation and adjustment was done by Mr. Cole of the Survey of Egypt. With the exception of the Palestine azimuth all measured bases and observed azimuths were taken into account.

The Palestine-Egypt connection revealed an azimuth error of E-P $16\cdot4''$ which was confirmed by an azimuth observed in the area by the New Zealand Survey Battery giving a result of E-P $16\cdot5''$.

The Palestine-Syria connection gave a difference in azimuth of P-S $13''$.

The combination of both the above gave a difference between Syria and Egypt of E-S $29\cdot5''$. The junction between Syria and Cyprus computed from the Syrian values gave a difference of C-S $20\cdot2''$ which indicated that the Syrian triangulation had an azimuth error of between $-20''$ and $-30''$. An adjustment was therefore made to the Syrian azimuths between the Palestine frontier and the Syrian points from which the Cyprus connection was made.

As a result of observations for the connection between Egypt and Cyrenaica it was established that the Italian azimuths were in error by approximate $50''$. In the readjustment of the triangulation the initial azimuth of the Italian side near Sollum was therefore corrected by $-50''$.

The Italian triangulation was then computed through to Derna, where it was found that the azimuth differed from that of the major triangulation by $48''$, and the net was adjusted to fit the major system. A scale difference of 1 part in 10,000 was evenly distributed from the base at Tobruk to the side at Derna.

Computation of the Italian major triangulation from Derna to Benghazi

gave an azimuth which agreed with the astronomical azimuth observed by the South African Survey Company.

The two bases measured by survey units at Agheila and Buerat were taken into account, and base and azimuth equations were put into the triangulation between those places. The remaining scale error was distributed between Buerat and the junction with the first-order network at Silma near the Tripolitanian frontier.

The Italian triangulation in Tripolitania was accepted for scale, position and azimuth, and corrections were applied to the geographical values to convert them from the Bessel to the Hayford figure. The connection between Tripolitania and Tunisia, which was observed by survey units, was satisfactory.

Geodetic research and field surveys in the Middle East

The above gives a brief summary of the principal triangulation systems that either existed or were observed by military field surveyors for operational use in the Middle East. It should be noted here that although, for technical purposes, survey activities in Persia and Iraq came largely under Middle East control, the detailed account of them is given in Chapter VII. Most of the labour entailed in the preparation of the triangulation data for use in the field fell on the shoulders of the Trig Computing Section which formed part of the G.H.Q. Survey Directorate. Much research was carried out concerning the various national triangulation systems within the theatre. It was necessary to supplement the data which had been provided from War Office sources and this entailed personal visits to the Survey Departments concerned wherever and whenever they were accessible. During these visits, some of them necessarily of short duration, as much information and data as possible had to be obtained, and good relations and confidence had to be established and maintained.

It had, then, to be decided how best to utilize all this information and this entailed policy decisions on the grid systems to be adopted, the projection and figure of the earth to be used and, in some cases, the assimilation of several different triangulation systems on to one common basis.

The problems confronting the computing staff of the Survey Directorate were many and onerous. A few only are quoted to serve as examples of the tasks which had to be undertaken. The section was almost always working in a hurry against time and during frequent periods of great emergency they had to work day and night. The success of their labours cannot be too highly appreciated.

The following represent some of the typical jobs that were undertaken:—

- (a) Compilation of trig lists on the military grid covering the whole operational area of the Western Desert.
- (b) The conversion of captured Italian trig data from geographical to rectangular co-ordinates on the Libyan grid, and the preparation of trig lists.
- (c) The preparation of double-entry tables for the Egyptian Red and Purple grids on the Egyptian Transverse Mercator system.
- (d) The preparation of double-entry tables for the Libya Zone.
- (e) The conversion of Greek co-ordinates on two different projections to rectangular co-ordinates on the Mediterranean Zone Grid.

- (f) The preparation of tables for the conversion of trig values on Cassini projection to Transverse Mercator for use by the Survey Directorate in Palestine.
- (g) The preparation of reports on all the various triangulation systems within the theatre, with notes of guidance as to their use.
- (h) The preparation of Survey Technical Instructions and pamphlets on a multitude of technical subjects dealing with field survey methods, use of grids, computations, etc.
- (i) Preparation of conversion tables to enable co-ordinates on one system to be converted to another.
- (j) Preparation of geodetic tables to facilitate computations on the various figures of the earth, e.g., Helmert, Clarke 1880, Heyford, etc.
- (k) Computation of the principal programmes of major triangulation carried out in the field.
- (l) Preparation of contour correction graphs for the graphical adjustment and smoothing out of triangulations.
- (m) Miscellaneous computations such as those for "sheet corners" of maps, to enable map sheets to be gridded.
- (n) Computation of co-ordinates on the appropriate grid system and the preparation of trig lists for areas of actual or potential operations in the Western Desert, Libya, Tunisia, Greece, Sicily, Italy, Palestine, Syria, Trans-Jordan, and the Balkans generally.

The topographical sections of the field survey companies were continuously employed on survey work either in the field or in the subsequent work of converting the results of their field surveys into maps. Some of this work was centrally controlled under the G.H.Q. Survey Directorate; the bulk was, however, decentralized so as to come under the executive control of Survey Directorates with Eighth Army in the Western Desert, Libya and Tunisia, Ninth Army in Palestine, Syria and Trans-Jordan, H.Q. B.T.E., and H.Q. Palestine Base. There was also Tenth Army in Iraq and Persia whose work is dealt with separately. (See Chapter VII.)

Some examples of field survey work undertaken are given below:—

- (a) *Major and minor triangulation required for geodetic purposes.*
 - (i) Palestine-Trans-Jordan Chain (South African Survey Company and 36 New Zealand Survey Battery) to provide a connection between the networks of Palestine and Egypt and to give mapping control over that area.
 - (ii) The Trans-Jordan extension system. (Computation by the Australian Survey Company.)
 - (iii) The Cyprus-Syria connection (512 Field Survey Company R.E.).
 - (iv) The Syria-Trans-Jordan connection.
 - (v) The Palestine-Syria connection (512 Field Survey Company).
 - (vi) The connection between the Egyptian and Italian systems on the Libyan border (512 Field Survey Company).
 - (vii) The connection between the Italian Eastern and Western systems in Cyrenaica (512 Field Survey Company).

- (viii) The link up between the Italian triangulation in Cyrenaica and that in Tripolitania (46 South African Survey Company, 36 New Zealand Survey Battery, 517 Field Survey Company and 524 Field Survey Company).
- (ix) Connection between the Italian triangulation in Tripolitania and the French network in Tunisia (524 Field Survey Company).
- (b) *Establishment of ground control for mapping, etc.* In all accessible areas where there was a requirement for new mapping or revision on various scales, whether this was to be carried out by plane-tableing on the ground or by air survey methods in the office, there was a need for the establishment of ground control points. In most cases the triangulation framework already available provided fixed points which were usually too far apart, and it was therefore necessary to break down this control by fixing the positions of a large number of subsidiary points. The methods for doing this depended largely on the nature of the existing framework, the terrain conditions, and the circumstances under which the work could be carried out, that is to say, whether in the face of the enemy, as often occurred in Libya, or under more or less peaceful conditions. The technical methods depended on the scale and nature of the map which it was desired to produce. A rapid battle sketch map or a very small scale map clearly required less precise fixation of control than that required for a 1/25,000 map which would be used for artillery shooting. A few examples of field survey work carried out in the Middle East theatre are quoted below, simply to give an idea of the types of jobs which had to be tackled:—

- (i) Ground control in Egypt, Syria, the Levant, Trans-Jordan and Palestine for mapping at scales ranging from 1/25,000 to 1/250,000 (Australian Field Survey Company, South African Survey Company, 36 New Zealand Survey Battery, Royal Marine Survey Section, and 13, 19, 512, 517 and 524 Field Survey Companies R.E.).

This programme included intersection observations across the frontier into Turkey to enable data to be established for the gridding of Turkish maps. Technically this work was of a more or less deliberate nature which permitted the use of normal triangulation methods for breaking down from the existing framework to a lower-order control.

- (ii) Ground control in the Western Desert and Libya, for mapping, revision and other field use. Here the work was more of an active service nature, often in the near presence of enemy forces. Some of it was done by normal triangulation methods, and where this was not either feasible or justified, astronomical observations were taken, and many miles of car and compass traverse were completed.

The units principally engaged on survey work in the battle area, first of all with the Desert Army, and subsequently with Eighth Army, were the Mobile Echelon of 512 Field Survey Company R.E., the South African Survey Company, and 514 and 517 Field Survey Companies R.E.

A large amount of new mapping was undertaken on scales ranging from 1/12,500 to 1/250,000 for which ground control was needed, to cover areas for which either no maps existed, or for which

the available maps were unsatisfactory. For the larger scales deliberate triangulation was undertaken. For some of the small scale maps further west astronomical determinations were made, and further control established by car and compass traverses.

There were also large numbers of desert tracks which were beacons and surveyed. These tracks and beacons often formed the only recognizable features in an otherwise featureless desert, and their surveyed positions, when incorporated on the maps, proved to be of very great help to the troops. The occasional hills which were marked on the maps were labelled on the ground with their names and where no other specific topographical features existed in a bare area of sand and stones, artificial marks, often consisting of old tar barrels, were erected, surveyed and marked with their map references.

In those areas where it seemed likely that battles were imminent, and where no satisfactory medium or large scale maps existed, air photographs were asked for and, to convert these into maps, it was necessary to fix the positions of control points. On many occasions the area in question lay beyond our forward defence localities and it was necessary to send survey parties into no-man's-land and beyond, right behind the enemy lines. To effect this, armoured car patrols escorted the survey parties, and much valuable work was undertaken in this manner, though naturally at the cost of some casualties. Unfortunately it frequently happened that the only transport available to the survey parties was totally unsuitable for the class of work involved. The armoured car escort naturally disliked having to accompany 3-ton lorries into and beyond no-man's-land. They were slow and were visible over long distances. It is essential that transport, tactically suitable for the job in hand, should be made available on such occasions. It is also desirable that the vehicles should be equipped with radio so that information of enemy movement and instructions can be passed to them during critical periods.

Much valuable survey for mapping purposes was done by 512 and 514 Field Survey Companies R.E. in central Cyrenaica during the critical period of May, 1942, just before the German attack in the Bir Hakeim area which led to the British withdrawal into Egypt. It was with difficulty that the scattered survey parties were collected for the withdrawal.

During the preparatory weeks leading up to the battle of El Alamein the survey units of Eighth Army were working at full pressure. Owing to the shortage, at that time, of Royal Artillery Survey units, the South African Survey Company undertook a considerable amount of what was really artillery survey work in the El Alamein area. In preparation for the battle, 15,000 bearings were computed from their co-ordinates for the artillery. The preparation of the block-plots for use by the counter-battery officers has been referred to in Section 2. For their preparation a large amount of ground control was required between the coast and the Qattara Depression.

One great difficulty during battle in the desert was the location of position at night so that unit commanders could report progress. It was thought that this difficulty might be solved by attaching sur-

veyors to the attacking units so that they could observe back on to vertical searchlight beams installed in known positions. Traversing horizontal beams from signalling lamps were also to be used. Personnel of the South African Survey Company were trained in this work, but in actual practice, it was found that, owing to the fear of their attracting air bombing, the searchlights were not allowed to go far enough forward. In any case the dust raised by gun-blast and shell explosions was so dense that it is doubtful whether the beams could have been seen.

Survey parties did, however, accomplish much important work during the early stages of the battle, beaconing areas behind our forward troops, fixing start lines, and marking lines of advance.

During operations the R.E. Field survey units co-operated in the normal manner with the R.A. survey units in order to provide them with the necessary framework control required for artillery purposes. In this connection there were a few unfortunate cases where, owing to a lack of complete liaison between the two, the R.A. surveyors established temporary grids which were not in sympathy with the grid on the maps provided by R.E. Survey. This naturally caused considerable confusion and, what was more serious, a lack of confidence. The matter was, however, put right and thereafter co-operation was restored to its customary high level.

- (c) *Mapping and revision in the field.* In addition to the provision of ground control, the survey of topographical detail was required over large areas for new mapping, revision, and for the plotting of defence works, etc. Where air photographs of the right type could be obtained the compilation of such detail was largely achieved by air survey methods, but there was a necessity in many areas for plane-table surveys on scales of 1/25,000 and smaller.

Of historic importance were the surveys for 1/50,000 mapping in the El Alamein area. These were started in the spring of 1941 by the Mobile Echelon of 512 Field Survey Company and were continued later by the South African Survey Company. At its inception this work was regarded by some as an unnecessary and uneconomical use of skilled surveyors in view of the fact that the British forces were far in advance of that area, but there were no large or medium scale maps of that district and it obviously formed, between the coast and the Qattara Depression, the most important potential defensive bastion to Alexandria, Cairo and northern Egypt generally. Later events proved its value and, shortly before the battle in October, 1942, the Daba-Alexandria series at 1/50,000 was extended by further mapping, also surveyed by the South African Survey Company.

In the Western Desert, and further west in Libya, large mapping programmes were completed by survey units operating with Eighth Army. These included straightforward mapping on large, medium and small scales for the standard series, the mapping of defences, railways and pipe-lines, the preparation of sketch maps for battle use, etc. Much of this work was rendered difficult by the presence of uncharted minefields, and the surveys of minefields was another task which had to be undertaken. Apart from this new mapping, there was a continual

programme of revision in this western operational area, much of which entailed ground surveys.

In Egypt itself, although the maps available were considerably more adequate than elsewhere in the theatre, it was necessary to extend the 1/25,000 map coverage and, in addition, the revision of the existing map series, the surveys of camp sites and training areas, and the survey of defence works had to be undertaken. Though some of this work was done by the Egyptian Survey Department, the bulk of it fell to the lot of the field survey units.

In Palestine, Syria and Trans-Jordan very extensive mapping projects were taken up. Limited areas only had been surveyed before the war on the 1/25,000 scale, and there was by no means adequate coverage even at 1/100,000. Surveys on these and other scales were undertaken by British, Australian, South African and New Zealand Survey Units. After their formation the units composed of Palestinian personnel also took their share in the work, and there was a welcome contribution by French personnel of the Service Géographique based on Beirut.

Of much importance were the surveys along the Syrian-Turkish frontier, and also those covering areas of strategic importance for the defence of Palestine and Syria against possible attack from the north and east when the German forces were striking deep into Russia and the Caucasus. For certain specified "fortress" areas there were the additional surveys of defence works.

A study of unit war diaries and other reports reveals the fact that, on the average, the standard of training in plane-table work was poor. In several cases work which had previously been done by one unit had to be resurveyed by another. There is probably little doubt that plane-tableing is the finest possible training for a topographical surveyor. It instils in the mind a grasp of the essential fundamentals of detail and ground form which cannot be attained by any other form of training or instruction, and it is to be hoped that more attention will be paid to this fact in the training programmes for the post-war military surveyor.

- (d) *Field surveys in the Sudan and Eritrea.* An account of the survey work carried out in connection with the campaign in East Africa is given in Chapter VI. The operations in Eritrea were, however, directly controlled by G.H.Q. Middle East, and therefore a reference will be made here to the survey activities undertaken in connection therewith. The survey unit concerned was 514 Field Survey Company R.E.

Almost immediately after its arrival from the United Kingdom this unit proceeded by road from Cairo to Khartoum. On its way it ran a compass traverse along the route from Shellal to Wadi Halfa controlled by astronomical fixations.

A road reconnaissance and quick survey from Aswan to Wadi Halfa was then carried out for the Chief Engineer, and a survey party was provided to determine astronomical fixes as a means of helping the R.A.F. to use the existing maps, which were of doubtful accuracy.

Triangulation work was then started to form a basis for carrying forward control with the force advancing to Keren, but not until the stand at Keren were the topographical sections able to keep pace with the advance. At Keren itself triangulation was carried out based on captured Italian data, covering our own gun positions and including

intersected points in the target area. A junction was then made backwards from Keren to the triangulation which had previously been started and abandoned owing to the speed of the advance.

Road revision of 1/50,000 maps of the Keren area was effected, and many other local road surveys and compass traverses were completed.

SECTION 5. MAP SUPPLY AND DISTRIBUTION

As stated in Section 1, early in 1940 a Survey Directorate went out to G.H.Q. Middle East, followed shortly afterwards by two survey units, one of which was No. 2 Field Survey Depot R.E. on the standard war establishment of one officer and 18 other ranks. A large base map reproduction unit was also installed which, with the assistance of the civil Survey Departments in Egypt and Palestine, undertook large programmes of map production and printing covering the operational theatre. Stocks quickly mounted in volume and the Depot responsibilities were heavy.

The British offensive in the Western Desert against the Italian force which had crossed the frontier from Cyrenaica into Egypt opened in December, 1940. For these operations detachments from No. 2 Field Survey Depot were assigned to the A.D. Survey, Western Desert Force, and a sub-depot, carrying stocks for the Force was opened by G.H.Q. at El Daba. A.D. Survey (W. Desert) organized his own forward depots and mobile distribution units, using personnel of Field Survey units.

For the operations in Greece in February, 1940, No. 9 Field Survey Depot R.E. was available. It had been recently formed in the Middle East, and, although a number of its personnel were captured in Greece, it was later reorganized and equipped and sent to Palestine, where it came under the control of the Survey Directorate with the Palestine Force. Local Palestinian personnel were largely used when rebuilding this unit. By about the middle of 1940 the map distribution organization in Middle East was as under:—

- (a) *Under G.H.Q. control* and manned by personnel of No. 2 Field Survey Depot.
 - (i) Base Map Depot at Abbassia (moved later to Tura caves). This carried stocks of all maps in use in the theatre. It took delivery of all maps printed under G.H.Q. arrangements, and distributed them in bulk to sub-depots. It also made detailed issues to G.H.Q. troops.
 - (ii) G.H.Q. sub-depot, located at G.H.Q. This carried small stocks for issue to branches and staffs.
 - (iii) Alexandria sub-depot carried reserve stocks of all the Western Desert and Delta areas for the W. Desert Force and the B.T.E.
 - (iv) Moascar sub-depot. This was designed to split the stocks held at the Base Map Depot as well as providing for B.T.E. in the Canal Area.
- (b) *Under the control of A.D. Surveys, Western Desert.*
 - (i) El Daba sub-depot carried main stocks for the Western Desert Force and was manned by personnel of 2 Field Survey Depot.
 - (ii) Forward map depots at Bagush and Matruh.

- (iii) A mobile distribution unit for operating with the forward troops. This consisted of "A" Echelon of four vehicles fitted up as map stores, one of which was attached to the headquarters of each division or independent brigade; and "B" Echelon of two vehicles, to run a shuttle service between the Forward Map Depot and "A" Echelon.
- (c) *Under the control of D.D. Surveys, Palestine and Trans-Jordan.*
 - (i) Main Map Depot at Jerusalem.
 - (ii) Sub-depots at Gaza and Tel Aviv, mainly for dispersing stocks.
 - (iii) Forward Map Depot formerly at Nazareth, later moved to Syria.

Issues to units and formations under command of Western Desert Force and Palestine Force were made through the above-indicated channels under control of the Survey Directorates with those forces. Direct issues, under G.H.Q. arrangements, were made to British Troops in Crete and in Cyprus. Issues to B.T.E. were made from stocks held in the G.H.Q. Depot earmarked for them, under authority from H.Q. B.T.E.

It was the function of G.H.Q. Depots to hold reserves of all operational maps. These were made up of two parts:—

- (a) Those held immediately at the disposal of forward troops. The amount of these reserves was based on figures supplied by the formations concerned, viz.:—
 - A.D. Survey Western Desert Force.
 - D.D. Survey Palestine and Trans-Jordan.
 - H.Q. B.T.E.
 - H.Q. R.A.F. Middle East.
 - Fleet Hydrographic Officer.
- (b) Second-line reserves to enable the above figures to be maintained in the event of any sudden demand, without having to call for rush reprints.

The total reserves under the above headings varied between 2,000 and 8,000 copies of any one sheet.

During October the Base Map Depot was moved from Abbassia to the Tura Caves which had been prepared for use not only for the Depot but also for housing the reproduction plant of 512 Company as a safety precaution against air attack.

The entry of Japan into the war, with the consequent threat to Australia and British possessions in the Far East, resulted in the transfer of the Australian Corps from the Middle East. In connection with this move, the outline of the security organization and methods which were subsequently to be employed for all major overseas expeditions was evolved. A Port Detachment of one officer and six other ranks was installed at Suez. A code was prepared for the identification of sheets, and the maps were packed in code-labelled bales in No. 2 Field Survey Depot and despatched to Suez, all subsequent transactions being carried out in code to which only the O.C. troops of each ship had the key. This operation, which lasted for some weeks, was carried through with complete success and preserved the essential security of the move.

An event of considerable interest was the evolution of the "Army" type of Field Survey Depot for handling map supply and distribution to Eighth Army when it opened the second offensive into Cyrenaica towards the end of 1941. The operations were of a fast mobile character with long lines of com-

munication. The original Desert Army had passed through many trials and tribulations in the matter of map supply which could nearly all be attributed to the fact that the Survey Service, according to existing policy, was not officially responsible for distribution to divisions and had, as a consequence, neither transport nor sufficient personnel to carry out such a task. The Desert Army always had long communications and was very short of transport. Whenever the claims of maps came into conflict with other commodities such as rations or ammunition, the maps were invariably left behind.

In the early days of Eighth Army this trouble was temporarily overcome by the use of transport belonging to the South African Survey Company which had moved up from East Africa. Field-section personnel of this unit were used as a "stop gap" emergency measure for map distribution purposes. The unit was fully mobile, and since its drawing and printing sections had a static role in Cairo during the period in question, there was a temporary surplus of unit transport available. It was obvious, however, that this temporary arrangement could not last, and that a new type of unit must be formed, with sufficient personnel and transport of its own to keep the flow of maps going to the forward troops. The war establishment of No. 2 Field Survey Depot was therefore amended before the advance of Eighth Army through Cyrenaica to include six map distribution lorries, one for each of the four divisions and one for each of the two corps headquarters. These lorries held replacement maps for the formations, and maps of the areas immediately ahead of current operations. Arrangements were made for map stocks which emanated from the base map depot to be supplied by sending consignments forward by train, air, road or sea, whichever was most convenient, to advanced map depots located at Matruh and Tobruk. From here stocks were fed to a forward map dump near Army H.Q. in the field. At this forward map dump lorries were available, and the dump acted as a link between the base and advanced map depots and the formation vehicles. Maps of areas in advance of those for which the formation vehicles could carry maps were held by this dump, and its lorries were used to replenish the formation vehicles. Without the forward map dump and its lorries the organization would have broken down.

The above organization, modified in some details, was subsequently adopted for use by the British First Army in North West Africa, and by the British Second and First Canadian Armies during operation "Overlord" in Europe during 1944-45.

CHAPTER VI

ITALIAN EAST AFRICA

The following maps and plates are relative to this chapter:

<i>Sketch Map 5. East Africa</i>	<i>Page</i>
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<i>Plates at end of book</i> {	
17. Eritrea 1:50,000	
18. East Africa 1:500,000	
19. East Africa 1:250,000	

SECTION 1. SURVEY ORGANIZATION AND NARRATIVE

Introduction

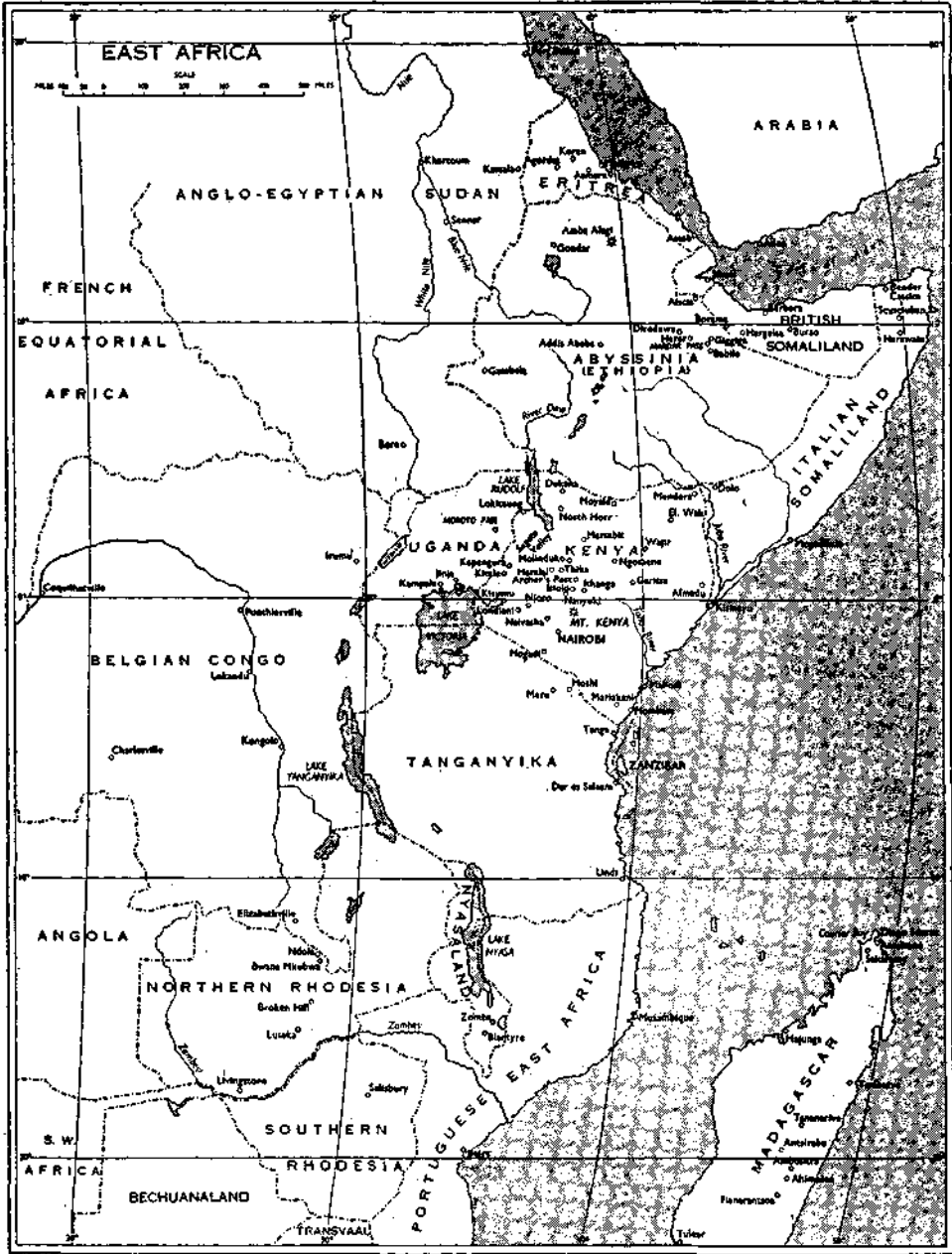
The pre-war status of Italy as an Axis partner made it practically certain that when convenient Mussolini would enter the war on the side of Germany. His opportunity came with the collapse of France and the withdrawal of the B.E.F. from Dunkirk, and Italy declared war on the Allies on 10th June, 1940. Broadly speaking, up to December, 1940, the initiative remained with the Italians, but in the four months between January, 1941, when we were able to take the offensive, and May of that year, a campaign took place which was remarkable for rapidity of movement, the vast distances covered, and difficulties of communications. The probable area over which operations might take place was a large one. With Italian Somaliland, Abyssinia and Eritrea it formed a solid block of territory with an area of over 1,000,000 square miles extending from the border between Kenya and Italian East Africa in the south to the northern boundary of Eritrea, and from the Anglo-Egyptian Sudan in the west to the Indian Ocean, British Somaliland, the Gulf of Aden, and the Red Sea in the east. Very little of this area had been properly surveyed, and there were large tracts for which little cartographic information was available.

The campaign was conducted in the form of two co-ordinated offensives, one from the north and one from the south. The northern operation against the Italians in Eritrea was under General Platt's command, based on the Sudan. The southern offensive against Italian Somaliland and Abyssinia, under the command of General Cunningham, was based on Kenya.

The primitive uncivilized nature of the theatre of operations with its variety of terrain, great distances and climatic difficulties, opened up a special and difficult problem for the Survey Service, which was composed of units from East Africa itself, the Union of South Africa, Southern Rhodesia, Nigeria and the Gold Coast, and the United Kingdom.

The northern operation in Eritrea

514 (Corps) Field Survey Company R.E. (under the command of Major H. S. Francis, R.E.) arrived in Middle East Command during the winter of 1940-41 and was immediately sent south to Khartum to operate with General

SKETCH MAP 5

Drawn by Ordnance Survey, 1951

Platt's forces against Eritrea. On its way south from Cairo it carried out some compass traverses including one of the route from Shellal to Wadi Halfa.

When it arrived in Khartum, planning was well advanced for the offensive against Eritrea, and there were many demands for miscellaneous mapping and other local surveys, including reconnaissance surveys for the Chief Engineer. Triangulation was undertaken to form a basic framework from which to carry forward a trig control during the advance on Keren, which was the key defensive position in Eritrea, and where it was expected that the Italians would put up considerable resistance.

The unit was equipped with standard lorry mounted reproduction plant which enabled much valuable map and other miscellaneous printing to be carried out, not only for the planning staff, but also for issue to the troops taking part in the operations.

There had been constant frontier clashes during the latter half of 1940, the Italians outnumbering considerably the British troops available from the Sudan. On 19th January, however, Kassala, an important British frontier post, was recaptured, and the offensive into Eritrea began. Agordat was taken on 1st February, and on the 3rd the advance towards Keren was continued. Movement was so rapid that the topographical sections of 514 Company were not able to keep pace in their attempt to carry forward the triangulation. Work on it was therefore suspended, and the unit moved forward to the Keren area where in the high mountain district fierce fighting took place before Keren itself was captured. During this period 514 Company established a triangulation control, based on captured Italian data, to cover our own positions, and intersected points in enemy-occupied territory for the fixation of targets required by the artillery.

For these offensive operations round Keren 514 Company produced a considerable number of maps, sketch maps and panoramas, including an excellent map of Keren itself, much of this work being compiled from air photos when they were available.

Keren was captured on 27th March, 1941, Asmara surrendered five days later, and Massawa was occupied on 8th April. Meanwhile in Abyssinia General Cunningham's forces, after a rapid campaign across the Juba River into Italian Somaliland, had struck north into Abyssinia and, with the capture of Addis Ababa on 6th April, and the surrender of the Duke of Aosta at Amba Alagi on 17th May, the campaign against the Italians in East Africa was virtually concluded.

On completion of its survey duties in Eritrea, 514 Company returned to Middle East Command, where it took part in the Western Desert Campaign. Its standard of mapping and survey work in preparation for and during the Eritrean operations was of a very high order.

Survey units taking part in the southern operations

- (a) *East African Survey Unit.* In March, 1939, when Hitler marched on Prague, a scheme was drawn up for the formation of a field survey unit in East Africa consisting of trained surveyors belonging to the Survey Division of the Tanganyika Department of Lands and Mines. These surveyors, who had joined the King's African Rifles (Reserve of Officers), were ready to take the field at short notice and consequently when the European war broke out in September, 1939, the unit could be mobilized for active service with little delay. Originally known as

the Field Survey Unit K.A.R., which title was altered at the end of October to 1 Field Survey Company, East African Engineers, it was mobilized on 1st September, 1939, and was located at Dar-es-Salaam. The personnel, which comprised practically the whole of the survey staff of the Department of Lands and Mines, were at first organized as a Headquarter Section, No. 1 Field Section, and a Map Reproduction Section. The initial war strength of the unit was dependent, not so much on the work it might have to do, as on the available personnel and equipment.

No. 2 Field Section was formed at Nairobi, the personnel being drawn from the Survey Departments of Kenya and Uganda. The formation of No. 3 Section was under consideration, embodying personnel to be drawn from Southern Rhodesia, when it became known that a separate survey unit was being raised in that Colony. The third section was subsequently formed in February, 1940. During the winter and early spring of 1940 the East African Field Survey Company was handicapped by shortage of personnel and by its own long lines of communication. Up to the end of April, 1940, its Headquarters and map reproduction section were at Dar-es-Salaam, the latter section being staffed mainly by civilians. No other facilities for map production were available at that period, and it was fortunate that the flat-bed offset machine belonging to the Survey Department was available. Later, when the East African Survey Group was formed with its own printing plant and personnel, the map reproduction section at Dar es Salaam was disbanded and returned to civil duties.

- (b) *Southern Rhodesian Survey Unit.* Early in March 1940, this unit, was mobilized at Salisbury (Southern Rhodesia). It was recruited from the staff of the Southern Rhodesia Survey Department consisting of licensed surveyors, survey assistants, mining surveyors and geologists, architects, draughtsmen and clerks. After a few days spent in training at Salisbury the Commanding Officer (Major J. E. S. Bradford) went on in advance to Dar-es-Salaam for discussions with the East African Survey Company Commander. Proceeding by road convoy the unit reached Nairobi on 28th March, after covering 1,650 miles in 13 days under bad weather conditions, and while in Nairobi East African native ranks and followers were obtained. European personnel were attached to the Map Reproduction Section at Dar-es-Salaam to gain experience of the work going on there, and to be trained in the reproduction processes with a view to the subsequent formation of a mobile map production unit.
- (c) *West African Survey Unit.* During July, 1940, the survey resources in East Africa were augmented by the arrival of a survey unit from West Africa. This unit was part of the Royal West African Frontier Force, and its personnel belonged to the Nigerian and Gold Coast Regiments. The officers were European personnel belonging to the civil survey organizations of the two colonies, and the trained surveyors, draughtsmen and lithographers were recruited from the native staff of the Nigerian and Gold Coast Survey Departments. It is worthy of note that the West African natives had, at that period, reached a far higher stage of technical survey development and training than had the East African, and they played a very important part in the work of the Survey Service in East Africa. Originally two separate detachments, controlled

respectively by Gold Coast and Nigerian Brigade Commanders, they were later combined into the West African Survey Unit.

- (d) *South African Survey Company*. This unit, composed of volunteers, came into existence some time after the outbreak of war. Mobilization was ordered in May, 1940, the strength of the unit then being 31 officers, one warrant officer, and 113 other ranks. It was known as the 1 (S.A.) Survey Company, South African Engineer Corps (S.A.E.C.). After a road and rail journey the unit reached Nairobi on 3rd August. An engineer survey officer of the Union Defence Force (Lieutenant-Colonel N. G. Huntly) was appointed A.D. Survey for the South African Force in East Africa and he acted as liaison officer with Force H.Q. on Survey matters affecting the South African units. He was incorporated into the Survey Directorate, East Africa Force Headquarters, when this directorate was formed in July, 1940.

The H.Q. sections of the unit included administrative and transport personnel, a geodetic (computing) section, a drawing section, and instrument repair and hygiene sections. Later, a photo-topo section was added and, in December, 1940, the lithographic personnel of the Army Printing and Stationery Service (A.P. & S.S.) was attached to the Survey Company for map reproduction purposes. Up till then this lithographic section of the A.P. & S.S. had been working independently and not under the control of the Survey Service. The balance of experience in most countries, both in peace and war, tends to show that there are overwhelming advantages in having map reproduction working under the same general control as the other processes entailed in the production of a map, such as the ground survey, the compilation, and the drawing. The various stages of map production require constant and close collaboration between the branches concerned and, even granting good liaison and co-operation between parallel organizations, there is no doubt that centralized control of all branches of survey and production, especially on active service, is desirable. As a result of this attachment three printing officers and about 50 other ranks were affiliated to the 1 (S.A.) Survey Company with their reproduction plant which was mainly mobile.

The personnel of the drawing section was drawn from various government, municipal and private drawing offices and, before leaving South Africa, some very useful and intensive training in topographical mapping was undertaken.

In the middle of December, two mapping sections arrived from the Union and were employed with the unit's photo-topographical section. These mapping sections had the advantage of about two years' training and experience in topographical work in the Union before the war, mainly on 1/25,000 mapping with and without air photos, but few had been trained as draughtsmen.

There were five field sections, each of four officers and 12 other ranks, with 20 or 30 African labourers. Their principal duties comprised triangulation and the fixation of control points for mapping, artillery requirements, and engineer purposes. In addition to the above sections a forward H.Q. and map depot were established and maintained from the end of August, 1940, till the end of March, 1941.

- (e) *No. 60 (Photographic) Squadron. S.A.A.F.* The importance of air photographs for mapping purposes needs no elaboration. These were of paramount importance in East Africa under active service conditions, owing to the scarcity of mapped detail over large areas of country, much of which was in enemy occupation and could not be surveyed by ordinary ground methods. During pre-war years, the use of air survey methods for economic development, mapping and geological reconnaissance had been rapidly increasing in the Dominions and Colonies, and in East Africa a lead had been taken by Tanganyika Territory where survey flights for such purposes were inaugurated in 1929.

In September, 1939, the survey aircraft in Tanganyika were taken over by the R.A.F., and during the first few months of the war no aerial photography was possible. A proposal that a Civil Air Survey Company, whose head office was in South Africa, should undertake the air survey of the northern frontier district was not sanctioned. In January, 1940, however, one of the Tanganyika aircraft which had been taken over by the R.A.F. was made available for the photography of certain areas in the northern frontier district using films and other photographic supplies provided by the Government of Zanzibar. Little was done, however, until the arrival of the South African Air Force (S.A.A.F.) personnel and equipment in July.

In June, 1940, No. 1 (Survey) Flight of the Photographic Squadron S.A.A.F. had been organized for operation in East Africa. Three Airspeed Envoy aircraft were flown up during June and July, but one was condemned as unsafe and could not be used, and another crashed *en route* killing all the occupants. Until the end of August, work was restricted, as only the one machine was available and the weather conditions were bad.

When the Survey Directorate (East Africa Force) was formed in July, the technical control of the Survey Flight came under D.D. Survey, and operational and administrative command remained with the Air Officer Commanding (A.O.C.) in East Africa. The function of this Flight was to take photographs of areas required by the Survey Directorate, to develop the films, and produce contact prints which were then handed over to Survey for the compilation of the maps by the photo-topo sections of the East African Group and the 1 (S.A.) Survey Company. Personnel of the squadron were attached to the latter unit to form a developing and printing section. In order to maintain effective co-ordination and liaison, a representative of the squadron attended the daily conferences which were held at the Survey Directorate.

One Anson aircraft was flown up to East Africa from the Union at the end of September, 1940, and in mid-October the one and only Airspeed Envoy, which had been carrying on a solo task, was flown down to the Union and a second Anson flown up in exchange. A third Anson came up in mid-January, but unfortunately one of the three was shot down a fortnight later.

The areas over which photography was required were now increasingly in places where the Italians could deploy fighter opposition. As a consequence the Ansons had to be taken off survey photographic missions and were used on map transport duties.

After being under warning notice for some time, 60 Squadron was transferred to Middle East in June, 1941, where it took over more suitable aircraft and proceeded to increase the reputation it had rightly earned during its sojourn in East Africa. In spite of so many difficulties and with limited resources, the never-failing efforts of pilots, ground staff and photographic personnel produced a great deal of most valuable and urgently required photography.

- (f) *Survey Directorate and East African Survey Group.* The Director of Survey, Middle East, who exercised a general control over survey activities in the East African Command, visited Nairobi during July, 1940, to study local survey conditions and to make recommendations for any necessary reorganization which he might consider necessary.

Up till July, the work of the East African and the Southern Rhodesian Survey units had been carried out independently of each other, though with a certain amount of liaison between the two officers commanding. The unit from West Africa had only just arrived and had not carried out much work as yet in the field. The impending arrival of the South African Survey Company and the presence of the air photographic resources of the South African Air Force, combined with the considerations stated above, made it obvious that some form of central Survey control was necessary. The War Office was asked to provide a Survey Directorate for Force H.Q., in order to control all Survey activities in East Africa. This was approved and, pending the arrival of the War Office nominee, the Commander of the Southern Rhodesian Survey Company (Major J. E. S. Bradford) was appointed to act as A.D. Survey.

It was also decided that an East African Survey Group should be formed, consisting of the three units from East Africa, West Africa, and Southern Rhodesia respectively. Major Bradford, while still retaining command of the Southern Rhodesian Survey Company, was appointed Commander of the Group. The 1 (S.A.) Survey Company was not at any time included within this Group but worked as a parallel organization reporting direct to the Survey Directorate at Force Headquarters which in fact, if not officially, included the A.D. Survey of the South African Force.

The object of this grouping was to enable the best and most efficient use to be made of the available technical resources of the various units. It should be noted that, in general, the separate units forming the Group had been raised and organized more or less on the basis of the personnel available rather than on any logical establishment based on probable survey requirements.

The general organization of the Group was to include a headquarters and depot as a semi-permanent establishment. This field H.Q. would undertake the provision and supervision of field parties, control the depot which would be a centre for refitting and reorganizing, and also act as a rest camp and training centre for both survey and military training. The lithographic production plant, together with the drawing and map compilation centre, were to be at Nairobi, near the H.Q. of the South African Survey Company. Arrangements were made for increasing the drawing strength of the Group by the addition of draughtswomen (civilians at first, but later recruited into the F.A.N.Y.), and

Asiatic draughtswomen who were civilians and were only employed on non-security work.

The Survey Directorate was established on 23rd July, 1940, and the Survey Group on 1st August, with Lieutenant-Colonel Bradford performing the dual functions of A.D. Survey and Commander of the Survey Group.

Survey conferences were held several times each week by Lieutenant-Colonel Bradford which were attended by Lieutenant-Colonel Huntly and the O.C. South African Survey Company. The O.C. 60 Squadron (S.A.A.F.) was called in whenever necessary. In his capacity as A.D. Survey Lieutenant-Colonel Bradford also attended the "Operations" conferences at Force Headquarters, and thus it was possible to keep survey activities and future planning in phase with operational requirements, and co-ordinate the work of the Survey Group and the South African Survey Unit.

Miscellaneous items of organization (Southern operations)

By the end of August, 1940, a central organization had been set up to deal with all survey records. It was known as "Central Survey Records" (C.S.R.). Later on it was found necessary to separate its various functions, and therefore, in December, 1940, three records branches were formed, known respectively as the Central Cartographic Records, Central Trig Records, and Central Photographic Records.

It was considered at the outset that field parties of the South African Survey Company and of the East African Survey Group would be best employed on trig and topographical work respectively in view of their weight of peace-time experience in these branches. By this arrangement, which was never a very rigid one, three sections of the South African Survey Company provided trig control for the topographical survey which was carried out by the units of the Group; another section was used for putting the existing Kenya triangulation in order, and also to train for artillery co-operation, and a fifth section was trained for topographical mapping. Later experience indicated that the wide professional training of the South African surveyors made it completely unnecessary to restrict them to trig work. They could, if it had been necessary, have been successfully employed at the outset on ground topographical surveys, and indeed they proved their ability later when they completed some very rapid and successful topographical field mapping of the El Alamein area in Egypt.

In a War Office letter to G.H.Q. Middle East in October, 1940, the technical responsibilities of the Survey Directorate (E.A.F.) were laid down. By these instructions D.D. Survey (East Africa) was made technically responsible for all survey and mapping connected with the operations of the East African Force. He was also made responsible for similar matters concerning Tanganyika, Kenya, Uganda, Nyasaland, Northern Rhodesia and Zanzibar, on which subjects he was to correspond direct with the War Office. Technical questions jointly affecting both the Middle East and East African Forces were to be resolved by D. Survey, Middle East Command, in consultation with the D.D. Survey in East Africa.

On 6th November, 1940, Colonel Hotine, the War Office nominee, arrived from the United Kingdom and assumed duty as D.D. Survey. Lieutenant-Colonel Bradford, who had been acting A.D. Survey pending Colonel Hotine's arrival, resumed duty as Commander, East African Survey Group. Colonel

Hotine was accompanied by a D.A.D. Survey (Major), one Captain (a map reproduction expert) and eight other ranks.

It was soon realized that map reproduction facilities were inadequate and would require greater co-ordination. The War Office was asked to send out a Map Reproduction Section R.E. and, in order to provide greater co-ordination with map production, the lithographic sections of the South African Army Printing and Stationery Services were attached to the South African Survey Company.

Divisional and Brigade Survey Sections

When offensive operations against the Italians started in December, 1940, it was decided to attach two officers of the East African Survey Group to the attacking force. They went into action with the 12 (A.) Division and 1 (S.A.) Brigade at El Wak, and the success of this attachment was influential in reaching a decision to form divisional and brigade survey sections, to deal with the conditions resulting from a 1,200-mile front, few and bad lines of communication, and large tracts of desert. Survey sections were formed and attached to 1 (S.A.) Division, 11 (A.) Division, and 12 (A.) Division respectively, to come under the operational control of the divisional commanders, though their technical control remained with D.D. Survey. Their tasks were roughly as follows:—

- (a) Preparation and reproduction of sketches to illustrate operational orders, etc.
- (b) Rapid sketch mapping from air photos of limited areas, the photos being taken by Army Co-operation Squadrons.
- (c) Fixation of position in bush areas, and the guiding of troops to their objectives.
- (d) Assistance, when necessary, with artillery surveys.
- (e) Assistance with map distribution.

In the case of the East African Group units, forward H.Q.s were established in the divisional areas. Each had a map store, and controlled the field surveys in the divisional areas. The survey officer at a forward headquarters was responsible for reinforcing the divisional survey section when necessary, and for its technical efficiency. He kept in touch with Divisional H.Q.s for these purposes, and assisted in all possible ways regarding surveys and map supply for the troops.

The South African Survey Company did not, however, establish a forward H.Q. in the area of the 1 (S.A.) Division. Arrangements were made for reinforcements for the divisional survey section to come direct from the South African Survey H.Q. at Nairobi. There was, however, a forward map depot, and the officer i/c the divisional survey section was responsible for the map supply of his division. Brigade survey sections were provided also by the South African Survey Company for the 25 (E.A.) Infantry Brigade and, later, for the 2 (S.A.) Infantry Brigade.

The period leading up to December, 1940, when active operations started, was a time of intense preparation and organization for the Survey Service. Mapping programmes, which are dealt with elsewhere, involved unremitting hard work for all concerned. Once started, the campaign was fought with

lightning speed. Throughout the ensuing months of fighting the survey staffs and executive branches were working literally night and day, often without rest for 48 or more hours at a time. There were many difficulties and temporary setbacks, which was to be expected when taking into account the rapid movement, ever lengthening lines of communication, and difficult means of transport over roads that were often impassable. The General Officer Commanding stated at the end of the campaign that the Survey Service never let him down, though there was one occasion when operational maps really did fail to reach the troops in time. This was for the battle at the Marda Pass. The maps were sent forward to the advanced area by air in plenty of time, and were duly unloaded on the airfield. By some mischance they were reloaded on a plane returning to Nairobi and, while the battle was being fought, they were discovered lying at Nairobi airfield!

With the capture of Addis Ababa on 6th April and the surrender of the Duke of Aosta at Amba Alagi on 17th May, 1941, the bulk of the Italian Army had been defeated and one of the principal objectives of the campaign had been attained. There was, however, plenty still to do before the operations could close down, and this applied to survey as to every other form of activity.

Other theatres were now clamouring for reinforcements, especially the Middle East. Colonel Hotine had relinquished his appointment as D.D. Survey East African Force towards the end of February, 1941, on being posted for duty in Greece, and he was succeeded by Colonel J. E. S. Bradford, who had been combining the appointment of East African Survey Group Commander with that of Commander of the Southern Rhodesia Survey Unit. The possibility of transferring some of the survey strength from East Africa to the Middle East was now being considered and, as a result of a recommendation submitted to the G.O.C. East African Force, the following moves and actions took place:—

- (a) 1 (S.A.) Survey Company moved to Middle East complete with all equipment and personnel, including the attached litho section. It was originally ordered to move by road about the middle of April, and left shortly afterwards. The unit was, however, recalled by Force H.Q. after one day's journey, and ordered to proceed by sea. Shipping was not available to move it until the end of June, 1941. After their departure, all reproduction work was undertaken by the East African Survey Group, which was shortly reinforced by a Map Reproduction Section R.E. from the United Kingdom.
- (b) No. 60 (Photographic) Squadron S.A.A.F., which had been doing such excellent work for Survey in spite of the lack of suitable aircraft, left for Middle East on 18th June. More suitable types of aircraft were awaiting them there.
- (c) A.D. Survey of the South African Survey troops (Lieutenant-Colonel N. G. Huntly) moved to Middle East for attachment to the Survey Directorate there.
- (d) The Central Trig Records, which had been controlled by the South African Survey Company, were handed over to the computing section of the East African Survey Group.

Enemy survey resources

Survey parties advancing with the field formations entered Addis Ababa on 6th April, 1941, and an advanced Survey Directorate was established there. An investigation was immediately made of the Italian Survey resources and quantities of survey instruments and equipment were found, together with large stocks of maps, map compilation material, and ample supplies of drawing office, photographic and printing stores.

Amongst the booty was the equipment of a map reproduction unit, including printing presses and a camera, though the lens from the latter was missing. There was also a well-equipped civil air survey organization and, though it was a private company, the director had been mobilized and the firm had been doing work for the Italian Army. Their offices were therefore taken over and the plant confiscated.

Reorganization of the Survey Service in East Africa

Colonel Hotine (late D.D. Survey, East Africa) returned to Nairobi from Cairo early in May, 1941, to arrange for the best application of the survey resources now remaining in East Africa to meet immediate needs and probable future military requirements. After investigation Colonel Hotine prepared a recommendation on the subject, taking into account the factors affecting the military situation, which were:—

- (a) Operations were continuing, and in view of the rainy season which was approaching, Italian resistance in difficult mountainous country might take a long time to overcome.
- (b) A British Military Mission was going to be established to arrange for the raising and training of Ethiopian troops.
- (c) The administration of the territory recently occupied would be a British responsibility.
- (d) Kenya would probably remain an intermediate base and training area.
- (e) It seemed possible that there would be an extension of the East African Command.

It was therefore necessary to maintain resources for carrying out field surveys and for improving existing maps, and it seemed clear that not only could the available resources be reduced no further but, on the contrary, they required some reinforcement.

The East African Survey Group, which alone remained in the Command, consisted of three units, none of which could operate efficiently on its own. Though it had been possible to operate successfully hitherto as a group, and though this could probably meet all foreseen requirements in East Africa with little reinforcement, the units could not usefully be employed elsewhere without complete reorganization and re-equipment. Consideration was given to the possibility of moving the Group as a whole to Addis Ababa, where it could make use of the Italian equipment, but it was considered better to bring the captured material back to Nairobi and retain the H.Q. of the Group there. It was recommended that the Divisional Survey Sections should revert to the operational control of the Group as soon as they were no longer required for active operations with divisions. The Survey detachment was to remain at Addis Ababa in order to form a link between the Survey Directorate and Advanced Force H.Q., the Divisional Survey Sections, the Administration of

Occupied Enemy Territory, and the Military Mission. It would also arrange for the evacuation of captured and requisitioned material from Addis Ababa to Nairobi.

With the altered operational situation it was considered appropriate to reduce the status of the Survey Directorate to that of a Corps type, with one A.D. Survey (Lt.-Col.) and one captain. At this time also proposals were submitted for an amended establishment for the East African Survey unit (now known as No. 55 Survey Company E.A.E.). Experience had shown that it was unbalanced in many directions, and it was only its embodiment in the Group that had allowed its potential survey strength to be used with efficiency. It was now desired to reorganize it so that it could operate fully as an independent unit. Recommendations of a similar nature were sent to the War Office regarding the 56 (West African) Survey Company which was to return to West Africa in August. In the case of No. 57 (Southern Rhodesian) Survey Company it was decided that no change in establishment should be made at that time.

Concluding notes

Although there remained a considerable amount of survey and mapping work to be done, the above summary deals with the principal items of survey organization for the campaign against Italian East Africa. Many of the difficulties, improvisations and hard "collar work" might possibly have been avoided by a more realistic and adequate pre-war consideration of probable requirements in case of war.

It would appear that more note might have been taken of the lessons to be learnt from the 1914-18 operations in East Africa, including the organization of adequate peace-time survey services in the Colonies, whose duty would have been to prepare good maps of potential operational areas. Apart from their requirement for war, such maps are a first essential for a proper economic development of any country. The development of a Colonial Survey Service on broader lines than heretofore seems to be essential.

The arrangements for collecting, in peace, copies of all maps produced by foreign powers were not good enough. Many captured maps were of a date that indicated that they should have been in the War Office map library some time before the war started.

Map reproduction facilities were a source of weakness. Arrangements might possibly have been made for some form of central map production establishment to have been set up, in peace-time, to serve the needs of the East African Colonies.

Although, under normal conditions, it was general policy that survey units should be controlled at army level, there seems to be no doubt that, under conditions such as applied in the East African campaign, the detachment of survey sections to divisions and even brigades, was justified. Under such circumstances the personnel must be well trained in rapid compilation from air photos, map revision and astronomical fixations, and must have some form of light portable reproduction plant. The sections should be small, very mobile and physically tough. They must be fully trained in all their technical and military duties.

SECTION 2. MAPS AND MAP PRODUCTION

Pre-war mapping situation

The potential area of operations in East Africa was a large one, including Kenya, Abyssinia, British, French and Italian Somalilands, and Eritrea, together with the border areas of Uganda and the Sudan. Very little of this had been systematically surveyed, and there were large tracts about which little topographical knowledge was available. About four-fifths of it was in Italian occupation and, though it was supposed, and later confirmed, that the Italians had carried out a good deal of survey work, little information was known about it until a later stage in the operations, when enemy map material was captured.

On the maps which were initially available from War Office sources the detail had been compiled from a variety of information. A small amount was based on accurate surveys. The remainder depended on travellers' route traverses, administrative officers' sketch maps, boundary commission surveys and other sources.

The following maps bearing various dates of publication by the War Office were in existence:—

1/2M. Standard African series covering the whole East African area. Sheets dated from 1936 (Juba River) to 1940 (Kenya), so were fairly well up to date, in so far as the revision material available at the War Office allowed them to be.

1/1,000,000. A series which covered Tanganyika, southern and north-western Kenya, and Uganda. There were no sheets covering Abyssinia or Italian Somaliland.

1/250,000. Parts of south-western Kenya and Uganda—31 sheets (1912–25).

1/250,000. British Somaliland—17 sheets (1934–39).

1/300,000. Tanganyika—34 sheets (1916).

Except for the standard African 1/2M series which covered the whole potential theatre, these maps were not of much value for operations in northern and eastern Kenya, Italian Somaliland and Abyssinia. There were also a few sheets at various scales which were not of any great operational importance, and one or two old Boundary Commission maps dating back some years.

In addition to their own G.S.G.S. map publications the War Office held in their map library sets of record copies of a certain number of foreign maps within the area, but it would appear from later evidence that these library sets were not as complete or as up to date as they might have been.

Probably the most up-to-date published maps of Abyssinia and Italian Somaliland were those of an Italian 1/400,000 series of which copies were on public sale in places such as Mogadishu, but only a very few of these sheets had been secured. During the five years of pre-war occupation of Abyssinia by the Italians, they carried out a great deal of mapping mainly from air photographs, and from 1938 onwards they published new sheets from time to time. It would appear probable that copies of these new productions might have been obtained by direct or indirect means from Addis Ababa or elsewhere in the territory but, as events turned out, it was not until the capital was occupied by British forces that copies were secured.

In the case of Madagascar and French Somaliland, it was presumably known that the French Service Géographique published new sheets at fairly

regular intervals, and yet the collection of record copies held in the War Office library in 1939-40 appears to have been incomplete and very largely out of date. For example, a sound and reliable 1/20,000 series in Madagascar covering Diego Suarez and its environs, including Courier Bay where a British force landed in May, 1942, existed in 1939, and could have been purchased anywhere in Madagascar, or direct from the French Service Géographique, but there was no complete library set held by the Geographical Section. Another unexpected but useful source of information was a set of 1/200,000 geological maps of Madagascar, up to date as at 1939. These maps were discovered in the Public Library, Johannesburg, and in the Geological Survey Offices at Pretoria and Salisbury, and copies were sent to the East African Force.

Early mapping activities

The entry of Italy into the war against the Allies was obviously a very real possibility ever since September, 1939. At that time there were some 39,000 square miles in the Northern Frontier District of Kenya, along the borders of Abyssinia and Italian Somaliland, for which there was no reliable topographical information. It would seem, therefore, that under such circumstances it would have been advisable, for defensive or offensive planning, to have concentrated survey resources as early as possible for mapping this area by a rapid survey in order to determine the positions of features important for military purposes, such as roads, tracks and water supply.

The East African Field Survey Company had been formed in September, 1939, and, as the strength of the military forces in Kenya at that time was such that a defensive policy would have to be adopted until reinforcements should arrive from West and South Africa, these limited survey resources were directed to the lines of communication and certain defensive areas. This work consisted of road traverses, astronomical and triangulation fixes to provide control, and the detail survey of such strategical points as the frontier camp at Moyale and other areas. Arrangements had been made in Southern Rhodesia for the formation of a Survey Company, but it was not until late in February, 1940, that H.Q. East African Force asked for this unit to be sent to East Africa. The unit was actually mobilized early in March and moved up by road. It was unfortunate that there was no survey representation at Force Headquarters in those early days to press the need for the early concentration of survey resources, and to advise how these resources should be employed to meet urgent mapping requirements.

Even when the Southern Rhodesian and East African survey units were both available together in Kenya they were employed during April and May, 1940, on the production of 1/100,000 maps, on regular $\frac{1}{4}$ -degree sheet lines and by normal ground methods, of areas which were not vital for impending operations. This, no doubt, would have been all right if the entry of Italy into the war was likely to be long delayed, but it was not covering the 39,000 square miles of unknown country along the Italian frontiers with maps which would be vitally necessary when active operations started. In actual fact, the two survey unit commanders made a joint recommendation to the General Staff that the policy governing this survey programme should be changed, and that rapid survey methods should be undertaken for the production of 1/250,000 or 1/500,000 maps where most urgently required. This recommendation was approved, but, if there had been a survey representative with Force H.Q., he

would have advised the General Staff that it was more important to have small scale maps of the whole potential area of operations, showing important tactical features, rather than a few well-mapped sheets on a larger scale, forming a solid block of survey over areas of less operational importance.

Rapid reconnaissance surveys to produce sheets of the Tana River area were carried out very quickly between about 25th May and 8th June, 1940, and the material was flown for reproduction by the map printing section at Dar-es-Salaam. By 14th June, copies of the maps were distributed. The maps were on the scale of 1/500,000, and were the forerunners of the standard series at that scale which became the regular issue for the fast-moving campaign in Abyssinia and Somaliland.

Mapping policy

When the Director of Survey, Middle East (Brigadier R. L. Brown) visited East Africa in July, 1940, he laid down certain general lines of mapping policy. Generally speaking, these instructions, though varied, amplified and altered in minor respects during the course of the campaign, remained the basis of all subsequent mapping programmes.

The policy, as then laid down, is summarized below:—

- (a) 1/2,000,000 series. This was the standard G.S.G.S. series of Africa. The Union of South Africa was asked to undertake the maintenance and printing of this series to the south of latitude 4° N.
- (b) 1/1,000,000 series. The Survey Service of the East African Force was to undertake the compilation, production and maintenance of this series on International sheet lines south of Lat. 8° N. This mainly concerned the area of potential operations and movement, at any rate during the early stages of the campaign.
- (c) 1/500,000 series. This was to consist of sheets compiled on a regular system of sheet lines measuring 2° each way, and was to be based on surveys of accessible areas, reconnaissance reports and any other map material that could be obtained. Special features were to be photographed from the air. Reference has already been made to the forerunners of this series, when sheets of the Tana area were surveyed by rapid reconnaissance methods by the East African and Southern Rhodesian Survey Units (Plate 18).
- (d) 1/250,000 series. Mapping on this scale was to be undertaken on regular 1° square sheet lines in all the more developed areas. The South African Survey Company was to undertake this task, and the first areas to be mapped were to include the Moroto Pass, Kapengura, Maralal, Archer's Post and the country towards Meru (Plate 19).
- (e) It was intended that survey parties should be disposed in such a manner that complete blocks of topography for the 1/250,000 and 1/500,000 series would be available in a comparatively short time.
- (f) 1/50,000 and 1/25,000. Use was to be made of the South African Air Photographic Unit for rapid air surveys of selected areas on these scales.
- (g) The projection was to be the Transverse Mercator, with grid belts having a width of 5° of longitude, with central meridians at 32° E., 37° E., etc.
- (h) Spheroid. Clarke 1880.

- (i) The East African grid system was to be on a yard basis, and the original intention was that it should extend northwards only as far as Lat. 8° N. This limit was, however, subsequently extended further.
- (j) It was recommended that civil map reproduction agencies, such as that at Dar-es-Salaam, should carry out such work as was required, in the manner to be laid down by the force commander.

Mapping programme (August, 1940)

By mid-August a mapping programme was drawn up, the work being split between the newly formed East African Survey Group and the 1 (S.A.) Survey Company. Early on the priority list were one 1/1,000,000 sheet and several at 1/500,000. In October, 1940, this programme was considerably extended, and included the production of 24 sheets at 1/500,000, 12 at 1/250,000, and 4 at 1/25,000 all to be completed by 10th December. The large scale maps were to cover Archer's Post, Isiolo, Marsabit and Nyambeni. Those on the smaller scales covered the frontier areas.

Grid system

A proposal which was made to H.Q. Union Defence Force, and agreed to by them, was that the East African grid system should extend as far as Lat. 12° S., and that, to the south of that latitude, the South African grid system should be used. The War Office, when informed about this, pointed out that this would leave Northern Rhodesia partly on the East African 5° belt system and partly on the South African 2° belt system. It was therefore decided that the East African grid should be carried south to the Zambezi River, leaving Southern Rhodesia and the Union of South Africa on the South African 2° belt. It was later agreed that the East African grid should extend northwards as far as Lat. 20° N.

Formation of Central Survey Records (C.S.R.)

At the end of August, 1940, a Central Survey Records organization was formed. Its main function was to maintain all survey records in an accessible form, to facilitate the distribution of survey information and data to all who required it, and for use at Survey H.Q. for map compilation.

The records comprised:—

- (a) Geodetic, astronomical and triangulation records.
- (b) Cadastral plans, original compilations from air photos, and plane-table sheets.
- (c) Air photographs and sortie diagrams.
- (d) Fair drawings and history sheets for all maps.
- (e) Secret maps, sketches and records used in map production.

At a later date, owing to the rapidly growing volume of work, it became necessary to subdivide this into three branches known as Central Trigonometrical Records, Central Photographic Records, and Central Cartographic Records. They operated under the technical control of the Survey Directorate.

During the period of rapid advance into Abyssinia, the production of maps of all kinds was maintained at very high pressure. The work of the photo-topo sections, who were responsible for the actual map compilation and

fair drawing from photographs, produced a constant flow of maps, all of which passed through the hands of the Central Cartographic Records (C.C.R.). A series on 1/250,000 scale was in course of preparation in February and March, 1941, embodying the latest information from maps which had been captured as the army advanced through Somaliland to Mogadishu and thence northwards to Harar and Addis Ababa. Every effort was made to issue maps at least one jump ahead of the troops, but movement was so rapid that it became necessary to stop work on those maps which overnight became of back area interest, and jump ahead of the troops once more. This 1/250,000 series, when completed, covered practically the whole of the eastern part of the operational theatre, including a revision of the existing G.S.G.S. series of British Somaliland.

Further mapping policy decisions

A second mapping conference was held by D. Survey, Middle East, in Nairobi in mid-November, 1940, when the following decisions were taken:—

- (a) The northern limit of the East African grid system was to be 20° N.
- (b) The responsibility for the local production and maintenance of the 1/2,000,000 series was to be limited to sheets lying to the north of Lat. 4° N., the Union of South Africa dealing with sheets to the south.
- (c) The East African Survey Service was to be responsible for the production of the 1/1,000,000 series as far north as Lat. 8° N., beyond which Middle East would assume responsibility.
- (d) East Africa was to be responsible for the production of all maps on scales larger than 1/1,000,000 for its own operational area.
- (e) Arrangements were to be made for the exchange of captured map material between East Africa and Middle East.
- (f) The map printing resources of the East African Survey Group were to be strengthened. To this end a request was sent to the War Office asking for a Map Reproduction Section R.E. to be sent out.

Map reproduction organization

Experience during the 1914–18 war and subsequently has shown that, for the most efficient application of modern map production methods, it is desirable that all the stages that go towards the making of a map, from the survey on the ground to the final photography and printing, shall be under the one basic control. This principle was followed when the British Military Survey Service was organized and built up on mobilization, and it was arranged that field survey units should be self-contained with sections capable of undertaking field surveys, compilation and drawing, and the reproduction and printing of the fair drawn map.

In East Africa the East African Survey Group had some hand-operated plant, and were supplied by Middle East with some more up-to-date machinery, though the latter required some additional European reproduction personnel in order to function properly. These resources were, however, inadequate to deal with the mapping programme which lay ahead, and the arrival within the theatre of the lithographic section of the South African Mobile Printing Company proved a valuable asset.

In the Union of South Africa the peace-time topographical maps were not printed by the Survey Department, as in most other countries, but by the

Government Printer, who was responsible for both letterpress and lithographic printing. On mobilization the Government Printer had become the Director of Army Printing and Stationery Supplies (D.A.P. & S.S.) in the Union Defence Force and, with the above-mentioned mobile printing unit he proceeded to East Africa as an organization which was quite separate and distinct from the Survey Company. The latter, therefore, did not have under its own control any map printing resources of any sort.

On technical grounds it was clearly necessary that both the East African Survey Group and the 1 (S.A.) Survey Company should be completed as self-contained mapping organizations by the addition of photographic and lithographic reproduction resources. To meet this requirement for the East African Survey Group, the War Office, as stated above, was asked to send out a Map Reproduction Section R.E. With regard to the South African Survey Company, the D.D. Survey (Colonel Hotine) took immediate steps, after his arrival, to recommend to the General Staff that the photo-litho section of the A.P. & S.S. should be attached to the Survey Company. This recommendation was approved and put into immediate effect.

At a later date, after the occupation of Addis Ababa, captured Italian printing plant was made available to add strength to the printing facilities.

Spelling of place names

In accordance with Middle East practice the spelling of place names conformed to the territory in which the places were situated, *i.e.* English spelling in Kenya, and Italian spelling in territories under Italian occupation. After January, 1941, however, it was decided to include in addition the more usual, though perhaps less accurate, spelling of certain places, *e.g.* Chisimaio (Kismayu).

Reproduction of captured maps

Captured maps continued to come in as the advance progressed, and much useful information was obtained in Mogadishu, but it was not until the fall of Addis Ababa that the great bulk of Italian map material became available.

Captured maps were forwarded to Survey H.Q. at Nairobi and were carefully examined, first of all with a view to the reproduction of those Italian maps which were required immediately for current operations and secondly with a view to using the information for the new production and revision of the East African publications.

Much of the captured material consisted of compilations from air surveys undertaken by the Italian Coniel organization which was operating in Abyssinia, and the fair drawings, generally the result of work with their Santoni stereo-plotter, appeared to be of a high standard.

To illustrate the speed with which the reproduction of Italian maps was undertaken, it is recorded that in May, 1941, 17 captured maps were reproduced, chiefly by direct photo-lithographic methods, without grids but with the marginal information translated into English, and were ready in 36 hours for immediate issue to the troops in the field.

Further notes on the East African mapping programme

Throughout the months of preparation, and during the period of the campaign itself, map production continued at very high pressure on the lines

laid down in the original policy. In addition to the regular 1/500,000 series, which included 62 2° sheets covering the whole battle area, there were 38 sheets on 1/250,000 scale, and a vast number of maps on larger scales of specific areas or places which were produced from air photos and ground surveys by field and divisional survey sections. In April, 1941, it was decided to extend the 1/500,000 series to the north of Lat. 12° N., and it was eventually carried up to Lat. 18°, taking in the whole of Eritrea.

By June, 1941, when the pressure of work had somewhat subsided, it was clear that, with the new information which was available from a variety of sources, a revision of the 1/500,000 maps could be undertaken. At the same time as this happened 56 (W.A.) Survey Company was placed under orders for transfer to another theatre, but alternative drawing reinforcements were expected in the shape of a drawing section from 512 (Army) Field Survey Company R.E. from Middle East. A revision scheme was accordingly drawn up at the end of June to deal with the whole of the 1/500,000 series. In some cases there was no further information to add to the existing editions but, in the majority of cases, a great deal of new information was available, both in the form of mapping material and also with regard to ground control for air surveys. During the course of the campaign, numerous extensions had been observed to the triangulation, and many new astronomical fixations had been determined.

Gazetteer

Before the 1 South African Survey Company was transferred to the Middle East, it had completed a gazetteer for use with the 1/500,000 map series. This contained over 23,000 place names, for which grid references were given. Its compilation took about 3,000 man-hours in addition to a further 600 man-hours for subsequent checking.

Air survey activities

Though field survey parties in East Africa were able to cover large areas by car reconnaissance, their operations were necessarily limited owing to the size of the potential battle area, and by the fact that they could work only to a very limited extent in enemy territory. It was thus apparent that air survey methods would be of the utmost importance.

A few areas in the northern frontier district of Kenya were photographed early in 1940, but little was done until the arrival of No. 1 Survey Flight of the S.A.A.F. in June, 1940. For its technical work this Flight came under the control of the Survey Directorate, but operational and administrative command remained with the Air Officer Commanding in East Africa. No. 1 Survey Flight later became No. 60 (Photo) Squadron S.A.A.F.

The photographs taken by 60 Squadron were used mainly for mapping work carried out at Survey H.Q. in Nairobi. In the field photographs were taken by Army Co-operation Squadrons and these were used by divisional and brigade survey sections for the rapid production of maps. Many of the maps were of the hasty sketch map type, which were constantly and urgently required by the troops for day-to-day operations, especially when faced with an enemy defence position and the prospect of a battle, or when some special topographical feature such as a river lay ahead.

The photography of certain river lines, defence positions and training areas formed one of the first tasks of the Survey Flight. In November, 1940, the following survey photography was ordered:—

- (a) The Somaliland boundary area, in the form of strips 14 miles apart.
- (b) Block photography for 15 miles on either side of the Marsabit-North Horr-Dukana road.
- (c) Extensions to the Marsabit defensive area.
- (d) Portions of the Omo River in southern Abyssinia.

The air survey of road strips and specific objectives in enemy territory went on ceaselessly so long as weather conditions and equipment permitted, and most of the routes by which the army advanced into Italian Somaliland were mapped from the air. Meanwhile other photography continued in northern Kenya and southern Abyssinia, so that it was possible to map considerable stretches of the Italian lines of communication and of the country round Lake Rudolf.

In December, 1940, as referred to earlier, a Central Photographic Records section was formed in Nairobi from personnel of the photo-topo sections of the East African Survey Group. Records of all air survey work were kept here, whether the compilation was done by the Survey Group or by 1 South African Survey Company.

During all its photographic operations the Survey Flight was much handicapped by a shortage of personnel, aircraft, spares and equipment, and suffered a severe loss when one of its aircraft was destroyed near Afmadu in Italian Somaliland.

In February, 1941, the aircraft situation was somewhat eased by using personnel and camera equipment of the Survey Flight in Glen Martin aircraft belonging to, and piloted by, personnel of 14 Squadron S.A.A.F. During the rapid advance northwards through Abyssinia, the squadron did most valuable work behind the enemy lines. However, by March, 1941, the lack of replacement aircraft brought these activities to an end.

In spite of the shortage of equipment and other resources 60 Squadron had played a vital part in the campaign, and its contribution in providing photographs for map production was of the highest order. This entailed high-pressure work and the utmost co-operation between the photographic staff, the photo-topo sections who did the compilation and drawing, and the printing sections who, often working for 48 hours at a stretch, produced the maps for an urgent operation in a minimum of time. The following is a typical example of such a job:—Photographs taken over the operational area or behind the enemy lines would perhaps reach Nairobi on, say, Monday evening. By midnight the development of the films and the production of prints would be completed, and the photo-topo sections were busy on compilation. Their drawings would be ready for reproduction by Tuesday night, and the printed map stocks would be handed over to the Survey Directorate for distribution in the small hours of Wednesday morning. The consignment required by the troops would be taken to an airfield nearby and sent forward by air to its destination, reaching the hands of the users probably about 48 hours after the photographs had been taken.

During the period when this urgent air-photo mapping programme was being undertaken, the photo-topo mapping sections of both the East African Survey Group and the South African Survey Company worked in the closest

collaboration, and the whole work of production was centrally controlled through the Central Cartographic Records section, whose officers constantly checked the work as it came from the photo-topo sections.

The great speed of the advance and the consequent lack of information of the exact requirements of divisions naturally introduced difficulties with regard to the production of air survey maps at Survey H.Q. at Nairobi. The large staff of compilers and draughtsmen who are necessary for the rapid preparation of maps of extensive areas could obviously operate only at the base, where also there existed facilities for rapid printing. The need for strip maps of roads lying along the probable axes of advance could generally be foreseen and provided for, but these usually did not cover a broad enough survey on either side of the road when a battle had to be fought. Even with a survey representative attached to divisional headquarters, it was often impossible to obtain information of detailed requirements early enough to allow of the preparation and distribution of special maps to all concerned in time. The road strip maps were regarded only as the initial route plans of the advance, to be supplemented by block photography when additional information as to enemy positions could be obtained.

Some of the above problems concerning the supply of urgent air surveys of battle areas were largely solved by the employment of division and brigade survey sections. The latter were able to produce maps when even the division survey sections were not close enough to complete them in time. Using photographs taken by Army Co-operation Squadrons, and working in close co-operation with brigade staffs, they were able to map enemy positions within a few hours of the receipt of the photos, and orientation and scale were checked up on the ground by the surveyors. The photographs taken by the Army Co-operation Squadrons were not up to the high survey standard of those taken by No. 60 (Photo) Squadron, whose personnel were highly skilled in this specialized branch of air photography, but even so, the maps of small areas so produced on the spot in small quantities proved invaluable. The maps were drawn in a bold exaggerated style when for infantry use, as distinct from those of a more conventional form which were required for artillery purposes. Thus hill features were depicted by exaggerated form lines, roads were shown by very heavy lines and, whenever possible, the maps were printed on a portable "Ditto" machine so that colours could be used.

Maps of enemy positions, with a reproduction of the actual air photographs shown alongside, were found to be very useful and, where the lack of reproduction equipment in the field did not allow of this, a set of photos was, if possible, supplied to the brigade or battalion commander for use in conjunction with the map.

SECTION 3. TRIANGULATION AND FIELD SURVEYS

An account of the original basic triangulation work in Kenya and its progress between 1906 and 1914 will be found in the *Historical Outline and Analysis of the work of the Survey Department of Kenya Colony* (Williams), published by the Government Printer, Nairobi.

With an average triangular error of less than two seconds, the observations appear to have been good, but the scale depended on one short measured base of 1.3 miles only in length, and the work was computed piecemeal instead of

on a well-organized comprehensive system. Here and there some figure adjustments were made and, although some check bases were measured, no adjustment was made for them and they were considered only as a check against gross errors.

This basic triangulation was projected in Cassini Soldner co-ordinates in 2° belts, the origins being the intersections of the odd-numbered meridians with the Equator. The Clarke 1858 figure of the earth was used and the unit of measurement was the British foot.

For military surveys carried out in connection with the operations, an East African war system of co-ordinates was adopted. The projection selected was the Transverse Mercator (Gauss Conformal), in 5° belts, e.g. 30° to 35° E., 35° to 40° E., etc. A scale factor of 0.05 per cent (1/2,000) was introduced, giving a scale error of 1/2,000 at the central meridian of each belt, zero at about 1° 49' on either side of it, and 1/2,200 at the extremities. The figure of the earth adopted was Clarke 1880, and the unit of measurement the British foot. To derive the military grid co-ordinates, feet were converted to yards, and 5,000,000 yards added to the northings and 450,000 to the eastings, thus ensuring that all grid references would be positive.

The basis of this East African war system was a closed loop of triangulation around Mount Kenya known as the Mount Kenya circuit. This loop consisted partly of a chain of triangles belonging to the basic Kenya triangulation, and partly of another chain, picked out from various independent triangulations observed during the early war period by the East African Survey Group and the South African Survey Company. This closed loop formed the basis for the computation of the existing Kenya work and the extensions therefrom. The origin of the Mount Kenya circuit was the trig station at Molinduko, the latitude and longitude of which were taken from the Kenya Survey Department's records and converted to Transverse Mercator co-ordinates using Clarke's 1880 tables. A length and azimuth for the side Molinduko-Ithanga were taken. The heights, as taken from the Kenya records, were not altered.

It is of interest to note that a feature of the computation of the East African war system was the use of "error contours" graphs in the process of adjustment, a useful and quick expedient which was used also in other theatres for various analogous purposes.

Observations for astronomical fixations formed a marked feature of the work in East Africa. They were required for the control of plane-table surveys and road traverses, and for the determination of position in bush or featureless country in connection with the guidance of troops to their objectives. The Daventry "pips" were used as wireless time-signals for astronomical observations. The accuracy of the "pips" was guaranteed to ± 0.2 second and, in general, consistently good results were obtained.

The records relating to triangulation were maintained by the Central Trigonometrical Records Section. The data were kept in an easily accessible form so as to be available to any one requiring this at short notice. This section also undertook the indexing, examination and filing of the data obtained amongst captured survey material. Enemy records supplied much useful and interesting information, and it was apparent that the Italians were fully alive to the value and importance of survey data in connection with military operations.

Although the bulk of the triangulation work was carried out by the South African Survey Company, it will be noted, from what follows, that the other

survey units took a fair share in the establishment of mapping control at one time or another. Some of the special tasks carried out are given below. The list is very incomplete and is given only to serve as an example of the sort of work undertaken.

- (a) *Sugota Valley.* In September, 1940, 1 South African Survey Company began the extension of the Kenya triangulation northwards along either side of the Sugota Valley, and this was pushed forward over a wide area to the frontier district bordering on Abyssinia.
- (b) *Marsabit area.* A local triangulation system was observed by the East African Survey Company in the Marsabit area. A short base was measured, and position was determined by astrolabe observations for latitude and longitude at one end of the base, where an azimuth was also taken. This local system was later connected to the Kenya triangulation.
- (c) *Isiolo chain.* The East African Survey Company also observed a local chain of 18 stations in the vicinity of Isiolo. This depended on five points of the Kenya triangulation, of which the latitudes and longitudes were taken from the Kenya records, and were converted to Transverse Mercator with the Clarke 1880 tables. An extension to this chain was later observed by 1 South African Survey Company, who also carried out a local triangulation to the north of the Isiolo chain for topographical work in the Archer's Post area.
- (d) *Isiolo-Marsabit chain.* This was observed by the East African Survey Group, and extended from the Kenya triangulation in the Isiolo area as far north as the Marsabit system. Additional fixations to the south and west were observed by the South African Survey Company.
- (e) *Ngomene area.* A triangulation was observed in the Ngomene area by the Southern Rhodesia Survey Company before it was incorporated into the East African Survey Group. The basis of the work was the Kenya network, and the co-ordinates of the initial stations were calculated from the latitudes and longitudes taken from the Kenya records, but converted to give them the values they would have had if the Kenya triangulation had been computed on the Clarke 1880 spheroid instead of the 1858.
- (f) Further triangulation was observed to fulfil the following purposes:—
 - (i) To control the survey of a training area at Njoro, where points belonging to the existing Kenya network were used by the East African Survey Group as a basis for their new work.
 - (ii) To control surveys in the Moyale area. For this local system, observed by the East African Survey Company, a 6,000-foot base was measured, and latitude, longitude and azimuth were observed.
 - (iii) To control air surveys at North Horr and Lokitaung. These two systems lay to the east and west respectively of Lake Rudolf. The Lokitaung system depended on a well-chained base over five miles long. Both systems were observed by the South African Survey Company, and an extension to the Lokitaung series was made by the East African Survey Group.

In August, 1941, a field party started work on a triangulation to connect the Lokitaung series in North West Kenya to the Uganda network, which was dependent on the geodetic chain of the 30th Meridian Arc. The intention was

to pick up the floating triangulation in the extreme south-eastern corner of the Anglo-Egyptian Sudan, of which certain points were common with the Lokitaung series. It was also proposed to connect across Lake Rudolf to the North Horr system, and thus to make a connection with the projected chain of triangulation along the Kenya-Abyssinia border. A connection with the Marsabit series would afford an opportunity of bringing the triangulation into touch with the East African war system.

For most of the triangulation work, the time factor was of the utmost importance, and methods had to be used which would give the required results in the minimum of time. Precision of observation depended therefore on whether the work was to be used as a triangulation from which extensions would be run, or whether it was to be used solely as control for plane-table or air survey mapping.

Field sections found on the whole that for rapid work the use of helios was impracticable for the following reasons:—

- (a) The simultaneous occupation of stations involved too many technical personnel, too much equipment and too many escort parties.
- (b) The reoccupation of certain stations could not be conveniently arranged.
- (c) Arrangements for detailed organization and timing were not possible under the existing operational conditions.
- (d) The means of communication between distant stations were too difficult.

Opaque signals were therefore generally used during rapid triangulation, and the length of sides was limited to 15–20 miles, depending on atmospheric conditions. Timber quadrupod and tripod beacons, with brushwood above and white calico below the neck of the signal were found to be satisfactory.

When triangulating for air-photo control over limited areas, where sides did not exceed ten miles, the use of flags observed eccentrically was found satisfactory, and for this type of work reduction to centre was not necessary.

On primary triangulation, with sides of from 30 to 50 miles, observing at night on to 5-cell torch batteries was found to give good results, but could only be used when five or six experienced observers were available. To ensure success, a very thorough preliminary reconnaissance was essential, and a system of signalling by morse code was necessary in order to control the showing of lights, etc.

In the rapid mapping of large areas the method of traversing roads by tacheometer was too slow. Also it was found that refraction and haze caused by the great heat adversely affected the use of optical instruments for this work. To achieve greater speed, use was made of a motor-car speedometer to measure the traverse legs, direction being measured by theodolite. It was necessary to run the car on a standard 30-lb. tyre pressure, and to establish, by trial and error over a measured distance, a factor which could be used to correct the recorded mileage. By this means about 20 miles of road a day were measured.

SECTION 4. MAP SUPPLY AND DISTRIBUTION

The East African campaign produced its own peculiar problems regarding map distribution, due very largely to the wide extent of the operational area, the long lines of communication between the map-producing organization and

the forward troops, the speed of the advance and the difficulties of transport, especially during the rainy season.

In the early days of its existence, the East African Survey Group, which included the East and West African and the Southern Rhodesian Survey units, undertook the distribution of the maps which it produced and the South African Survey Company undertook the distribution of maps by means of its own transport.

By November, 1940, the problem of map supply and distribution to the field formations was assuming such vital importance that the General Staff, acting on technical advice from Survey regarding availability, decided on the scales of issue, and what maps (scale, area and type) would be required for a particular operation. Responsibility for distribution was delegated to the Survey Service at Force H.Q., which was to arrange for direct issues to units under headquarter command, and for issues in bulk to divisions and to the Air Force. The intention was that, during mobile operations, distribution would be controlled by the General Staff, who alone had sufficient information regarding locations of units to ensure distribution without delay.

The D.A.D. Survey on the Survey Directorate was placed in charge of map distribution, and arrangements were made for the transfer of map stocks held by A.P. & S.S. At that time the main stocks were at Nairobi, where a bulk map store was established in the vaults of the National Bank of India. All maps, as they came from the printers, were delivered to the above store and, immediately a new sheet was received, a routine distribution was made to units and formations without further instructions except in the case of secret and most secret maps. A monthly list of new publications was distributed to all concerned.

It soon became apparent that, owing to the enormous area covered by the operations, and the need for quick issues as new areas were entered, some form of decentralization was essential to ensure rapid and efficient distribution to the forward troops. Forward map depots were therefore set up as close as possible to the H.Q.s of the divisions taking part in the advance. A Survey officer was placed in charge of each and, during December, 1940, the following map depots were put into operation:—

- No. 1 at Kitale for 25 Brigade area.
- No. 2 at Nanyuki for 1 South African Divisional area.
- No. 3 at Garissa for 12 West African Divisional area.
- No. 4 at Bura for 11 West African Divisional area.

They were mainly concerned with the distribution of the standard map series. Special operational maps were despatched from Nairobi direct to the formations concerned, with the co-operation of the divisional and brigade survey sections.

The normal stock held by a forward map depot was 1,000 copies of each sheet of the 1/500,000 series covering the divisional area (1/500,000 being the standard operational map for the East African campaign), 100 copies of the sheets of the same series outside the divisional area, and from 100 to 200 copies of the smaller scale 1/M and 1/2M series. Small stocks of other published maps were carried. This represented about two-thirds of a divisional issue and was intended to cover wastage and replacements. The provision of a complete issue to a new division was arranged for by Survey H.Q. at Nairobi.

Requisitions for maps were passed through Divisional H.Q. for check and

approval, to O.C. Forward Map Depot. The maps were bundled ready for issue, and divisions arranged for transport to units. The detailed arrangements for distribution within the division were made by the G.S.O. 3, with the O.C. Map Depot acting in an advisory capacity. In case of great emergency, provision was made for issue direct to units or individuals without reference to Divisional H.Q., but normally direct application to the Map Depot was strongly discouraged.

In addition to the issue of maps, it was the duty of the Map Depot officers to collect surplus maps from outgoing units or formations and, after destroying those that were unserviceable, to sort and put the remainder back into stock. The guiding policy, which was strongly impressed on the Map Depot officers, was that the Survey Service existed to assist the fighting troops to the best of its ability, that maps were of little value until they actually reached the hands of the users, and that it was better to give double ration than to allow a unit to go into action with no maps at all or too few. They were also instructed to keep all concerned in their area fully and regularly informed of the maps which were available in the depots.

When 11 (A.) and 12 (A.) Divisions advanced into Italian Somaliland, Nos. 3 and 4 Map Depots were soon too far behind to be of value. Their stocks were therefore amalgamated, and a single depot moved forward early in March and was established in Mogadishu. Progress of operations gradually reduced the usefulness of the Kitale and Nanyuki depots, which were successively closed on 8th March and 7th April respectively.

Air transport was used largely for conveying maps in bulk from Nairobi to the forward areas and, though the reservation of aircraft accommodation was sometimes difficult to obtain, this method worked satisfactorily.

It has already been noted that, as operations became more mobile and movement more rapid, the map depots were too far back to function efficiently. At this stage the divisional and brigade survey sections took over the job of distribution. No attempt was made to hold large stocks, as supplies were being flown up regularly from Nairobi, and lorries were being used as mobile map stores. It was found that general distribution of the 1/500,000 map on the full scale of issue was not only impracticable but unnecessary. The fighting units experienced difficulty in the storage and transport of full scale issues, many of which, owing to the speed of the advance, were not used. Smaller and more frequent issues of sheets required for immediate use were therefore made and distribution was effected at the request of Divisional H.Q. This, in fact, became one of the most important tasks of these small units.

When Addis Ababa was captured, and an Advanced Survey Directorate was set up there, a Map Depot was also established. Stocks were replenished by supplies sent up by regular air service from Nairobi.

The depot at Mogadishu was closed on 16th June, and on 26th July the bulk map store at Nairobi was given up.

CHAPTER VII

PERSIA AND IRAQ

The following maps and plates are relative to this chapter:—

	<i>Page</i>
<i>Sketch Map 6. Persia-Iraq</i>	166
<i>Plates at end of book</i> { 20. <i>Iran $\frac{1}{4}$ inch to 1 mile</i>	
	21. <i>Iraq 1:50,000</i>
	22. <i>Iran 1:25,000</i>

SECTION 1. OPERATIONAL BACKGROUND

The war was not going too well for the Allies at the beginning of April, 1941. The German invasion of Yugoslavia made it necessary for a British Expeditionary Force to be sent over to Greece, already hard pressed by Italian forces operating through Albania. Simultaneously, Field-Marshal Rommel counter-attacked in Libya, forcing the Desert Army, which had occupied Benghazi, to retreat back into Egypt. The subsequent evacuations from Greece and Crete completed this somewhat gloomy picture.

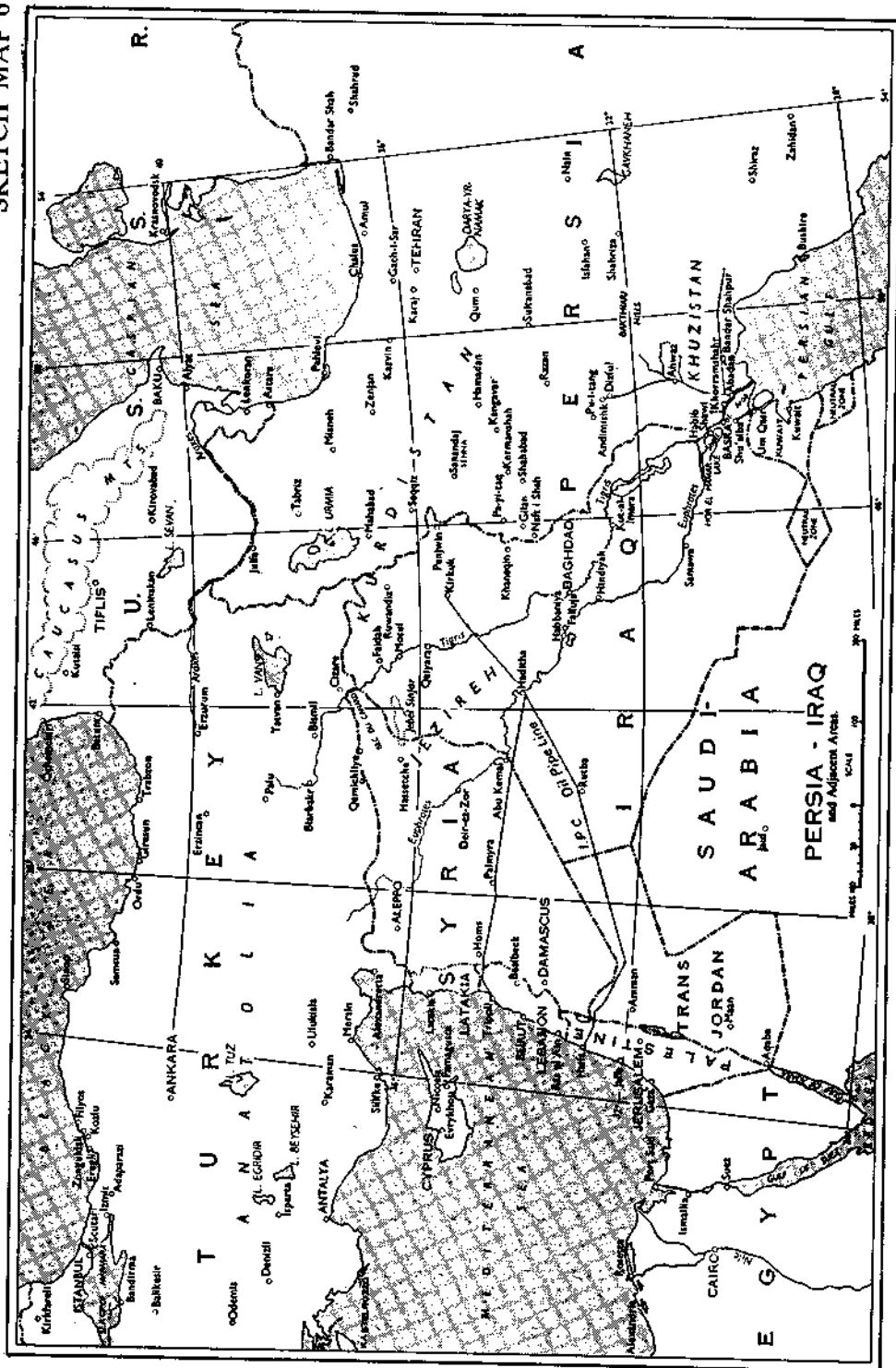
Enemy propaganda in Iraq had for some time been very active and German agents had succeeded in their efforts to seduce certain military and political elements in the country. At the critical moment under review this pro-Axis element in Iraq, headed by Rashid Ali, staged a revolt against the Regent.

The rights given to Great Britain by the 1930 Treaty included the maintenance and use of certain stations by the R.A.F., one of these being at Habbaniya on the Euphrates, about 45 miles west of Baghdad. Iraq had been granted independence and, apart from the personnel at these R.A.F. stations, there were no British troops in the country. To prevent it from falling under German control the despatch of troops to Iraq was now essential. Fortunately, at that moment a force consisting of one Indian infantry brigade with ancillary troops and one field regiment of artillery was embarking at Karachi for Malaya, and this force was diverted, reaching Basra on 18th April. A small airborne force of infantry landed at Shu'aiba at about the same time. There were numerous incidents in the Basra area, but no organized resistance.

On 7th May, Lieutenant-General E. P. Quinan reached Basra from India and took over command of all British land forces in Iraq. On the same date Force Headquarters and the Headquarters of 10 Indian Division and of a second Indian infantry brigade reached Basra.

The initial directive issued to the Force Commander was as follows:—

- (a) To develop and organize the port of Basra so as to ensure the maintenance of such Allied forces as might be required to operate in the Middle East, including Egypt, Turkey, Iraq and Persia.
- (b) To secure control of all means of communication, including airfields and landing grounds, and to develop these to the extent requisite to enable the port of Basra to function to its fullest capacity.



The Force Commander was further instructed to plan a system of defences to protect the Basra Base against attack by armoured forces supported by strong air forces, and to take steps to protect the R.A.F. installations at Habbaniya and Shu'aiba, the lives of British subjects in Baghdad and elsewhere in Iraq, the Kirkuk oilfields, and the pipe-line to Haifa. He was also to ensure the safety of the Anglo-Iranian Oil Company's installations, and its British employees in South West Persia if found necessary.

To carry out these tasks it was intended to increase the force up to three infantry divisions and possibly one armoured division as soon as such troops could be sent from India.

On 30th April, 1941, two of Rashid Ali's infantry brigades from Baghdad, supported by artillery and armoured cars, concentrated round Habbaniya and threatened the R.A.F. camp there. Hostilities broke out on 2nd May, when the camp was shelled, and the situation daily became more critical. One battalion was flown up from Shu'aiba to Habbaniya to reinforce the garrison and, on 6th May, with extensive support from R.A.F. bombers based on Habbaniya itself, and with wholehearted support from the Iraq Levies who were stationed there, the plateau overlooking the camp was cleared, and the Iraqi troops retired to Falluja.

Early in May operational control passed to Middle East Command and a small mechanized force of all arms was despatched from Palestine, arriving at Habbaniya on 18th May. Falluja was occupied and the combined British force advanced on Baghdad. The Iraqis asked for an armistice on 31st May.

20th Indian Infantry Brigade reached Baghdad by overland route from Basra on 12th June, and 21st Indian Infantry Brigade, after sailing up the Tigris to Kut, arrived at Baghdad a week later. By the third week in June the Headquarters of 10 Indian Division was established in Baghdad with the Headquarters of 20th Indian Infantry Brigade in Mosul and one battalion guarding the Kirkuk oilfield. Detachments were sent out to Haditha, Rutba and Falluja to release troops who had come over from Palestine and Trans-Jordan.

Back at Shu'aiba there were the 25th and 17th Indian Infantry Brigades and a medium battery R.A. One battalion was protecting the lines of communication to Baghdad and a fourth Indian infantry brigade was landing at Basra. With the collapse of the Rashid Ali régime, and the improved situation in Iraq, operational control reverted to the Commander-in-Chief, India, on 18th June.

Syria, under Vichy French control, was a source of great potential danger. It was of vital importance that the Germans should not establish airfields or other bases there. Early in June, 1941, Imperial and Free French forces moved from Palestine into Syria, the main thrust being along the coast towards Beirut. The plan included also a concerted thrust from the east, and General Quinan was asked to provide two Indian infantry brigade groups which should move up the Euphrates valley from Iraq into Syria. He was also asked to protect the railway from Iraq to Turkey where it ran through Syrian territory. This involved a redistribution of troops, including the move northwards of fresh formations which were arriving at Basra, so as to ensure the safety of the oil installations, to maintain effective control in Iraq, and to protect the lines of communication while the Syrian operations were in progress.

Advanced Headquarters of 10 Indian Division reached Abou Kemal on 30th June, and operational command of the columns advancing into Syria

passed to the G.O.C. Palestine and Trans-Jordan. Meanwhile a small force was assembled at Mosul for operations in the Bec du Canard to clear the Qamichliye-Hassetché-Ras el Ain area of Vichy troops, to secure the use of the railway to the Turkish frontier, and to attack the northern flank of the French forces in the Jezireh, thus establishing a threat towards Aleppo.

Happily this unfortunate episode in Syria did not last long, and fighting ceased on 12th July. 10 Indian Division (less 20th Indian Infantry Brigade which was back in the Mosul area) remained in Syria until released for subsequent operations in Persia. It reverted to command of the G.O.C. Troops in Iraq on 10th August, 1941.

On 22nd June, while the operations in Syria were still continuing, Germany attacked Russia on a wide front from the Arctic to the Black Sea. During the weeks following, as German armies pushed eastwards into Russia, overran Greece and Crete, and surged towards Egypt, the strategic situation in Iraq and Persia became more and more critical.

The end of hostilities in Syria and the German advance into Russia resulted in a changed situation in Iraq. A revised directive was issued to General Quinan on 29th July, 1941; his new instructions were, broadly speaking, as under:—

- (a) The object was to hold northern Iraq against any enemy attack coming through Turkey and/or Persia, and to develop facilities for the maintenance and employment in Iraq of a force which might amount to 10 divisions and 30 squadrons of the R.A.F.
- (b) Plans were to be prepared for holding the northern frontier of Iraq against hostile advances through Anatolia or Persia. Permanent defences in this area were to be sited so as to deny the main lines of approach by enemy armour into Iraq from Turkey or Persia so as to slow up the advance and force it into unsuitable country. Plans were also to be drawn up for an advance into Turkish or Persian territory so as to seize defiles and to carry out extensive demolitions.
- (c) A force was to be held ready to enable the occupation of Abadan and Naft-i-Shah to be carried out at short notice.
- (d) Basra Base was to be developed to maintain 10 divisions and 30 squadrons R.A.F., and Um Qasr and Koweit were to be developed as subsidiary ports.

It will be noted here that the potential area over which maps and survey might be required for operational and administrative purposes was being greatly expanded.

Mention has been made of the activities of German agents and propaganda in Iraq. They had been no less busy in Persia, where the strategic prize was so valuable. In addition to the oilfields, which were of such essential importance to the Allies operating in the Middle and Far East, Persia formed a land link between East and West, and also the only remaining land link between the Allies and Russia. German fifth-column activities were increasing rapidly and, when the Persian Government refused to accede to Allied representations that they should expel the Axis agents, it was necessary to take action to enforce their expulsion.

A striking force was concentrated on the Persian frontier in the Basra area consisting of:—

- (a) 8 Indian Infantry Division.
 - One mechanized cavalry brigade.
 - Two Indian Armoured Regiments.
 - One Army Co-operation Squadron R.A.F.
- } To occupy the refineries
and oilfield at Abadan.
- (b) Two companies of infantry with naval support to occupy Bandar Shahpur and seize the port and shipping.

Abadan was occupied with little serious opposition and, after occupying Khorramshahr, 18th and 25th Brigade Groups moved on towards Ahwaz early on 28th August.

Further to the north another operation was launched by two Indian armoured brigades on the night of 24th/25th August. Based on Khanaqin, the object was to secure the Naft-i-Shah oilfield and the Pa-yi-taq Pass through which ran the route to Tehran 600 miles distant. The southern of the two columns, after securing the Naft-i-Shah oilfield, pushed on through Gilan to Shahabad on the Kermanshah road. The northern column found the Pa-yi-taq Pass strongly defended, but with air support this was cleared and the two columns joined up at Shahabad and moved on to Zabiri. The planned attack on this position never took place as, on 28th August, a truce was agreed. Kermanshah was occupied by a detachment to secure the refinery and, on 30th August, 2nd and 9th Armoured Brigades entered the town. Contact was made with the Russians who were advancing towards Kermanshah and Hamadan from the north.

On the conclusion of hostilities in Persia the plan for dealing with the situation in that country was as follows:—

- (a) To station troops in Hamadan, Kermanshah, Shahabad, and thence along the lines of communication to Khanaqin.
- (b) To hold Khuzistan with the minimum of forces with headquarters at Ahwaz, and with a detachment at Sultanabad.
- (c) All troops not required in Persia to return to Iraq.

Tribal risings in Persian Kurdistan were dealt with by active patrolling by 9th Armoured Brigade from Senna and Kermanshah, and by 21st Indian Infantry Brigade between Kermanshah and Khanaqin. Khuzistan remained quiet, and most of the troops in that area were withdrawn to Iraq.

As the Persian Government still failed to surrender the Axis nationals British and Russian forces made a simultaneous entry into Tehran on 17th September, 1941.

The Headquarters of 6 Indian Division with 27th Indian Infantry Brigade arrived in Basra on 12th September with orders to relieve 8 and 10 Indian Divisions in Khuzistan and West Persia.

A reduction of forces took place at the end of September when 9th Armoured Brigade from Tehran and 5 Indian Division (less one brigade group) from Kirkuk began to return to the Middle East Command. On 18th October, both the British and Russian troops withdrew from Tehran, the former moving to Sultanabad and Hamadan.

During the winter of 1941–42 work continued on the construction of the fortress area in northern Iraq and in Persia. 6 Indian Division (less one brigade) remained in Persia, the whole of 8 Indian Division and two brigades of 10 Indian Division being employed on the defences in Iraq. One brigade each of 6 and

10 Indian Divisions were on protective duties in the Basra-Shu'aiba Base area, on the lines of communication Basra—Baghdad and Baghdad—Habbaniya—Rutba, in Kirkuk, and guarding the oil pipe-line. The 2nd Indian Armoured Brigade Group concentrated in Northern Iraq in November. In spite of severe winter conditions, good progress was made on the defence areas.

At the end of October, 1941, plans were prepared to receive in Iraq two British divisions, also eight squadrons of aircraft for later despatch to the Caucasus. 50 Division (less one brigade group which remained in the Middle East Command) began to arrive in Iraq in mid-November and concentrated in the Kirkuk area. At this time, when the Germans were driving hard towards Kharkov and into the Crimea, General Quinan received a new directive which gave as his primary task the defence of Iraq and Persia against an enemy advance from Anatolia or the Caucasus. In this he was to act in close co-operation with the Ninth Army in Palestine and Trans-Jordan. He was to be prepared for the following possible operations:—

- (a) Operations in Anatolia in co-operation with troops of Middle East Command and possibly also the Turkish Army.
- (b) Co-operation with the Russian Army in the defence of the Caucasus and North Persia.

To meet these contingencies he was to be prepared to maintain 10 divisions and 30 squadrons R.A.F. in Iraq and up to six divisions in Persia. He was also to develop all road, rail and river communications necessary to maintain these forces, and to ensure also the maximum possible deliveries of supplies and war material to Russia.

Changes in the general strategic situation made it necessary to send 50 Division back to Middle East Command, and its move from Kirkuk began on 12th January, 1942. On the same date operational control in Iraq and Persia once more passed from India to the Middle East Command. The forces under General Quinan's command then became the Tenth Army.

The arrival of part of 4 British Corps in Iraq during January, 1942, gave a temporary increase of strength, but this was short-lived. Part of the Corps was actually diverted to India while *en route* from the United Kingdom; the remainder, after a very short stay in Iraq, was sent on to India before the end of February and became 4 Indian Corps.

In February, 1942, revised instructions were issued from G.H.Q. Middle East to Ninth and Tenth Armies. With the limited force available it did not appear feasible to stop a hostile advance in strength through Persia and Syria, so the intention was to impose the maximum delay in order to gain time for reinforcements to arrive. If the enemy should come down from the north with superior forces, Tenth Army was to fight delaying actions and hold them on a rearward line through Dizful, Pa-yi-taq and Abou Kemal, extending westwards towards Damascus in Ninth Army area. This would mean abandoning extensive defensive positions round Mosul, and concentrating all efforts on strengthening new positions in Central Iraq.

By May, 1942, the German advance in Russia had reached a stage which made possible an enemy attack from the Caucasus through Persia. It was essential to ensure the safety of the airfields, bases, ports, oil supplies and refineries in Iraq and Persia. The plan was that Tenth Army should hold up the enemy as far forward as possible by sending light forces up to the river Araxes so as to cover the airfields in northern Persia. In any event the enemy

was not to be allowed to establish himself south of the general line Pahlevi-Kazvin-Hamadan-Senna-Saqqiz-Ruwandiz Gorge. The Russian High Command would not grant any facilities for Tenth Army to reconnoitre and prepare the ground in North Persia which was in the zone of Russian control, but reconnaissance parties were sent forward and, after establishing good relations with the Russian troops on the spot, collected some of the essential information.

Preparation of defences and communications went on steadily and, at the end of May, 1942, the Germans launched their expected spring offensive in Russia. Simultaneously German forces attacked in Cyrenaica, and the danger grew more immediate. Initial enemy successes in southern Russia during the summer of 1942 made it still more likely that they might occupy the whole of the Caucasus and invade Persia. Rommel's successes in Egypt, which took him to within 50 miles of Alexandria, not only made it impossible for forces to be moved over from the Middle East Command in case of need, but actually led to the withdrawal of troops, equipment and transport from Tenth Army to reinforce Eighth Army in Egypt.

Early in August, 1942, it was estimated that German forces might reach the R. Araxes in North Persia by late October. This caused a speed-up of defence preparations in the area. It was vital that the enemy, after his Caucasus successes, should not be allowed to follow up by striking at the oilfields and installations at the head of the Persian Gulf.

A separate Persia-Iraq Command was formed during September, responsible direct to the War Office, and the Commander, General Sir Maitland Wilson, established his General Headquarters in Baghdad on 15th September. His principal tasks remained, as before, to secure the oilfields and installations in Iraq and Persia from land and air attack, and to ensure the transport of maximum supplies from the Persian Gulf to Russia. The only troops available to meet an invasion consisted of two Indian divisions of two brigades each, and one Indian armoured division, all being under strength and short of transport. In addition Polish personnel who, with 3 Carpathian Division already in the Middle East, were to form the Polish Army, were assembling at Khanakin after evacuation from Russia. To augment this force 5 and 56 British Divisions were diverted to the Command, to be followed by 7th (British) Armoured Brigade from India and 5 Indian and 3 Carpathian Polish Divisions from the Middle East Command.

By the end of September, 1942, owing to Russian resistance at Stalingrad, the likelihood of a winter campaign in North Persia was receding, and the earliest date by which the enemy might reach the R. Araxes was put at 15th November. The available troops for defence were located mainly in the Persian Highlands about Hamadan and Kermanshah, where the winter climate was severe. The force in Persia was therefore reduced to one division with one motor brigade located at Qum and Andimishk, the remainder of the force being moved back to winter training locations on the Iraq railway.

Towards the end of November, the Eighth Army victory at El Alamein, the opening of the Allied offensive in North Africa, and the more favourable course of operations in Russia made a German threat to northern Persia during the winter most unlikely. The earliest date for possible operations was now estimated as about mid-April, 1943.

By this time also the strength of the force in the Command had been increased to two British divisions, one British armoured brigade, three Indian

divisions, one Indian armoured division, and one Polish division. By agreement with the Iraq Government it was arranged that the Iraq Army would deploy two divisions for the defence of the passes leading from the Lake Urmia area into northern Iraq, in co-operation with the Polish Army to whom the defence of that region was entrusted.

Though the eventual possibility of an enemy attack through northern Persia was the dominating consideration, there was always the chance that he might attack through Anatolia in the spring of 1943. Plans for the employment of Tenth Army in northern Iraq were always, therefore, kept under review.

As the months passed the Russian victories and the successful Allied operations in North Africa rendered a general threat to northern Persia in 1943 more and more unlikely. This, combined with Allied pressure and successes in other theatres, led to a reduction of the forces in the Persia-Iraq Command. In January, 1943, 5 (British) Division went to Middle East Command followed by 56 (British) Division in February. The remaining formations were regrouped and located in the Mosul-Kirkuk area, and on 17th February General Sir Henry Maitland Wilson left the Command, being succeeded by Lieutenant-General Sir Henry Pownall. Headquarters Tenth Army returned to India in April, 1943.

The activities of German fifth column agents and the lawlessness of certain Persian tribes made it necessary to undertake armed reconnaissances in addition to the guarding of installations and lines of communication. The possibility of a turn in the tide of war also could not be overlooked, so it was essential to maintain plans and arrangements for sending troops into northern Persia at short notice if so required.

The fortunes of Paiforce improved month by month during 1943. Though the immediate danger of enemy invasion had gone, Iraq and Persia still constituted a most important and valuable strategic geographical centre. Forward planning with a view to serving other theatres both in troops and resources could now be undertaken, and the flow of material aid to Russia was stepped up in face of continuing climatic and other difficulties. The arrival of American transportation units, magnificently equipped and trained, was a most welcome addition for the operation of the railways, ports and road haulage in Persia. Demands for oil reached fantastic heights and, in two years, half a million tons of spirit went through to Russia. The transport of material and supplies to the Russians ended in 1945, by which time 5,000,000 tons had passed through Persia.

The above brief summary of the activities in the Persia-Iraq Command is sufficient to indicate the vast area over which there was a potential requirement for maps, both for operations and for administrative purposes. Some details of the mapping and survey work undertaken are given in the following pages.

SECTION 2. SURVEY ORGANIZATION AND NARRATIVE

The pre-war survey situation in Iraq and Persia

An account of the survey work carried out in Iraq and Persia during the first world war is given in the "Records of the Survey of India, Vol. XX (The War Record 1914-20)," published by the Survey of India in 1925.

The results of those surveys were published in map series on $\frac{1}{4}$ -inch and

$\frac{1}{4}$ -inch scales. The former extended generally from Long. 40° E. eastwards to Afghanistan and India, and as far north as Lat. 40° N. There were various gaps, notably in south-western Iraq. The $\frac{1}{4}$ -inch series covered less extensive areas, but was based for the most part on systematic surveys. It proved to be of considerable value as a basis for revision during 1941-42.

Before the 1914-18 war there were no triangulation systems in either Iraq or Persia. During that war a large amount of triangulation was observed, but it was disjointed in character, and much of the work, especially in Persia, was of inferior quality. It was on this control that much of the mapping work during the 1914-18 war had been based.

A valuable legacy of the first world war was the Iraq Survey Department, which had been established under the technical direction of Survey officers from India. Between the two wars this Department observed a system of primary and secondary triangulation covering the more highly developed parts of Iraq. This was of the utmost value in 1941-43 as a basis for extensions by military surveyors both in Iraq and in Persia. There was also a large amount of minor triangulation in Iraq which had been observed before the primary and secondary networks, but which had not been adjusted to them. A levelling net had also been observed over certain parts of Iraq.

In Persia, although some scattered areas had been covered by triangulation of reasonable quality, they had not been properly connected together or to the Iraq framework.

It was laid down, therefore, during the 1941-42 campaign, that all new triangulation or other forms of control which might be established should be connected directly with the Iraq primary or secondary networks wherever it was possible to do so. All new work was therefore adjusted and computed in these terms except in the valley of the Euphrates near the Syrian frontier, where there was no Iraq geodetic work available till the late summer of 1942. In that area connection was subsequently made between the Iraq triangulation and that of Tenth Army, so that the latter could be adjusted and expressed in the fundamental terms.

Until about 1929, the Iraq Survey Department, whose chief function was the execution of 1/50,000 and larger scale surveys for land settlement and revenue, kept up the $\frac{1}{4}$ -inch maps and extended the surveys on this scale. After 1929 the work had to be abandoned through shortage of trained personnel.

Other surveys of good quality had been carried out by surveyors of the oil companies, and they were incorporated in the $\frac{1}{4}$ -inch maps between the two wars, but their extent was very limited and, by 1941, both the $\frac{1}{4}$ -inch and $\frac{1}{2}$ -inch maps were much out of date.

The Survey of India was responsible until 1929 for the upkeep of maps to meet operational requirements as far west as Long. 40° E., but in that year the War Office assumed responsibility as far east as Long. 48° E. All originals and other records of the $\frac{1}{4}$ -inch and $\frac{1}{2}$ -inch maps of this area were transferred from India to the War Office in that year.

The Cairo Survey Conference (April, 1940)

In April, 1940, the Director of Survey, Middle East Command, held a Survey conference in Cairo at which Colonel E. O. Wheeler represented the Survey of India. Amongst other items the mapping and survey requirements for Iraq and Persia were discussed, and the following decisions were reached:—

- (a) India was to resume responsibility for surveys, computations and mapping on $\frac{1}{4}$ -inch and larger scales as far west as Long. 40° E., and between Lat. 40° N. and Lat. 28° N. The southern limit of India's area was to extend eastwards along Lat. 28° N. from Long. 40° E. to the shores of the Persian Gulf, which it was to follow eastwards to India.
- (b) Two overlapping Lambert metre grids were to cover Iraq and neighbouring areas, each grid zone forming a belt of about 8° in latitude. The Clarke 1880 spheroid was to be used.
- (c) As the $\frac{1}{4}$ -inch was recognized as being the most important military map, every effort was to be made to bring it up to date from the best material available. It was considered impracticable to bring the $\frac{1}{2}$ -inch map up to date as well as the $\frac{1}{4}$ -inch.
- (d) The production of a new 1/50,000 series covering the developed parts of Iraq and south-western Persia was to be undertaken, largely with the assistance of revenue surveys, and air photographs taken by the Anglo-Iranian Oil Company.

To implement these decisions, action was taken without delay. The Survey of India called for record copies of all $\frac{1}{4}$ -inch sheets to be sent out from the War Office pending the acquisition of the original material. Survey officers from India and the Middle East Command met in Baghdad where they arranged details regarding the proposed grid system, and also investigated the triangulation situation. At the same time a detachment of computers from the geodetic branch of the Survey of India was sent to Baghdad in order to determine and adjust the common stations between the minor work and the Iraq geodetic triangulation, so that the former could be converted to the same terms as the latter.

While the above work was going on in Baghdad, the Indian geodetic branch converted all the existing trig data of Iraq into terms of the two overlapping Lambert grids. At the same time an attempt was made, using the common points and connections established between the various systems by the Baghdad computing detachment, to adjust all the trig data, both in Iraq and in Persia, to bring it into line with the Iraq geodetic triangulation. This was successful in the vicinity of the geodetic network but, near the western frontier of Iraq and in Persia, the poor quality of the original material and other causes made the attempted adjustment in these areas valueless. Trig lists were published.

The computing detachment in Baghdad completed its task only about two weeks before the outbreak of Rashid Ali's revolt, and there were inevitable delays in the receipt of mapping material in India. Despite intensive action by all concerned, both trig data and mapping preparations were far from complete when the small Expeditionary Force sailed for Basra in April, 1941.

Record copies of all available 1/50,000 and larger scale maps were acquired in Baghdad and sent to India. These were much out of date, especially with regard to roads and railways. Arrangements were also made to obtain from the London office of the Anglo-Iranian Oil Company copies of air photographs which they held covering parts of Persia. These were used for revision of the $\frac{1}{4}$ -inch sheets and for the production of the new 1/50,000 series. As soon as the record copies of maps had been received from London, new editions of the $\frac{1}{4}$ -inch sheets were put in hand in India, and work was begun on the 1/50,000 series of Iraq and south-western Persia.

With regard to the new map sheets which were to be produced in India, a decision had to be reached on the problem of what sheet lines were to be adopted. As in other theatres, this provoked argument and counter-argument. The reader is invited to turn to Chapter XII, Section 3, where some comments are made on a similar problem which arose in connection with the maps of Greece.

The pre-war $\frac{1}{4}$ -inch and $\frac{1}{2}$ -inch maps of Iraq and Persia were on graticule sheet lines, bounded by meridians and parallels, and were not, therefore, rectangular in shape. When work was begun in India on the 1/100,000 series the sheets were laid out on a rectangular grid line system in order to conform to the 1/50,000 series which it abutted at the outset and which was likely to be absorbed subsequently.

While production of these two series went ahead in India on a grid sheet-line basis, the Survey Service in Iraq found it necessary to take up the local production of certain 1/100,000 sheets to meet an urgent demand, together with the concurrent revision of the $\frac{1}{4}$ -inch sheets. Every device had to be used to ensure speedy production. The Survey Directorate in Baghdad obtained the original drawings for the $\frac{1}{2}$ -inch maps from the Iraq Survey Department, and the the quickest and easiest procedure was, therefore, to produce the 1/100,000 series as half-degree sheets, conforming to the national $\frac{1}{2}$ -inch maps, and to incorporate field corrections. To use grid-sheet lines as was being done in India would have involved much extra labour. It was decided in Iraq, therefore, to adopt as standard the graticule half-degree lay-out for the new 1/100,000 series and to scrap all the work that had been done in India on grid-sheet lines. Subsequent experience proved this to be wise.

Arrival of Survey unit in Iraq

The first Survey unit to reach Iraq was No. 1 Indian Field Survey Headquarters, under the command of Lieutenant-Colonel J. B. P. Angwin, R.E., who acted as A.D. Survey of the Force until the arrival of a D.D. Survey. This small unit, consisting only of a headquarter section and a general section, including about six surveyors and draughtsmen, landed at Basra on 10th May, 1941, three weeks after the arrival of the Expeditionary Force, taking with it a stock of maps with which to open up a map depot. Its only map-producing equipment was a sun-printing outfit. The strength of the general section was sufficient to deal only with the map stocks which had been brought and, by working at very high pressure, to meet the many miscellaneous survey demands which at once arose.

Almost its first task was to produce a sketch map of the Habib Shawi area, a few miles north of Basra, where there was some trouble with the rebel force. This was compiled from air photographs, some of which had been taken by naval reconnaissance aircraft, and other miscellaneous material; 25 sun-prints were made and issued, a small beginning to what later became a busy and extensive map production agency. There was also a revision of a 1/10,000 sketch map of the Basra-Shu'aiba area, previously compiled in India from air photographs, which was issued with corrections marked up in red ink.

Owing to a case of cholera the arrival of No. 1 Indian Field Survey Company was delayed for some weeks, and the small headquarter unit was left unsupported during this important early period.

Survey Headquarters moves to Baghdad

Large map stocks now began to arrive from India, and a second officer was called for and was flown in as reinforcement. At the outset the claims of the Survey Service to adequate accommodation for map storage lacked recognition amongst the claims of other services, but the need was continually stressed until an old palace on the bank of the Shatt-el-Arab, alongside the unit, was allotted and was converted for use as a map depot.

On 3rd July, after the rebels had been rounded up, A.D. Survey, with about half his unit and a stock of maps, moved to Baghdad with Advanced Force Headquarters. Here again strong pressure was necessary to secure accommodation for map stocks, and to provide technical operating space for the incoming Indian Survey Company. Excellent accommodation was ultimately allotted.

A comprehensive record section was established, whose primary duty was the collection of useful survey and mapping material from every available source. There were the Iraq Survey Department maps which were used for incorporation in the $\frac{1}{4}$ -inch and 1/50,000 series. There was also a lot of material obtainable from the oil companies and other sources which had not previously been used, and whose existence had been unknown in India. Much valuable help in this connection was received from Mr. Booth of the Iraq Survey Department, who placed the material and data in his possession at the disposal of the Survey Service. Of particular value were the originals of the $\frac{1}{2}$ -inch maps which, though out of date, provided a basis for the 1/100,000 series.

Meanwhile the operations in Syria had broken out and there was a demand for sketch maps showing desert routes in the Euphrates Valley near the Syrian border. Some of these had originally been prepared by geologists of the Iraq Petroleum Company, and they were reproduced for use by the columns which moved into Syria from Iraq. These desert routes were not marked on any of the published maps, and the reproduced sketch maps proved of great value in assisting the outflanking movements into Syria.

Surveys in the Basra Base area

Soon after the departure of A.D. Survey to Baghdad in July, survey work was required for the Basra Base defence plan. Much of this area was desert, so desert beacons, consisting of bitumen drums, were placed in position at selected points, and their co-ordinate positions were determined and marked on them in white paint. In the absence of visible detail from which to resect position, fixations were made by car and compass traverse. These beacons were used as reference points to assist in the siting of the defences. Lines of levels were surveyed to ascertain areas of possible flooding from the Hor-el-Hamar lake. An important survey job in connection with the defence scheme was the field revision of 1/50,000 sheets covering the area. Conditions for work were very trying, with shade temperatures often exceeding 120° F.

Early survey work in Persia

When our troops entered Persia in August, 1941, to enforce the demand for the expulsion of German agents, No. 1 Indian Field Survey Company had only just reached Baghdad. It was immediately faced with many urgent tasks, including the reproduction of several $\frac{1}{4}$ -inch sheets from black pulls. On

arrival, this unit had only one double-demy hand-fed rotary press driven from a power lorry. Fortunately, it was possible to arrange for rotary converters to be installed so as to utilize the main Baghdad electricity supply. This one machine was a constant source of anxiety in case it should break down in the middle of an urgent programme and, when No. 4 Indian Field Survey Company's reproduction group arrived at Basra in November, equipped with two double-demy presses in trailers, one of them was immediately sent up to Baghdad.

Ground survey sections and detachments carried out reconnaissance surveys in West Persia for the correction of major communications on the existing maps. The survey parties, which were based on Kermanshah, Sultanabad, and the Dizful-Ahwaz area, worked on a system of rapid reconnaissance revision, corrections being made with reference to local detail, and a definite time-limit was set to the work in each area. In some places the map detail was so inaccurate that fixations could not be made from it. Car and compass traverses were therefore run, being tied in at both ends to fixations which appeared to be reliable. This system, though not precise, effected great improvements to the maps in a reasonably short time, and permitted the publication of interim editions. One interesting method, used probably for the first time under active service conditions, was a rapid traverse by mechanical transport from Qum to Tehran, using the Hunter short-base technique.

On the conclusion of the armistice in Persia, a goodwill mission was sent to Tabriz to meet the Russians in the hope of effecting co-operation in survey tasks. The surveyor who accompanied this mission was able to carry out some useful reconnaissance surveys along the line of march through the Ruwandiz Gorge and up the east side of Lake Urmia.

Arrival of D.D. Survey in Iraq and some problems of organization

At the end of October, 1941, Colonel G. F. Heaney reached Baghdad from India, and assumed duty as D.D. Survey of the British Forces in Iraq. By December, the survey units available comprised four small headquarter units and three Indian Field Survey Companies. Two of these latter (Nos. 1 and 4) had reproduction groups. No. 2 Indian Field Survey Company had no reproduction group. The organization of these units was briefly as under:—

An Indian Field Survey Headquarters was commanded by a Colonel or a Lieutenant-Colonel, depending on whether his appointment was that of a D.D. Survey or an A.D. Survey. It consisted of a headquarter section of clerical staff and orderlies, and a general section for technical work. Other sections, such as drawing, map supply or survey park sections might be added as found necessary.

An Indian Field Survey Company consisted of a headquarter section, a general section, two ground survey sections, an air survey section and, where desirable, a reproduction group.

It was quite clear that to meet the dated requirements of the General Staff, the survey resources for ground and air survey and for map production would be fully strained. All air survey, drawing and map reproduction was therefore concentrated in Baghdad under No. 1 Indian Field Survey Company. Only the ground survey sections were left with the other units, and those of No. 1

Company were attached to Nos. 2 and 4 Companies respectively. No. 2 Company began work in the field during November based on Mosul, and No. 4 Company, based on Kirkuk, started three weeks later.

With the arrival of D.D. Survey and his headquarter unit, and two more A.D.s Survey each with his headquarter unit, defects in the organization became apparent. D.D. Survey had been rightly regarded as being on the staff of Force Headquarters, but he was the only officer on the establishment of his headquarter unit and it was clear that he would require technical officer assistance. Moreover, his own unit had to be attached to one of the Indian Field Survey Companies for administration. The status of the lieutenant-colonels commanding the other three headquarter units was also ill-defined and unsatisfactory. They did not fit into the picture either as staff officers (A.D.s Survey) or as regimental officers. With survey control centralized at Force (or Army) Headquarters it was undesirable that they should be assigned to either corps or divisions and, even assuming that there had been sufficient work at Army H.Q. to justify the absorption of all these senior officers, it was obvious that the clerical and technical personnel which would accompany them with the headquarter units was far in excess of what was required.

For some months after their arrival in the theatre the headquarter units remained near their respective field survey companies, and the A.D.s Survey formed superfluous links between the centralized survey control at Force H.Q. and the survey companies themselves. There was a tendency for them to usurp many of the functions of the unit commanders with regard to field and other technical work, and there was an unnecessary duplication of correspondence and records. Early in 1942 two of the A.D.s Survey were recalled to India, one of them being replaced by an officer from the Middle East Command. The headquarter unit belonging to D.D. Survey and No. 1 Field Survey Headquarters were amalgamated to form a Survey Directorate to which the A.D. Survey of No. 2 Field Survey Headquarters was attached, his headquarter and general sections being left in abeyance. No. 4 Field Survey Headquarters was also left in abeyance, the personnel being attached to other units for work.

Although these changes improved the balance of the whole survey organization, there were still many defects to be remedied. D.D. Survey and A.D. Survey, though forming part of the Survey Directorate staff, were still recognized as being the commanding officers of their headquarter units, which entailed much administrative work for which they had no time, and for which their senior rank made them unsuitable. Nos. 2 and 4 Indian Field Survey Headquarters still existed on paper, a fact which necessitated a lot of returns and records. Finally, one of the difficulties in the way of a proper reorganization was that these units were on Indian establishments, and any amendments required the sanction of G.H.Q. India. It was not always certain that this sanction would be granted.

The winter and spring of 1941-42

With the possibility of a German attack through Turkey in the early spring of 1942, there arose an urgent demand from the General Staff for the following maps to be ready by 1st February:—

- (a) Revised editions of all $\frac{1}{4}$ -inch maps of Iraq extending northwards from about the latitude of Baghdad, and westwards into Syria as far as Long. 40° E. The publication of a 1/100,000 series was also required,

and all these maps were to be revised for communications and other principal detail.

- (b) 1/25,000 maps of defence areas near Faidah, Mosul, Qaiyara, Pa-yi-taq, Hindiya, Falluja and Majura.

In addition to the above, there was a constant demand from the engineer and administrative services for improved maps of Persia and large scale maps of base areas, and miscellaneous requirements from Intelligence and other branches for sketch maps and other forms of printing.

By mid-December, however, the threat to Turkey was lessened by the Russian resistance, and the completion date for the above programme was extended to 1st April, 1942. By March the threat had receded still further.

The introduction of the 1/100,000 series was a policy decision of some interest. As has already been mentioned, there were, over northern Iraq and western Persia, some $\frac{1}{2}$ -inch maps originating from first-war and between-wars surveys, which were much out of date. In southern Iraq there was a 1/50,000 series based on between-wars surveys by the Iraq Survey Department and the oil companies which, though reasonably modern, were in need of much revision. As these series of maps covered areas which were potentially threatened by a German advance through southern Russia, they varied in tactical importance as the threat developed or receded. After consideration of the material available, and the resources for handling it, the decision was taken, with the concurrence of the Middle East Command, to concentrate on a single homogeneous series on 1/100,000 scale, using the best material available in each locality, whether $\frac{1}{2}$ -inch or 1/50,000. The maximum possible revision was to be incorporated on whatever basic material was most suitable, and the work was to proceed on as firm a basis of priorities as the changing threat permitted.

To provide control for these surveys, triangulations were observed in the Faidah, Mosul, Qaiyara and Majura areas. The R.A. survey units also required trig data in connection with the defence schemes. The fixation of this control was completed in November and December, 1941.

At the request of D. Survey, Middle East, a connection was observed between the Iraq geodetic triangulation and the Syrian primary network to the west of the Jebel Sinjar range. The two systems had been based on separate origins and, though close agreement was found in azimuth and scale, there was a considerable discrepancy in position between the two.

On the occasion of a reconnaissance by an armoured brigade westwards to the Syrian frontier, a survey detachment carried trig control by the Hunter short-base traverse method along the line of march, eventually closing on the starting station. This method, which had been used in Persia a short time earlier, was now tested at high speed in desert country. Subsequent experience confirmed that even under unfavourable climatic conditions it was possible for two observers, assisted by a small party, to progress at a rate of about 25 miles a day over a considerable period, maintaining an accuracy of about 1 in 6,000. This particular traverse, after a distance of about 200 miles, closed with an error of ± 50 metres.

For the new $\frac{1}{2}$ -inch maps of the desert areas west of the Tigris an extensive programme of Hunter short-base traverses was undertaken, and this control formed the basis of all new survey work on $\frac{1}{2}$ -inch scale in that area.

Field mapping was in full swing over a wide area by the first week in December, 1941. It extended from Deir-ez-Zor in Syria to the Pa-yi-taq Pass

east of Khanaqin, and from Hindiya (50 miles south of Baghdad) to the Turkish frontier north of Mosul. This frontier was rigidly closed and, though the maps immediately beyond it were in urgent need of revision, it was never possible for surveyors to have access to the ground. The field-work included the revision of all the $\frac{1}{4}$ -inch maps within that area, and surveys for 1/25,000 maps of selected defence zones.

Mechanical transport was largely used by the survey parties. Before its use for desert surveys in about 1929 there were enormous areas in Iraq which were barred to the surveyor who was working on foot or with animal transport only. Under such conditions he had always to remain within close reach of a water supply, and was in danger from nomadic tribes if he ventured too far without escort. During the 1914-18 war, armies had seldom operated far away from the rivers, but, under more modern conditions of almost complete mechanization, all this was changed. The desert became the potential manœuvre ground for opposing forces, and an intimate knowledge of the desert topography was of great importance to the General Staff. The effect of all this on the Survey Service was, of course, very material, and large expanses of desert could no longer be regarded as of no military importance and left unsurveyed.

A surveyor, equipped with two lorries and enough food for a month, could now go practically anywhere and without danger from the local tribesmen, provided he took reasonable precautions and kept his section officer informed of his proposed camp sites. The use of motor transport naturally resulted in a great speed-up of work and, with its use, an individual output of over 500 square miles each month of $\frac{1}{4}$ -inch survey could be expected. Very careful organization of vehicle maintenance was, however, essential.

The very severe winter of 1941-42 was a very trying one both for the surveyors themselves and for their transport. The casualties amongst vehicles of the force as a whole, owing to frozen cylinder blocks, were very high. Even in Baghdad early in December the thermometer registered 13° F. of frost. In Mosul, zero temperatures were recorded, and in western Persia, where triangulation parties were struggling against blizzards and deep snow, conditions were arctic. In January, the weather became even worse, and was succeeded by a period of mud conditions, during which time movement across the desert, except along metalled roads, was impossible.

The units available for field-work were Nos. 1, 2 and 4 Indian Field Survey Companies. No. 1 Company had two ground survey sections engaged on reconnaissance revision in Persia and eastern Iraq early in November, but they were soon transferred to the technical control of Nos. 2 and 4 Companies. Thereafter No. 1 Company was employed almost exclusively on air survey, fair drawing, and map reproduction, and had no regular programme of field-work though, on occasions, small detachments were sent out for minor jobs, generally in the nature of 1/25,000 surveys of limited areas.

The first task allotted to No. 2 Indian Field Survey Company for revision and mapping was in the zone lying to the west of Long. 44°, and included the defence positions of Faidah, Mosul, Qaiyara, Falluja and Majura and other places where there was a requirement for 1/25,000 maps. Where large scale surveys already existed, such as at Falluja, they were revised, but most of the new 1/25,000 maps were made from air photographs for which ground control, height fixation, and other supplementary ground-work were required.

The main programme was concerned with the revision of the $\frac{1}{4}$ -inch maps of northern Iraq, and the field surveys necessary for the production of the new

1/100,000 series areas where $\frac{1}{4}$ -inch maps were available. The first rapid reconnaissance revision was done on the 1/100,000 scale, where $\frac{1}{4}$ -inch maps existed, otherwise on the $\frac{1}{2}$ -inch scale. On some sheets, where there was little reliable detail on which to base the revision, these rapid surveys were regarded as only a "stop gap" pending the completion of proper surveys based on a trig control.

By the middle of May, 1942, when No. 2 Indian Field Survey Company began its programme of plane-table surveys in Persia, it had completed the following work:—

- (a) Reconnaissance revision covering 15 $\frac{1}{4}$ -inch sheets.
- (b) More rigorous revision, almost equivalent to completely new survey, covering 16 $\frac{1}{4}$ -inch sheets.
- (c) Large scale surveys for the revision of 80 square miles on 1/20,000 scale covering the approaches to the important bridge over the Euphrates at Falluja.
- (d) Supplementary survey and heighting for 1/25,000 air surveys covering an area of nearly 1,300 square miles.
- (e) Various minor large scale surveys of airfields, and for administrative and other purposes.

To No. 4 Indian Field Survey Company was allocated the responsibility for field surveys east of Long. 44°, which included Persia. The work of first importance was the provision of trig control for the field mapping which was to follow in the spring of 1942.

As the existing triangulation in Persia was of poor quality and unsuitable as a basis for extension, it was imperative that all survey work should be based on fresh control connected rigidly to the Iraq geodetic net. To enable plane table surveys to begin early in 1942, it was also essential that a new triangulation, which would serve as a basis for further extensions, should be completed in western Persia during the winter of 1941–42.

Three chains were projected, each of them to be based on the Iraq secondary net in the vicinity of the frontier as under:—

- (a) Via the Ruwandiz Gorge and Mahabad, to connect up with work of the 1914–18 war in the valley between Mianeh and Zenjan.
- (b) From Penjwin, east of Kirkuk, across Persian Kurdistan to Sanandaj and thence to Hamadan.
- (c) From Khanaqin *via* the Pa-yi-taq defile to Kermanshah and Hamadan, and thence northwards to link up with the first chain in the vicinity of Zenjan.

Unfortunately, the refusal of the Russians to allow entry into their zone in north-western Persia ruled out the proposal to link up with the 1914–18 work between Mianeh and Zenjan. In addition, the very severe winter conditions made it impossible to carry the triangulation across the mountains in the Ruwandiz Gorge area, and the political situation in Persian Kurdistan did not permit the work to be extended across the border. The first project, therefore, had to be abandoned for the time being. A start was made on the second chain, but here again climatic and political conditions prevented it from being extended across the frontier during the winter.

The abandonment of the first two projects rendered it essential to complete the third before the spring. In spite of most severe cold, with temperatures

falling sometimes to minus 20° F., and facing blizzards and deep snow, the survey parties got through to Kermanshah in January, and by March had reached Hamadan. A subsequent link-up with the Iraq geodetic work *via* Sanandaj and Penjwin proved the triangulation to be of high standard, and this chain formed the backbone of all further triangulation in western Persia during 1942. Meanwhile every opportunity was taken to connect up with the disjointed triangulations carried out during the 1914-18 war, and with those of the Turkish-Persian boundary commission of 1913-14, and thus enable a re-computation and adjustment of some of this old work to be done.

While the Khanaqin-Hamadan chain was being observed, a supplementary triangulation was undertaken to control an air survey of the Pa-yi-taq area. The weather was appalling, but the task was completed, and it was followed by a strengthening of the connection between the Khanaqin-Hamadan chain and the Iraq secondary work near Khanaqin. Observations were also started in south-western Persia to control an air survey of the Pul-i-tang area and to connect up with the Khanaqin-Hamadan chain. The need for speed, the use of mechanical transport, and the topography of the country influenced the methods employed. The existence of roads which followed the centres of valleys favoured the establishment of pairs of stations some five or six miles apart on either side of the valleys. The triangulation chains followed generally the line of the roads, and consisted, where possible, of a series of quadrilaterals about 15 to 20 miles long and about 5 to 6 miles wide. Under favourable conditions a good observer could complete two stations each day from a central camp on the road.

Scale checks by Hunter short-base observations applied at intervals, and azimuth checks measured either by morning and evening sun observations or from Polaris, avoided the possibility of gross errors.

Two sections of No. 4 Indian Field Survey Company had begun reconnaissance revision surveys in north-eastern Iraq in early December, one of these sections being diverted to No. 1 Company during January to assist in the heavy drawing programme. By the end of February, 1942, seven $\frac{1}{4}$ -inch sheets up to the Turkish-Persian frontier had been completed. Here again the work was done on 1/100,000 scale except for a few areas where 1/50,000 maps, compiled in India, were used as a basis for revision.

During December, 1941, and January, 1942, five plane-table surveyors of No. 4 Company completed the field-work for a sketch map survey of 115 square miles on 1/10,000 scale of the Ahwaz area where an important base was being developed. The field-work took 15 days, and was amplified by air photographs of parts of the town. The detail survey was based on graphical triangulation starting from two trig points, and was checked by a 5,000-metre measured base. On completion of this task the section carried out a similar-type survey on 1/5,000 scale in the Andimishk area, and a 1/25,000 sketch survey of part of the Pul-i-tang defence position.

Another section of No. 4 Company took over from No. 1 Company the responsibility for the compilation of a large scale survey of 380 square miles around Hindiya. Most of the area was already covered by good, though out-of-date 1/10,000 maps, so the revision work was done on blue-prints of these for final publication at 1/25,000.

By May, 1942, No. 4 Indian Field Survey Company had completed the following programme of field-work:—

- (a) Reconnaissance revision surveys on $\frac{1}{4}$ -inch, 1/100,000 or 1/50,000 scale covering 23 $\frac{1}{4}$ -inch sheets.
- (b) Sketch survey at Ahwaz at 1/10,000 covering 115 square miles.
- (c) Large scale survey at Hindiya on 1/10,000 scale covering 380 square miles.

At the end of January, 1942, it had been decided to take up the reconnaissance revision of the maps of southern Iraq and south-western Persia, which were much out of date and which were a source of irritation and embarrassment to users in the line of communication and base areas. This task had no high operational priority, but was obviously of importance and therefore, during a pause of two months between the completion of work in northern Iraq and the start of plane-table surveys in western Persia, the work was undertaken. The reconnaissance revisions were carried out on the largest scale maps available which, over a large part of the area, consisted of the 1/50,000 series which had been compiled in India in 1941 from air photographs and other material obtained from the Iraq Survey Department.

The non-co-operative attitude of the Russians interfered considerably with the programme in northern Persia. They were occupying a zone which lay north of a line running from the tripartite junction between Turkey, Persia and Iraq across to the south end of the Caspian Sea. All attempts on the part of British or Indian survey parties to enter this zone were stopped by the Russians.

There were difficulties also as a result of unrest amongst the Persian tribesmen in Kurdistan. It was desired to observe a triangulation to link up some work already completed round Hamadan with the Iraq geodetic system and, as the movement of troops into Kurdistan from the east was forbidden in order to avoid incidents, it was decided that survey parties should enter the area from the west across the Iraq frontier. After protracted negotiations this was arranged, and the surveyors found the Kurds both friendly and helpful. In the south, where the tribesmen of the Lur and Bakhtiari Hills were notorious for looting and raiding, arrangements were made for Persian gendarmerie escorts to accompany the survey parties. On the whole the Persian villagers were found to be friendly.

The late spring and summer of 1942

The potential threat of a German offensive through the Caucasus into north-western Persia following the resumption of their offensive in southern Russia introduced, during April, 1942, a fresh General Staff requirement affecting the survey programme. The new programme covered an area extending from the Bakhtiari Hills in the south to Lat. 36° N., and from the Iraq frontier in the west to Long. 50° E. This was enlarged during May so as to extend as far north as Lat. 37° N., with reconnaissance surveys even further to the north as far as the Russian frontier, if the Russians could be induced to permit access into their zone.

In addition, 1/25,000 maps were required of several defence positions along a general line running through Razan Pass-Kangavar-Sanandaj, and all the maps covering this whole area were to be ready by 31st August. This was later extended to 15th September as a result of a postponement of the German offensive in southern Russia.

No. 2 Indian Field Survey Company maintained its headquarters at Kirkuk

until the end of June, when it moved to Sanandaj, remaining there till the middle of August. When it was clear that permission for surveyors to enter the Russian zone would not be granted No. 2 Company was moved to Zagheh, just west of the Razan Pass, in order to start work on new 1/100,000 and 1/50,000 surveys.

No. 4 Indian Field Survey Company moved from Baghdad to Kermanshah in April, and to Hamadan in May, remaining there until the early part of 1943.

The reproduction groups of Nos. 1 and 4 Indian Field Survey Companies, with their heavy printing equipment, were more or less immobile, and had been grouped together in Baghdad, in the form of a semi-permanent base installation. With the possibility of operations on the northern Iraq frontier in the spring of 1942, the reproduction group of No. 4 Company was made mobile and was attached to No. 2 Company, which was operating in northern Iraq. When, however, the enemy threat through Turkey receded, and survey work was concentrated in Persia, this mobile reproduction group rejoined its own unit. Leaving Baghdad by road on 1st June, it arrived at Hamadan two days later, successfully negotiating the steep climb over the 7,500-foot Shah Pass with its heavy printing trailers.

The plan for possible operations in western Persia in the event of a German drive through the Caucasus during the autumn of 1942 involved such an increase in the size of the force that it was clear that survey resources must be increased. There was an urgent need also for further air survey photography. A photographic survey flight of 60 Squadron S.A.A.F. had done valuable work in Iraq earlier in the campaign and now, as No. 1434 Flight R.A.F., it was transferred from Syria for another tour of duty in the Iraq-Persia theatre. Three Indian Ground Survey Sections were sent on temporary loan from India in June. The headquarters of the Mobile Echelon and three topographical sections of 512 Field Survey Company R.E. arrived from Egypt in July and, in the same month, 19 Field Survey Company R.E., consisting of headquarters, reproduction section, and three drawing sections, also arrived from Cairo, their printing equipment arriving later by sea. It had been obvious that the resources of Nos. 1 and 4 Indian Field Survey Companies would not be sufficient to meet the map reproduction and printing demands for the enlarged force, so the additional strength provided by the arrival of 19 Field Survey Company was very welcome.

Communication difficulties with Persia ruled out Baghdad, or indeed anywhere in Iraq except possibly Basra or Shu'aiba, as a location for 19 Field Survey Company. It was essential that the place selected should be near the base for security reasons and, after much consideration, Ahwaz was chosen, where a suitable building existed for the installation of a base printing unit. The presses were in operation by about the end of November and their early programme included the printing of reserve stocks of $\frac{1}{4}$ -inch and 1/100,000 maps. As an insurance against the possible total loss of paper stocks in Cairo, at a time when German forces were driving deep into Egypt from Libya, large quantities of paper were sent across from Cairo with 19 Field Survey Company.

Strategically and technically Ahwaz was satisfactory, though it was difficult to exercise close control over the work there from the Survey Directorate at Baghdad. Also, the climate was very trying in the hot weather, when the temperature rose to 132° F. in the shade. Living quarters were in tents, there was little in the way of recreational facilities, and a high rate of sickness resulted. The heat naturally caused technical difficulties in printing but, to the credit of

all concerned, the work went on well, with high output and a cheerful overcoming of all difficulties.

During the first few months in Iraq, all maps had been printed in black and brown only. There were complaints that the detail was not clear so red was introduced for roads, tracks and footpaths, and also for the grid letters and numbers on maps of 1/100,000 scale and smaller. In the case of larger scales this was not done as it was considered that the map detail was not usually congested, and that as they were usually produced in a hurry to meet an urgent demand, time would not be available for the extra printing. For the same reason requests for showing water features in blue could not be complied with.

As a first measure, roads were classified according to width and were given numbers referring to their vehicle-carrying capacity. Later on the necessity was stressed for distinguishing between concrete, tarmac, and other forms of metalled surface, as such differentiation was important for movement planning. Symbols were therefore introduced to indicate roads as under:—

Concrete or tarmac	Solid line
Metalled, gravel or other surface	Long heavy pecks
Natural surface	Double lines of short pecks

A series of "Going" maps was published early in 1942 covering much of Iraq and parts of western Persia. The "Going" information was overprinted in colour on a specially designed 1/500,000 map which was printed in black, red and grey. The overprint colours followed the style adopted as standard in the Middle East, viz.:—

Good going	Red
Fair going	Yellow
Difficult going	Green
Impassable	Blue

The reconnaissance for these maps was carried out very hurriedly, using $\frac{1}{4}$ -inch sheets. The basic 1/500,000 maps were compiled before the results of the new surveys were available, and contained little topographical detail.

The survey programme in Persia in the spring of 1942 differed considerably from that in Iraq six months previously. The Russian recovery during the winter made it probable that there would be no immediate danger to northern Persia until some months after a resumption of the German offensive on the southern Russian front. This afforded time for a considerable mapping and survey programme before that threat should become imminent. Many of the maps had already been revised for communications and major changes during the autumn, and the spring programme comprised a large amount of original surveys based on the new triangulation control which had just been established.

In many ways western Persia was ideal country for the small scale topographical surveyor. It consisted in the main of a large plateau, with an average altitude for the valleys of about 4,000 feet above sea level. Where they were not bare rock, the lower slopes of the hills were undulating grass slopes, trees being scarce. Water was plentiful, and the "going" in the valleys was good, enabling vehicles to move across country with a fair amount of freedom. Though malarious in the valleys after May, there was very little sickness amongst the field parties. Below 6,000 feet it was hot during July, August and September. The rainy season extended from October to March, with little rain during the

rest of the year. Frequent high winds caused a lot of dust, which seriously interfered with the work of the surveyors, especially those engaged on triangulation during the early summer.

Observers of No. 4 Indian Field Survey Company extended the triangulation in western Persia as fast as possible during the spring of 1942, computing the results as they went along, and the western plateau was soon covered. The work of the plane-tablers was controlled by a rigid time-table, to ensure the completion of the fair drawing, reproduction and printing of all sheets by 31st August. The arrangement of work was such as to provide surveys on 1/100,000 scale of those areas only for which maps on this scale were considered necessary by the General Staff. These same surveys were used as material for compiling the new $\frac{1}{4}$ -inch editions. The remainder of the area was surveyed on $\frac{1}{4}$ -inch scale. There was no time to await the completion of the 1/25,000 surveys of the selected defence positions so as to incorporate them in the smaller scale maps.

The average rate of progress originally laid down was 150 square miles each surveyor a month for new 1/100,000 work, and 500 square miles for the $\frac{1}{4}$ -inch surveys. In order to work up a head of work for the rigidly-planned reproduction programme a higher output had to be encouraged and enforced in the case of some of the earlier sheets, at the expense of some accuracy and loss of detail in the higher hill country. Once the surveyors had become accustomed to the work, the higher rate of production was comfortably maintained, and it was considered that it might even have been increased without loss of material accuracy. It was remarkable the way in which these hurried surveys stood up to check against large scale ground and air surveys of the same areas which were done later when time permitted. It was, indeed, a highly creditable performance on the part of the Indian surveyors who carried through this project under great pressure, and it was not surprising that, at the end of the summer, most of them were showing signs of exhaustion.

During June, 1942, when it seemed that the expected German offensive in southern Russia had been postponed, the completion date for the survey programme was extended to 15th September. It was then possible to take up a larger area on both 1/100,000 and $\frac{1}{4}$ -inch scales. All this field-work was completed and was passed for drawing and publication before the end of July.

For the selected defence positions which were sited to guard mountain passes in northern Persia against a possible German offensive from the north, 1/25,000 maps were required. At first these were prepared by making straight enlargements from existing $\frac{1}{4}$ -inch or 1/100,000 maps, on which the defence detail was marked as indicated by the formations on the ground. This method was, however, found to give such inaccurate results that it was necessary in most cases to carry out rapid 1/25,000 sketch surveys. Good topographers engaged on this work produced some outstanding results in speed and quality, and the resulting maps proved to be entirely satisfactory for the purpose required. The plane-table field sheets were mosaicked, reproduced, and printed in black and brown. It was arranged that these defence positions should be covered also by air photography so that deliberate air survey maps could replace the sketch maps at a later stage.

No. 1434 Flight R.A.F. had reached Tehran early in July and, by the end of August, had covered with vertical photography about 2,400 square miles of the defence areas. Other zones of possible operational importance were photographed, bringing the total up to about 5,000 square miles. By early

September the weather had deteriorated to such an extent that little further survey photography was possible.

The rate of supply of air photographs was, however, not quick enough to guarantee the completion of the deliberate air survey maps at 1/25,000 scale covering the whole of the defence areas, including both the defence and target zones, by the end of September. It was therefore agreed that only those portions in each of the positions concerned which contained the defences themselves should be covered in the first place by deliberate 1/25,000 air survey maps, and that the whole of each area, including the target zones, should first be mapped by 1/50,000 ground surveys. These latter surveys were completed during September by sections of Nos. 2 and 4 Indian Field Survey Companies, and comprised five sheets at Razan, one at Askaran, and seven at Kangavar.

The whole of the air survey strength of the Indian Field Survey Companies was assembled in Hamadan at the end of July, 1942, under the command of No. 4 Company. It was reinforced in September by a drawing section from 19 Field Survey Company R.E., and together they formed an Air Survey Group. By the middle of March, 1943, this group had completed about 30 sheets on 1/25,000 scale of the defence areas in north-western Persia, besides other work on 1/50,000 scale.

Formation of the Persia-Iraq Command, and the autumn and winter survey programme, 1942-43

When the Persia-Iraq Command was formed in September, 1942, Colonel K. M. Papworth was appointed D.D. Survey. Pending his arrival, Colonel Heaney left Tenth Army for Baghdad, Lieutenant-Colonel L. de V. Carey officiating as D.D. Survey, Tenth Army, in his absence. An establishment for a G.H.Q. Survey Directorate had been sanctioned, and personnel for this were obtained from survey units in the Command. Office procedure was organized to deal with survey control, map reproduction, survey records, and all the other incidentals appropriate to the new Command organization. Colonel Papworth assumed duty on 24th November, Colonel Heaney returning to Tenth Army, where the Survey Directorate was reduced in size and reorganized on lines more suited to a mobile army headquarters.

Although Paiforce was now a separate Command, responsibility for the general control of survey policy and the posting of senior survey officers remained with the Director of Survey, Middle East.

The G.H.Q. Survey Directorate now took over control of 19 Field Survey Company at Ahwaz and No. 1 Indian Field Survey Company in Baghdad. This left Nos. 2 and 4 Indian Field Survey Companies under Tenth Army command.

A new map distribution unit was formed (No. 10 Indian Field Survey H.Q.) for operational map distribution in Tenth Army. It was organized with personnel and transport which would provide sub-sections to work with corps and divisions, as was the practice in the Middle East Command. As the personnel for this unit had been hitherto running map depots at Baghdad and other places, it was necessary to replace them by a distribution unit which would work under G.H.Q. One Palestinian map depot was therefore obtained from Middle East which, on arrival, was posted to Ahwaz.

The Mobile Echelon of 512 Field Survey Company R.E. had returned to Middle East at the end of October, 1942, and, early in November, the two

topographical sections of 19 Field Survey Company R.E., which had not accompanied that unit when it came to Iraq in July, crossed the desert from Egypt and joined up with their parent unit at Ahwaz.

By mid-September, 1942, all the ground surveys required to complete the programme laid down by the General Staff had been finished. The period in the field had been a strenuous one, with its effect on men and vehicles. Sections were therefore brought into their headquarters as they completed their tasks, and they were given an opportunity for rest and refitting and some military training.

In the middle of October, a fresh programme of field-work was started. This extended the recent surveys eastwards in the direction of Tehran and Nain. Work was on the $\frac{1}{4}$ -inch scale except for a small area west of Tehran, where $\frac{1}{2}$ -inch maps were available. These sheets were revised at 1/100,000 scale. No. 2 Indian Field Survey Company worked north of Lat. 35°, and No. 4 Company to the south of it. In spite of bad weather during November, the programme was finished by the end of December.

Meanwhile, during the autumn pause in ground mapping, the triangulation had been extended north-east and eastwards to provide control for the further mapping referred to above. Under most difficult weather conditions two triangulation chains were carried over the mountain range north of Tehran, reaching the Caspian Sea near Amul and Chalus. But as the coast-line was under Russian control the two chains could not be connected. Another triangulation extension was observed extending from Isfahan southwards to Shahriza, and eastwards to Nain on the road to India.

It had long been desired to connect the new triangulation in Persia with the Iraq geodetic framework. An attempt to do this in October had to be abandoned owing to floods and political difficulties, but later on, 19 Field Survey Company R.E. undertook the task, completing it in February, 1943.

With all this field-mapping there was, of course, a vast quantity of drawing to be undertaken back at headquarters. During the winter of 1942-43 survey units were employed on the following:—

- (a) Fair drawing of the recently completed work in the field.
- (b) Fair drawing of $\frac{1}{4}$ -inch sheets of southern Iraq which had been revised during the previous spring.
- (c) Compilation and fair drawing of $\frac{1}{4}$ -inch sheets of north-western Persia, incorporating some Russian 1/200,000 material which had been obtained on an exchange basis.
- (d) The air surveys of defence positions in Persia.
- (e) The redrawing of $\frac{1}{4}$ -inch maps of the Caucasus.

Statistics were kept by the Survey Directorate for all the fair drawing undertaken, and some representative figures of output may be of interest and are given below. These represent work on average sheets with a good standard of drawing. The sheets formed part of the mapping programme for Persia, and were drawn by No. 1 Indian Field Survey Company in the summer of 1942 during the heart of the hot season. Draughtsmen worked for eight hours a day for six days a week. In some cases double shifts were adopted of about 7½ hours a shift.

Fair drawing was normally on the scale of the published map. Separate originals were drawn for outline, contours, and roads. Grid letters and figures were included on the road drawings, but the grid lines were cut in on the

negatives. The fair drawings were mounted on thin sheets of metal to prevent distortion, and place names were typed separately and stuck on with "Durofix." The times shown below include that taken to stick on the names. The operation of drawing the three fair models and typing the names were thus carried out concurrently. The figures given represent an average number of man-days per sheet over six sheets for each of the scales represented:—

Scale	Number of man-days				
	Names	Outline drawing	Contours	Roads	Total
$\frac{1}{2}$ -inch	13	18	15	10	56
1/100,000	4	15	19	7	45

The practice of mosaicking the original field documents as they were received from the field-parties became universal. The field-sheets were cut up and mosaicked so as to form complete sheets, the pieces sometimes being laid down on to a projection of the sheet on glass to ensure correct positioning. One of the principal reasons for this method was to be able to make a quick reproduction of the results of the new survey without any delay. In such cases the mosaic was copied as it stood and printed in brown, with the principal names hand-drawn, and with the main communications and streams overprinted in black. Provided the quality of the field-sheets was good it was thus possible to publish an advanced edition of a sheet within a few days of receipt of the field documents. This type of advanced edition was particularly valuable for the preliminary 1/25,000 sketch maps of the defence positions.

In the case of the 1/100,000 series a usual method was to enlarge the $\frac{1}{2}$ -inch originals up to the scale of production. The corrections resulting from the reconnaissance revision were made up in the form of addition and deletion models which were handed, as they stood, to the publication section. The deletions were duffed out on the negatives, and bromide prints then made on which the additions were drawn in black. The bromides were then reproduced.

The rapid sketch maps that were prepared of the defence positions and certain base areas were naturally not up to the standard of accuracy which would be required for artillery purposes. It was, therefore, necessary to mark them clearly in such a way that they would not be used for this purpose. A note such as "Sketch survey only. Not for artillery use" was printed boldly in the margin.

The final phase (1943)

The relief of Stalingrad by the Russians in November, 1942, and the beginning of the Russian offensive westwards altered the whole political and strategical picture in Persia and Iraq.

By the end of January, 1943, all the Axis forces had been driven by Eighth Army out of Libya into Tunisia, and the last stages of the operations in North Africa were begun, which ended in the final defeat of all enemy forces in Africa during May. The threat to the Middle East was over, and in March this resulted in a reorganization of the military Command in Persia and Iraq and a big reduction in the size of the force.

Early in 1943, there had been a proposal to form a new G.H.Q. Survey

Company somewhat on the lines of the unit which had been operating at G.H.Q. Middle East. The new directive for Paiforce in March caused this proposal to be dropped. Under the new Command organization the following survey units which had been under Tenth Army passed to the direct technical control of the G.H.Q. Survey Directorate:—

- 4 Indian Field Survey Company.
- 10 Indian Field Survey H.Q.
- 13 Indian Drawing Section.

No. 2 Indian Field Survey Company had left Tehran for the base at the end of January and embarked for India in March, and the resulting survey organization after the departure of H.Q. Tenth Army to India in April was as under:—

- G.H.Q. Survey Directorate
- 19 Field Survey Company R.E.
- 1 Indian Field Survey Company.
- 4 Indian Field Survey Company.
- 10 Indian Field Survey H.Q.
- 14 (Palestinian) Field Survey Depot.
- 51 Drawing Section I.E.
- 52 Drawing Section I.E.
- 14 Computation Section I.E.
- 21 Survey Park Section I.E.

In February, 1943, approval was given for the formation of a Polish artillery survey regiment, one field survey company and a field survey depot. Personnel were selected from amongst the officers and other ranks of the Polish Army in the east, and the build-up of the survey units began. Training with British and Indian units was arranged, and equipment was provided from British sources, including one double-demy printing press in trailer, which had become redundant when 4 Indian Field Survey Company was re-equipped with mobile demy machines. These Polish survey units eventually left Paiforce in September, 1943, on transfer to the Middle East.

Suitable personnel were selected also from the Iraq Army for the formation of an Iraq Army Survey Branch, and courses were held for them by No. 1 Indian Field Survey Company, and later by the Iraq Civil Survey Department.

During April, 1943, 19 Field Survey Company R.E., on completion of its field programme, left Ahwaz and moved back to the Middle East Command in May. In this same month the appointment of D.D. Survey, Paiforce, was abolished, and Colonel Papworth was transferred to the G.H.Q. Survey Directorate, Middle East. There were alterations in the map depot organization also at this time. The map depot at Kermanshah closed down in April and 10 Indian Field Survey H.Q. moved back to Baghdad. 18 (Palestinian) Field Survey Depot arrived in Baghdad on 24th May from Middle East and took over the map depot there from 10 Indian Field Survey H.Q. and also the depot at Kirkuk. A detachment from 14 (Palestinian) Field Survey Depot took over the map depot at Tehran.

Three check bases were measured in Persia during April and May, 1943, by 4 Indian Field Survey Company. They were located at Hamadan, Tehran and Isfahan, and provided a very satisfactory scale check on the existing triangulation in West Persia.

There was a big exodus of survey units from Paiforce during July. The following left the Command:—

- 1 and 4 Indian Field Survey Companies.
- 10 Indian Field Survey H.Q.
- 21 Survey Park Section.
- 51 and 52 Drawing Sections.
- 14 Computation Section.

To satisfy the survey requirements of the Command after the departure of the above units the following new units were formed on 17th July:—

- | | |
|-------------------------------|---------------------|
| 81 General Section I.E. | 1 Officer, 24 O.R.s |
| 82 Ground Survey Section I.E. | 1 Officer, 59 O.R.s |
| 83 Reproduction Group I.E. | 1 Officer, 58 O.R.s |

The personnel for the above was found mainly from Nos. 1 and 4 Indian Field Survey Companies. The equipment came from the same source.

With the departure of the units mentioned above, together with No. 2 Indian Field Survey Company, which had left previously, it is fitting that due credit should be paid to their remarkable achievements. From their arrival in 1941 until shortly before their departure they were fully employed on productive surveys. In this time some 120,000 square miles in Iraq and over 100,000 square miles in Persia were either re-surveyed or revised at scales of 1/100,000 or $\frac{1}{4}$ -inch, and in some cases at both scales. The rate of progress of original $\frac{1}{4}$ -inch survey was as high as 600 square miles a man each month, and that of 1/100,000 survey over 100 square miles a month. In addition, some 76 sheets covering approximately 4,500 square miles at 1/25,000 or 1/50,000 were prepared from air photographs and ground surveys.

In Persia alone over 2,500 miles of triangulation was completed and, although speed was a prime factor, and the accuracy aimed at was only that required to provide a framework for the plane-tables, examination showed that it could be considered for the most part as being of the same order as the Indian minor triangulation or the Iraqi secondary work.

The difficulties against which the surveyors had to contend were formidable, and some of them have been already mentioned. It is sufficient to recall that the terrain in which they worked varied in altitude from the plains of Iraq to the mountain ranges of Persia, where surveyors were often working at over 10,000 feet and in temperatures of from 0 to 127° Fahrenheit.

The units possessed survey tradesmen of the highest order, and in particular plane-tables who, for small and medium scale work in mountainous country, had few equals. The draughtsmen and printing personnel maintained an equally high standard.

The British units, 19 Field Survey Company R.E. and the Mobile Echelon of 512 Field Survey Company R.E., contributed most valuable service during the months which they spent in the theatre. It was noticeable, however, that the standard of skill as plane-tables amongst British personnel was far below that of the Indian surveyors. This was, of course, to be expected in view of the fact that the Indian topographers spent a large part of their peace-time service on plane-table surveys. The Palestinian Field Survey Depots, which came over from the Middle East, helped very considerably in the difficult task of map storage and distribution.

Thus, during the spring and summer of 1943, the survey service with Paiforce

was reduced almost to the status of a care and maintenance party. When Colonel Papworth was transferred to the Middle East, Lieutenant-Colonel L. de V. Carey, R.E., assumed command of the survey organization which remained. The reduced establishment was able to meet all demands made upon it to fulfil the two principal remaining roles of the Command, namely, the protection of the oil installations, and the keeping open of the overland route to Russia.

Lessons

In the sphere of survey direction and control, the arrangement whereby an A.D. Survey commanded a small headquarter unit which was not an integral part of the General Staff was unworkable and unfortunate. In due course this was rectified.

The need for proper military training before Indian Survey Units were sent overseas does not seem to have received sufficient consideration. Although the technical training was of a high standard, it was noticeable that officers and N.C.O.s did not have a proper idea of their military responsibilities. It would also appear that, in the selection of officers and N.C.O.s for these units, too much attention had been paid to their seniority in the Survey of India, in which Department most of the personnel had served before the war. This was, perhaps, in the natural order of things when it is realized that a civil staff had been hurriedly mobilized for military service overseas. In a number of instances men who were technically fitted for senior posts in the civil department were found to be entirely unsuited to become officers or N.C.O.s in a military unit.

The technical achievements of these Indian Survey Units in Iraq and Persia were magnificent, but it is very probable that, if they had been involved at an early stage in active military operations, they would have found themselves up against conditions and difficulties to combat which their military training was insufficient.

On the administrative side these units were organized in such a way that the responsibility for discipline and administration was largely left to the adjutant and quartermaster. This had the effect of making the junior officers feel that their responsibilities were purely of a technical nature, and would have left them ill-equipped to fend for themselves had the units become split up during operations as happened in other theatres.

On the other hand, for the particular type of survey work on which they were employed in Iraq and Persia, the Indian Survey Units were technically well organized and equipped. The Indian equivalent of a British topographical section provided two trig observers and eight topographical surveyors. Each topographical surveyor had three or four unskilled men who, by carrying equipment and generally ministering to the surveyors' needs, left him free to concentrate on his technical work.

The late arrival of survey units in Iraq was a great handicap. Where there is likely to be a big programme of survey and mapping work in an operational theatre an early start is of vital importance. It would have been of great advantage, therefore, if the Indian Survey Units had been sent to Iraq at a much earlier stage so that they could have been available in greater strength to deal with the requirements of the Expeditionary Force.

The patchwork character and poor quality of the first-war triangulation in Iraq and Persia have already been noted. The evidence indicates that elaborate adjustments which were applied to the old trig observations of inferior quality

were not worth while. Events showed that, provided the primary and secondary Iraq work had been converted into terms of the Lambert grid, this was probably all that was necessary. The intersected points and minor stations of the Iraq Survey Department were seldom of much value, through lack of adequate descriptions, to enable them to be identified with certainty on the ground.

The question of map sheet lines has been commented on earlier in this chapter. The existing maps of the theatre were on a graticule lay-out. It was a mistake, therefore, for India to have designed an extensive series, before the landing of the Expeditionary Force, on a rectangular grid lay-out. In the event most of the work done in India in this connection was of little value. The lesson to be learnt is that, for new military mapping in a potential or actual operational theatre, the national sheet lines should be adhered to as far as possible.

SECTION 3. AIR PHOTOGRAPHY FOR MAPPING AND REVISION

Towards the end of 1941, when D.D. Survey (Persia and Iraq) was faced with extensive mapping commitments, D. Survey, Middle East, arranged for the transfer from Egypt to Iraq of a Survey Flight of 60 Squadron S.A.A.F. It arrived in Mosul at the beginning of December, and remained in Iraq until April, 1942, when it was transferred back to the Middle East for survey photography in Syria. It was called for again to undertake urgent photography in Persia later in the year.

This unit was the only one available for the task, and there were numerous demands for its services. As it was transferred to Iraq primarily for survey purposes, the Survey Directorate retained control of its photographic activities, and outside demands were met to a limited extent only when they were not likely to interfere with the survey programme. The unit was equipped with F-8 cameras with 7-inch lenses, covering a film area of 7 in. \times 7 in. These cameras were old, and caused a lot of trouble, seriously interfering with output.

On arrival in Iraq, the Survey Flight was equipped with Maryland aircraft. Under the operational conditions existing at the time, these were very suitable for air survey photography, and were used effectively up to an altitude of about 25,000 feet. It would, of course, have been a very different matter if there had been enemy air opposition, in which case good-performance machines would have been essential. After a month or two, however, the Marylands were withdrawn, and were replaced by Blenheims which had an effective height for survey photography of only about 17,000 feet. Several unsuccessful attempts were made to obtain better machines.

Air photography is very dependent on weather conditions and the weather in northern Iraq and Persia was most unsuitable for air photography in winter-time owing to clouds and rain, especially in the mountainous areas. From the date of the unit's arrival in December until March, 1942, there were comparatively few days suitable for photography, and progress was slow. It was soon apparent that there was no hope of completing all the defence-position maps required by the General Staff by the end of January, 1942. The presence of snow over large areas added to the difficulties of interpretation and also, of course, hindered the work of the ground survey parties who were working on the triangulation, detail checking, and height control.

Having completed all the photography in northern Iraq that was possible

under the bad weather conditions, the Flight moved down to Habbaniya in the hopes of finding better weather. From this centre several areas in central and southern Iraq and southern Persia were photographed, and also some important base areas, notably Khorramshahr and Abadan, where photographs were required at 1/25,000 scale for camouflage-testing purposes.

All essential areas had been photographed by about mid-April, 1942, including some where it was anticipated that a demand for large scale maps might arise later, so the Survey Flight was withdrawn to the Middle East.

The first photographs were available about mid-December, 1941, and a strong air survey section was formed by concentrating under one control all the surveyors in the theatre who had been trained in air survey mapping work. Until the end of April, 1942, they were fully employed on the mapping of the defence areas and other tasks. By May the results of their work had all been published, and these comprised:—

- (a) 1/25,000 maps of defence areas; 33 sheets covering a total area of about 1,540 square miles.
- (b) 1/12,000 sketch survey of Um Qasr.
- (c) Planimetry only of a 1/25,000 survey of the Pul-i-tang defence area (165 square miles). This was completed later by 4 Indian Field Survey Company.

As a result of the extensive new mapping programme in western Persia, asked for by the General Staff in April, 1942, D.D. Survey asked for the return of the Survey Flight which had previously been in the theatre, and which was now renamed No. 1434 Flight R.A.F. After some delay it moved across from Syria and began photographic operations about the middle of July, 1942, based on Tehran.

The programme undertaken by No. 1434 Flight mainly concerned photography for the preparation of 1/25,000 maps of defence areas in north-western Persia, to replace the hastily prepared sketch surveys which had been made as a first measure to assist the initial siting of the defence works. Priority for photography was given to a series of defence positions which guarded certain vital passes against a possible German offensive from the Caucasus.

Photography of these positions, covering about 2,400 square miles, was completed during August and early September. By the end of September the weather in northern Persia had begun to deteriorate but, on completion of the above task, photography was undertaken of the Gach-i-sar area covering a defile on the road from Karaj to Chalus on the Caspian Sea. This was completed before the unit left the Command again in November, as was also the photography of several other areas for which air-photo cover was required in case they should later become operational zones.

In all, 1434 Flight took vertical photographs covering a total of about 5,000 square miles during its stay in the Command, most of which was carried out between the end of July and the first week of September, 1942.

To compile the maps from the photographs, the whole of the air survey strength of the three Indian Field Survey Companies was assembled in Hamadan at the end of July, 1942. This was reinforced in September by one drawing section from 19 Field Survey Company R.E., and they formed one composite Air Survey Group.

By the middle of March, 1943, the Group had completed about 30 sheets

of the defence localities on 1/25,000 scale, and two sheets of the Gach-i-sar area at 1/50,000.

The usual method adopted for the field-check, except in areas of high hills, was to supply blue-prints, sheet by sheet, of the compiled outline, which were taken out into the field together with a set of photographs. Roads and tracks were classified, and doubtful detail corrected. Sufficient heights were fixed by clinometer, combined with resection and intersection, to enable contouring and form-lining to be carried out on the photographs in the office.

A blue-print of the compiled outline was then made on kodatrace, and on this the contours were traced from the photographs. This method was found to give better-quality results than the "black and white" method, whereby the outline and contours were drawn in black and white respectively on the same piece of kodatrace, and separated by photography against alternate black and white backgrounds.

In high hilly country, sets of photographs were taken out on the ground before the compilation of the outline, and clinometer readings for heights taken to selected points marked on the photographs from stations similarly marked. Distances for computing the heights were later determined in the office after completion of the minor control plots.

It may be useful to record a few statistics of output in air survey production, as such knowledge is useful when framing or estimating programmes of work. The table given below refers to work carried out by No. 1 Indian Field Survey Company on 1/25,000 scale for the period December, 1941, to May, 1942. The photography for this work had all been ordered on 1/25,000 scale, but it actually averaged about 1/21,000. All surveyors worked eight hours a day for six days a week. Output figures shown represent square miles per surveyor-week.

Area	Description of country	Area in square miles	Output (square miles per surveyor-week)			
			Outline only	Contouring only	Outline and contouring	Outline, contours and completion for publication
1	Rolling	482	21	30	13	10
2	Broken plain	35	23	26	12	11
3	High hills (very steep)	194	19	10	7	6
4	High hills	60	20	16	9	8
5	Low hills and plain	168	18	15	8	7
6	Low hills and plain	96	23	14	9	8
7	Flat	209	32	32	16	12
	Average		22	20	10	9

Note.—The normal contour interval was 25', which was opened out to 50' in steep hilly country.

CHAPTER VIII

SOUTH EAST ASIA

The following maps and plates are relative to this chapter:—

	<i>Page</i>
<i>Sketch Maps</i> {	<div style="display: inline-block; vertical-align: middle;"> 7. <i>India, Burma and Malaya</i> 8. <i>Burma, Assam and Bengal</i> </div> <div style="display: inline-block; vertical-align: middle; text-align: right;"> 198 200 </div>
<i>Plates at end of book</i> {	<div style="display: inline-block; vertical-align: middle;"> 23. <i>Burma 1 inch to 1 mile</i> 24. <i>Assam and Burma ¼ inch to 1 mile</i> 25. <i>India 1:25,000</i> 26. <i>Thailand (Siam) 1:25,000</i> </div>

SECTION 1. A BRIEF HISTORY OF THE BURMA CAMPAIGN

Strategical considerations

Burma forms a barrier of rivers, hills and malarial jungle between India and southern China, Thailand, and Malaya. To supply China with essential war requirements the Burma Road had been constructed from Rangoon through Mandalay and Lashio to Chungking. There was also an air-supply route from Calcutta to Chungking *via* Myitkyina.

When the Japanese swept westwards early in 1942 they naturally included Burma as one of their principal objectives, not only to protect their gains in the Pacific and Malaya but to cut off China from her supply sources in the west, and to act as a springboard for an invasion of India.

The Burma campaign defeated these plans, and China was never completely isolated. In face of stupendous difficulties a new road was constructed by American engineers through north-eastern Burma to join up with the original Burma Road, and a new air-supply line was opened up across the now famous "Hump" to Chungking. Allied forces, after the initial retirement from Burma, fought back from India, and transformed the attempted invasion by the Japanese into a chaotic and costly retreat ending with the enemy surrender in August, 1945, and the reoccupation of Singapore.

The following brief summary gives the principal events of the campaign which will serve as an operational background to the survey story.

The retreat from Burma (December, 1941–May, 1942)

On 8th December, 1941, following the Japanese attack on Pearl Harbour, Britain and the United States declared war against Japan. On the same day Japanese forces landed in Thailand and north-eastern Malaya, and a week later crossed the Burmese frontier and captured Victoria Point. In January they struck west from Thailand and advanced on Moulmein. 17 Indian Division retreated across the Sittang River, and Rangoon was evacuated early in March.

As a result of negotiations with Marshal Chiang Kai-Shek, Chinese divisions were made available for operations in Burma, and General Stilwell (U.S. Army)

was appointed Chief of Staff to the Marshal to act as liaison officer between the British and Chinese commands. On 14th March, he reached Lashio, about 120 miles north-east of Mandalay on the Burma Road, in command of the Chinese forces in Burma.

The British retreat continued to Mandalay, which was evacuated at the end of April and, from there northwards to the Indian frontier, the British troops and those under General Stilwell had to traverse nearly 300 miles of mountain and jungle with no roads or other communications. Crossing the R. Chindwin at Kalewa, General Alexander's gallant troops—their spirit still unbroken despite severe casualties and continuous retreat—then passed into India late in May, 1942, and were incorporated into the 4 Indian Corps based on Imphal. General Stilwell crossed the Chindwin higher up and passed into India *via* Homalin.

The Japanese entered Myitkyina on 7th May, and on the west flank in Arakan they struck from the Irrawaddy towards the Indian frontier through Taungup and Akyab. All Burma was now in enemy occupation except for a few strips of territory in the north.

The build-up period (May–December, 1942)

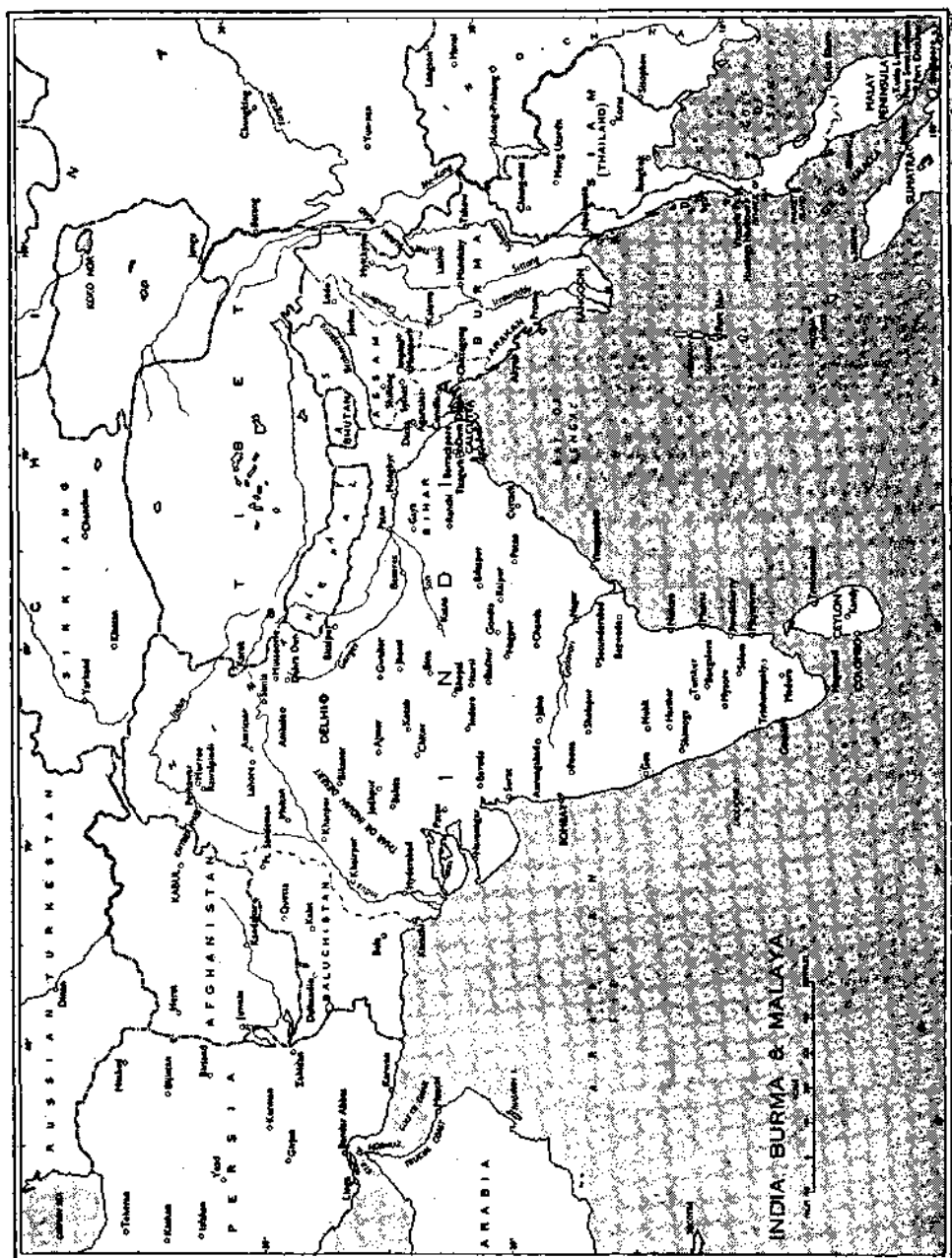
With the monsoon starting in May, and the need for the enemy to establish his supply lines, this was a more or less static period. The allied forces built up and trained their formations, and took post along the frontier. During this period much road construction was carried out both in Assam and in the forward areas, the road from Dimapur (Manipur Road) to Imphal receiving special attention, and also its extensions beyond Imphal towards Tiddim and Tamu respectively. Further to the north clearance work was started for the first stage of the new road running south from Ledo, which was to provide an alternative land route to China. Airfield sites were prepared in Assam.

General Stilwell resumed the training of Chinese divisions in India, reinforcements being flown in from China across the "Hump" by the newly established air-ferry service which, in December, 1942, became the India-China Wing of the U.S. Army Air Force Transport Command. General Stilwell's main objective, with his American and Chinese troops, and in conjunction with new Chinese armies which were being trained in Yun Nan by U.S. officers, was to reopen the land route to China by reoccupying northern Burma and building a new road from Ledo across the mountains to link up with the old Burma Road beyond Myitkyina and Bhamo.

The operational front along the India-Burma frontier fell, topographically, into three main areas:—

- (a) The Northern Front, which was based on Ledo at the terminus of the Bengal-Assam railway. This eventually comprised the operational area of the Northern Combat Area Command (N.C.A.C.) and extended into Burma from Ledo over the mountains and across the upper Chindwin into the Hukawng Valley, and on towards the northern section of the Rangoon-Myitkyina railway. It included such places as Myitkyina itself, Mogaung and Indaw, with Bhamo and Lashio still further to the south-east. This front was the scene of General Stilwell's operations in north-east Burma, and for those of Wingate's "Chindits." The new road from Ledo to link up with the old Burma Road was built through this area.

SKETCH MAP 7



- (b) The Central (Manipur) Front, which was based on Dimapur (Manipur Road), a station on the Bengal-Assam railway. This included such places as Kohima, Imphal, Ukhrul, Tamu, Kalewa, Kalembo and Tiddim, all of which were made famous during the heavy fighting by Fourteenth Army during 1944.
- (c) The Southern (Arakan) Front, based on Chittagong and Comilla. This comprised a coastal strip of creeks, mangrove swamps, rivers and jungle-covered hills, and included such places as Cox's Bazar, Maungdaw, Buthidaung Donbaik and the Kaladan and Mayu River valleys. Further south down the coast towards Rangoon were Akyab Island, Ruywa, Ramree Island and Taungup.

These three sections of the total front stood along the mountain wall dividing India from Burma. While Fourteenth Army dealt with the main enemy forces on the central and southern fronts, General Stilwell struck back in northern Burma, with the Chindits harrying the Japanese communications, and the Ledo Road was gradually extended south-eastwards towards Myitkyina.

The first Arakan campaign

It is now necessary to return to the latter part of 1942. During the monsoon period the coastal road from Chittagong towards Maungdaw was developed, and air-strips were built. In mid-December a British offensive was launched by 14 Indian Division with the object of capturing Akyab. This was unsuccessful, and by the middle of May, 1943, the force was back behind Maungdaw and on the defensive to prevent the enemy from pressing through to India *via* Chittagong.

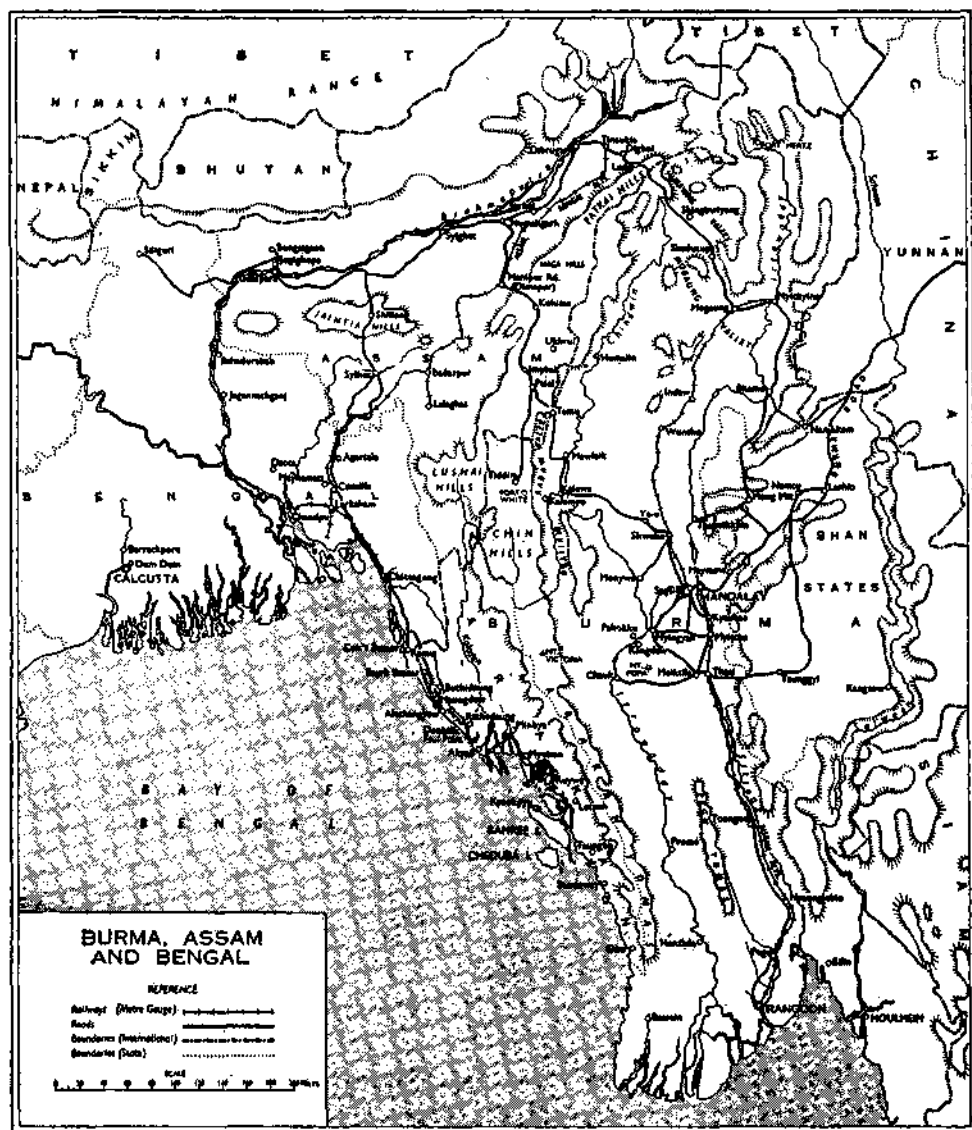
Wingate's first expedition

In July, 1942, an Indian brigade had been placed under General Wingate for special training in long-range jungle penetration duties, and in February, 1943, this force left Imphal for Burma. The main object of this operation was to determine whether a large force could operate on air supply alone. The task given to the force was to cut the railway between Mandalay and Myitkyina, then to cross the Irrawaddy and cut the line between Mandalay and Lashio, thus hampering the Japanese supply communications in north-eastern Burma, and harrying the rear of the enemy forces operating against General Stilwell's troops on the northern front. The first railway was cut successfully and much interference was caused to the enemy communications generally, but the difficulties of air supply at that time and the heavy sickness-rate necessitated the abandonment of the second main objective. The force, split up into several dispersed groups, made its way back to India, and the expedition was over by June, 1943.

The formation of South-East Asia Command (S.E.A.C.)

In the latter part of 1943 a new Allied Command for South East Asia was set up with Admiral Lord Louis Mountbatten as Supreme Commander. General Stilwell was appointed Deputy Supreme Commander, and he combined this function with those of Chief of Staff to Marshal Chiang Kai-Shek, Commanding General of U.S. forces in the China-Burma-India theatre, and Commander of the American and Chinese troops of the Northern Combat Area Command on the northern front.

SKETCH MAP 8



Drawn by Ordnance Survey, 1951

Vigorous action was taken to build up allied air strength, with special emphasis on air supply, which it was intended should form the principal means of supplying all requirements to the allied forces when they should eventually operate through Burma. It was also made clear by the Supreme Commander that operations would be conducted in all weathers despite the monsoon. Arrangements were made for the development of the Bengal-Assam railway by U.S. Railway Engineers during the winter of 1943-44, and for the building of roads from railheads to the front.

At the Quebec Conference in August, 1943, a considerable quota of landing craft and other shipping to facilitate amphibious operations down the coast had been allotted to S.E.A.C., but these were later cancelled at the Tehran Conference and allocated back to the European theatre. This altered plans, as it ruled out the possibility of conducting large scale sea-borne assaults along the Arakan coast during 1944, and made it necessary to plan for a re-entry into Burma from the north, across the mountain barrier.

The second Arakan campaign (January-April, 1944)

Fourteenth Army decided to push south on the Arakan front so as to clear the Mayu peninsula and secure the mouth of the Naaf River for aiding sea supply. This operation was to be undertaken by 15 Indian Corps, consisting of 5 and 7 Indian Divisions with 81 West African Division out on the flank in the Kaladan valley. The attack was launched on 19th January, 1943. Maungdaw was taken and progress made, but early in February the Japanese counter-attacked in the coastal sector and by means of by-passing tactics, 5 and 7 Divisions were isolated. 26 and 36 Indian Divisions from reserve restored the situation, and by the end of February the enemy's counter-stroke had been defeated. This success was made possible owing to the great assistance given by air supply.

In March, when the enemy's main assault was delivered in Manipur, both 5 and 7 Divisions were switched across to the central front, and 36 Division was later moved back into Army reserve, but 25 Indian Division had arrived, and a line was established to maintain the allied gains during the malarial season of 1944.

Wingate's second expedition

A new long-range penetration force was built up by General Wingate, and it was planned that this should be flown in to landing areas which had been selected by him during his first expedition. The areas were in that part of the northern front around Mogaung, Indaw and Bhamo. The object was to strike against the rail, road and river systems on which the enemy depended for his communications, and to harry the rear of the Japanese force fighting against General Stilwell's troops as they moved south. Four Chindit brigades were flown in, and a fifth marched in over the Naga Hills from Ledo. Supply was entirely by air, heavy fighting was experienced, and considerable damage was inflicted on the enemy rear installations.

Operations on the northern front

General Stilwell started his march back into Burma at the end of 1943. The new Ledo Road and pipe-line followed his advance over the mountain range to Shingbwiang, crossing the upper reaches of the Chindwin, the Hukawng

and Mogaung valleys, and thence eventually towards Bhamo and beyond to link up with the old Burma Road. By mid-March the Mogaung valley was reached, just at the time when the Japanese launched their offensive across the R. Chindwin further to the south towards Assam and the Bengal-Assam railway. This move threatened the Japanese lines of communication. General Stilwell was operating under the tactical command of Fourteenth Army and was instructed to drive ahead, being aided by Wingate's Chindits in rear of the enemy facing him, and with a U.S. Commando Force known as "Merrill's Marauders" out on his northern flank. By May, 1944, he had captured Myitkyina with its valuable airfield at the terminus of the Rangoon-Myitkyina railway. He was supplied throughout by air, an advantage which the enemy did not enjoy, and by this operation the Japanese were cleared from the area lying between the allied forces and China.

The Japanese offensive on the central front (March, 1944)

While General Stilwell was advancing into Burma further to the north, the enemy built up his forces in the centre. The enemy offensive on the Arakan front was in the nature of a diversion, and he selected for his main assault the Manipur area on the central front. It seems clear that his objectives were:—

To seize the advanced allied base at Imphal, and to capture Kohima and Ukhul.

To cut the Bengal-Assam railway and thus disrupt the allied lines of communication.

To overrun the Assam airfields, and so hinder the air traffic across the "Hump" to China.

The Japanese plan was evidently based on the hope of a quick success to enable them to make use of our supply dumps, as they had no properly organized air supply, and their land supply communications were slow, strained and difficult.

In the middle of March, 1944, three crack Japanese divisions attacked across the R. Chindwin. The Fourteenth Army Commander had decided to withdraw his troops holding the frontier and to fight in the Imphal Plain. 17 Indian Division therefore withdrew from Tiddim, and 20 Indian Division from Tamu, joining 23 Division in Imphal. They were considerably harried all the way back by the advancing enemy.

At this time 5 and 7 Indian Divisions were switched over from Arakan largely by air, and 33 Indian Corps and 2 (British) Division were ordered to move in from India, the primary objective being to reopen the road from Dimapur to Kohima, to prevent the enemy from penetrating into the Assam valleys, and to link up Kohima with 4 Corps at Imphal.

After a siege of 15 days Kohima was relieved by troops of 33 Corps, and by mid-May the whole Kohima ridge was cleared. The assault on Imphal was repulsed with heavy casualties to the enemy, and by the end of May the whole of Imphal Plain was practically clear of Japanese troops. The crisis on the central front was now over. The monsoon had started at the end of April, and by the middle of July the enemy base at Ukhul had been captured.

Pursuit to the south

11 Army Group, under General Giffard's command, had been formed when S.E.A.C. was set up in November, 1943. When General Leese was

appointed C-in-C. Allied Land Forces (A.L.F.S.E.A.) on 11th November, 1944, the name "Army Group" was dropped. 15 Corps, which had formed part of Fourteenth Army, now came directly under the command of H.Q. A.L.F.S.E.A., and Northern Combat Area Command also came under General Leese's command. The intention was to capture Mandalay, while N.C.A.C., by taking Lashio, would protect and secure the line of the new road route to China.

The Fourteenth Army plan was to drive the enemy across the R. Chindwin into the plain north of Mandalay and force him to battle there. 11 East African Division harried the Japanese back to Tamu, while 5 Indian Division chased the remnants of 33 Division through Tiddim, and by 19th August the last remaining Japanese were thrown out of India.

Early in December troops of General Slim's army, consisting of 4 and 33 Corps, crossed the Chindwin at Kalewa where, two and a half years before, he had commanded the British rearguard in retreat from Burma to India.

Meanwhile a second allied force was converging towards the selected battle ground from the north. This was the N.C.A.C. which General Stilwell had led to Myitkyina before returning to the United States in October, 1944. It included five Chinese divisions, "Mars" Force (which replaced Merrill's Marauders) consisting of U.S. and Chinese troops, and 36 (British) Division which had been sent to reinforce N.C.A.C. 36 Division relieved the Chindits in the Mogaung area and began to move down the railway from Mogaung in August, while the Chinese Sixth Army moved on a parallel axis. On 16th December 36 Division made contact with 19 Indian Division of Fourteenth Army, thus linking the forces of the northern and central fronts. In addition, a Chinese Expeditionary Force, which had been trained in China by American officers, appeared from Yun Nan after seven months' fighting, having crossed the Salween River.

The road from India to China was reopened on 27th January, 1945. The jungle country now lay behind Fourteenth Army, and movement conditions became easier. Both corps advanced on Shwebo and Monywa. General Slim's intention was that the enemy force should be destroyed around Mandalay, and Rangoon captured before the monsoon broke in May.

The advance through Burma was dependent on air supply. It was not feasible to build and stockpile airfields across the R. Chindwin, and anywhere south of Mandalay was outside the radius of action of the northern airfields. It was necessary, therefore, to develop operations down the Arakan coast so as to establish airfields in that area. From there the Mandalay-Rangoon road and rail system could be supplied by air and stockpiled by sea. It was, in fact, the only means of effecting air supply south of Mandalay.

15 Corps had been pushing down the Mayu peninsula since the main battle had shifted from Arakan to the central front in March, 1944. The plan was that 15 Corps should capture Akyab and Ramree by sea-borne landings so as to secure airfields from which Fourteenth Army could be supplied by air during its advance through central Burma.

Certain outside factors now affected the situation. A new Japanese offensive in China caused certain valuable air-supply squadrons and some Chinese divisions to be diverted from Burma back to China. Also the German winter offensive in the Ardennes sector of the European theatre upset plans which had been made to send further divisions from Europe to Burma. At the end of February, Marshal Chiang Kai-Shek halted the southward advance of his

Chinese divisions in eastern Burma, and all these factors combined to slow up the allied offensive.

The enemy, moreover, succeeded in withdrawing over the Irrawaddy and concentrated his forces south of the river, thus upsetting the plan to bring him to battle north of Mandalay and destroy his forces there. General Slim then planned the final moves of his victorious campaign which, as a result of clever strategy, and magnificent achievements on the part of Fourteenth Army, brought about the complete defeat of the Japanese armies in Burma. The intention was that 4 Corps should cross the Irrawaddy in the Pakkoku area about 100 miles south of Mandalay and, by a quick mechanized dash across to Meiktila behind the enemy lines, disrupt his defence and cause chaos in the enemy rear areas. Meanwhile 33 Corps was to cross the river just above and below Mandalay.

7 Division crossed the Irrawaddy near Pakkoku by assault on 14th February and the concerted attack began on the 19th. On the following day 17 Division passed through 7 Division's bridgehead and pushed on rapidly to capture Meiktila with its airfield.

In the meantime 19, 20 and 2 Divisions had each forced crossings higher up the Irrawaddy, and Mandalay was captured on 21st March. The concentration of 5 and 17 Divisions with a tank brigade in the Japanese rear at Meiktila, while they were still trying to drive back the three divisional bridgeheads further north, gave the depleted Japanese divisions very little hope of survival. After a few weeks' fighting around Meiktila, Mandalay and Pakkoku, in which the Japanese suffered heavily, Fourteenth Army regrouped with 4 Corps (two divisions and a tank brigade) moving rapidly down the railway from Meiktila towards Rangoon, while 33 Corps moved down the Irrawaddy. At this stage the only doubt was whether 4 Corps, whose needs had first priority, would reach Rangoon before the monsoon should make the supply position impossible. They reached Pegu, 50 miles from Rangoon, on 29th April, but were held up there for two days by the Rangoon garrison and heavy rain. They were clear of opposition and ten miles south of Pegu, when 26 Division landed from the sea on 2nd May.

These last stages of the campaign presented a very difficult situation for the Survey Service. The course of the operations has therefore been given in some detail.

The third Arakan campaign

It is now relevant to consider the operations that had been conducted along the coastal front in Arakan, which played an important part in the final stages of the operations leading up to the capture of Rangoon. The topography of Arakan is such that the hills sweep down towards the sea, leaving only a narrow strip of land along the coast suitable for operational movement. By Christmas Day, 1944, 15 Corps (two Indian and two West African Divisions) had reached Foul Point, and on 3rd January 25 Division was ferried across to Akyab Island, which had been evacuated. This provided a vital airfield and there followed swiftly a commando and infantry landing on the Myebon Peninsula, 35 miles east-south-east of Akyab. In view of the rapid advance of Fourteenth Army and the approaching monsoon in May speed was essential, and a succession of amphibious operations made steady progress down the coast. 26 Indian Division landed on Ramree Island by sea-borne assault, thus enabling a further airfield to be developed. Then followed landings by other formations at

Kangow (22nd January), where some of the bitterest fighting in the whole campaign was experienced, at Ruywa (17th February), and at Letpan (19th March).

At this stage two divisions of 15 Corps were sent back to India in preparation for operation "Zipper," the planned invasion of Malaya. For the sea-borne assault on Rangoon by 26 (Indian) Division, Gurkha paratroops were dropped to neutralize the coastal batteries at the mouth of the estuary. The main landing force was transferred to landing craft from their transports, sailed up the estuary, found Rangoon evacuated, and occupied it on 2nd May. Contact was then made with Fourteenth Army, which was approaching from the north.

The closing stages

15 Corps and divisions withdrawn from the main force were sent back to India where, with other troops, they were regrouped to form a new Fourteenth Army for the invasion of Malaya.

Divisions from 4 Corps and 33 Corps in Burma then formed a new Twelfth Army whose task it was to capture Moulmein and trap and destroy the remaining Japanese in Burma. After inflicting further heavy casualties Twelfth Army forced the Japanese across the R. Sittang.

Operation "Zipper" was planned for 9th September. It provided for a landing in the Port Swettenham area, 200 miles to the north of Singapore, by seven divisions and an armoured brigade; a parachute brigade was to be dropped on Singapore and a commando brigade landed on the island from the sea.

Before that date, however, the Japanese had realized their defeat as a result of the allied offensives in the Pacific and in Burma, and the dropping of the atom bombs on Hiroshima and Nagasaki on the 5th and 9th August precipitated their surrender, which took place a few days later.

SECTION 2. SURVEY ORGANIZATION

The build-up of a Military Survey organization in India for operations in South East Asia, and its subsequent control and activities, were attended by many difficulties and complications. It may be well, therefore, to consider shortly the facts and policies that governed the various stages of development, the principal sources from which the organization sprang, and certain factors which emerged during the process which had a considerable effect on the problem.

The Survey of India

Peace-time survey activities in India were controlled by the Survey of India, a highly efficient organization which operated under the Department of Education, Health and Lands. The Surveyor General, holding the rank of Brigadier, and his principal officers were, as a rule, officers of the Royal Engineers who held specialist survey qualifications. In most cases these officers joined the Survey of India as junior officers, and stayed with it for the remainder of their active career. Apart from them, the majority of the remaining personnel were of Indian nationality, and their standard of proficiency and training as surveyors and map makers was very high.

In some respects, therefore, it will be seen that there were points of resemblance between the Survey of India and the Ordnance Survey of Great Britain. With regard, however, to fundamental policy affecting military survey

relations with the General Staff, and the formation of a military survey organization to operate with the Army on active service, there were distinct differences between British and Indian policies.

In Great Britain there was, before the war, a Geographical Section of the General Staff, which formed one of the sections of the Directorate of Military Operations and Intelligence at the War Office. This section was officered principally by R.E. officers holding specialist survey qualifications, and it was responsible for advising the General Staff on all matters concerning military survey and mapping, and for implementing the resulting survey and mapping policy laid down by the General Staff, including the preparation of maps and other survey data for war and the technical aspects affecting the formation of survey units and their training. During the course of the war this section was greatly enlarged, and eventually assumed the status of a War Office Directorate known as the Directorate of Military Survey. (See Chapter I, Section 1.)

The Director General of the Ordnance Survey in Great Britain did not owe any responsibility to the War Office on military survey matters. He was responsible only for the control and administration of his department which, though owing allegiance to the Ministry of Agriculture, devoted its energies, during the war period, to military map production in accordance with the mapping programmes laid down by the Director of Military Survey at the War Office. (See Chapter I, Section 2.)

In India, however, there was, in peace-time, no proper survey representation at G.H.Q., and nothing comparable with the Geographical Section at the War Office.

To clarify subsequent developments, it may be well to summarize the pre-war organization of the Survey of India, as it bears an important relation to the course of events. As in the case of the Ordnance Survey of Great Britain, the Survey of India was responsible for the execution of triangulation and topographical field surveys, the preparation of maps, and their printing and publication on various scales. Map publication was mainly concentrated at Calcutta, and a geodetic branch, which was responsible for scientific and other special work, and some of the topographical survey, drawing and map publication branches were at Dehra Dun. For topographical surveys in the field the Survey of India was organized in "Circles" as under:—

- (a) The Eastern Circle, based on Shillong (Assam).
- (b) Independent topographical parties working in Burma and southern India.
- (c) The Frontier Circle (topographical and military) which worked in north-western India, in liaison with Northern Command and Western District. It had its H.Q. at Simla, and maintained a liaison with G.H.Q. It was primarily responsible for mapping and survey in connection with any operations which might take place on the North West Frontier. Each of the above was under the control of a Director.

From the military aspect, the Survey of India's original responsibilities were:—

- (a) To provide such maps of India, Burma, Afghanistan and Iran as might be required by the defence services.
- (b) In the event of war, to provide two field survey companies and two survey H.Q.s for service on the North West Frontier, and a Survey Depot (administrative).
- (c) To carry out annually a small amount of training in military survey.

When war broke out in Europe in 1939, and later in the Middle East in 1940, there was, in effect, no military survey organization in India, other than the liaison between the Director of the Frontier Circle and G.H.Q., which was concerned primarily with possible operations on the North West Frontier. There was nothing in the nature of a Survey Directorate or Geographical Section General Staff at G.H.Q., and no survey units in actual being.

The ensuing transition from peace activities to those required for a maximum war effort naturally took place slowly. A good deal of help was gained from the experiences of the R.E. Survey organization in the Middle East during the early stages of operations in that theatre. Military survey training which took place in India late in 1939 and early in 1940 helped to crystallize ideas, as did also the Survey Conferences which were held in Cairo during the summer of 1940 and in Delhi early in 1941, the latter being attended by survey representatives of India, Middle East, and the Far East. These conferences were especially valuable for settling policy questions regarding responsibility for the mapping of potential operational areas in South East Asia.

From an early stage in the war the civil activities of the Survey of India were subordinated to war needs though, during the early war period, certain civil functions continued with a strict control of priorities. Some of these were considered essential to the administration of the country and, at a time when there were large fluctuations in demands for war maps, it was undesirable that personnel should remain idle during lulls in the war-work. Later on, when military operations had started in earnest, the demand for war mapping was so great that practically all civil activities were suspended.

The pre-war and subsequent operational responsibilities and activities of the Survey of India for mapping and map production are described in Section 3. It may be noted here, however, that the map reproduction and printing resources, though adequate according to peace-time standards, had no opportunities of local expansion. There was no source from which competent Indian lithographic tradesmen could be recruited in any numbers. This was unlike the United Kingdom, where there was a large number of civilian printing firms which formed a valuable pool of map reproduction power, either for carrying out the actual map printing on a contract basis or for the provision of skilled personnel for mobilization into survey units. The existing printing equipment in India, moreover, was not of the most modern design, and was not entirely suitable for rapid mass-production output.

Formation of a Military Survey organization

By the middle of 1941, the pre-war commitments for the supply of two field survey companies and two survey H.Q.s for service on the North West Frontier had been extended to provide:—

7 H.Q.s	}	For service anywhere.
6 Field Survey Companies		
3 Park Sections		
2 Map Supply Sections		
1 Survey Depot		To remain in India.

These commitments were extended further during subsequent months, but by July, 1941, one Survey H.Q. and one Field Survey Company had been

formed and had gone overseas to Iraq. Two more of each had been formed and were awaiting orders to proceed to the same destination. One Survey H.Q., a Map Supply Section and a Park Section were on the stocks, with further units to follow shortly after. After their formation the Survey of India retained responsibility for their maintenance with regard to personnel.

The necessity for a strong base drawing and map production organization, additional to the military field organization, soon became very clear. The number of sufficiently skilled lithographic technicians in India being very limited, it was necessary to reinforce them by the importation, through army sources, of technical tradesmen who had been mobilized into British survey units from the printing trade. A special military establishment was formed to hold this personnel, who were attached to the Survey of India.

A military Survey Depot, combined with a Survey Training Centre, was formed for the administration of survey units as they were formed, and to undertake the training of surveyors for the survey units.

A Central Map Depot (military) was established in Delhi, with smaller map depots serving the eastern, southern and north-western armies. Arrangements for map distribution are described in Section 6. A survey stores organization was also created.

Air photography

This subject will be dealt with more fully in Section 4, but one important item of organization in connection with it should be recorded here. During the latter part of 1942, the Indian Government chartered the photographic resources, including three aircraft, of the Indian Air Survey and Transport Ltd. It was realized that air photography would play a large part during any campaign in connection with programmes of new mapping and revision. The charter was operated under the orders of the Surveyor General, who placed aircraft and photographic resources at the disposal of the Director of Survey as necessary.

Colonel D. R. Crone, a Superintendent of the Survey of India, who had specialized in air survey technique, was appointed Air Survey Officer, Survey of India, to co-ordinate all air survey work and training, both civil and military, and to operate the Indian Air Survey and Transport Charter on behalf of the Surveyor General.

The above notes give a short background picture of the survey situation in India during the early war period, with special reference to the Survey of India, and the action taken towards the formation of a military survey organization. The mixture of civil and military responsibilities and loyalties will be noted, and the effect of this on the course of events on the military operational side will be seen in succeeding paragraphs.

First campaign in Burma (1941-42)

Towards the end of 1941, when Japanese forces were threatening Burma, a small military survey organization was raised in Burma consisting of:—

An A.D. Survey with an Indian Field Survey H.Q.

One Indian Field Survey Company on a special establishment.

One Map Supply Section.

There was also, in Maymyo, the residue of a Burma (Civil) Survey party and a reproduction unit with camera and flat-bed printing press. The rapid Japanese advance into Burma put a stop to the work of revision and triangulation and the newly raised military units were employed on map distribution and emergency printing. In April, 1942, they had to evacuate Maymyo and, by devious routes, and in dispersed groups, they found their way back to India, having lost their equipment and many of their numbers.

A.D. Survey (Burma) was able to move the more important of the Burma survey records as far as Myitkina but, during the final stages of the retreat, could get them no further. They were buried in the grounds of the Forest Officer's bungalow, the officer being a Burmese who elected to stay on. After the recapture of Myitkina in May, 1944, H.Q. A.L.F.S.E.A. made every effort to recover the records, but they had evidently been found and removed by the Japanese. It is understood that they were recovered in Singapore after the Japanese surrender.

Survey organization (Spring, 1942)

In the spring of 1942, the war in Burma was obviously going badly, and the defence of India became a paramount issue. The Eastern and Southern Commands in India were converted to field armies known as the Eastern and Southern Armies respectively, and Survey representation with these formations was provided by the creation of one Survey Directorate headed by a Deputy Director (Colonel G. Bomford) consisting of three British officers and approximately 50 other ranks. The D.D. Survey had as his mandate:—

- (a) The control of mapping and survey work for both armies.
- (b) To act as deputy to the Director of Survey (Military Circle) in connection with surveys in Assam, and for liaison with China.
- (c) To exercise control over survey units in Burma. This latter item did not, however, materialize owing to the evacuation of troops from that country.

At this time, then, the military Survey Service for India consisted of:—

The Director of Survey (Colonel E. A. Glennie) with the Military Circle. He had no military staff, and continued to exercise his civil survey functions with the Survey of India.

Three Indian Field Survey Companies and associated Survey H.Q.s which had been in Iraq since 1941 and were still there.

The relics of the Survey H.Q. and Field Survey Company which had returned from Burma, disorganized and without equipment.

A Survey Depot for map storage.

The Survey Directorate for the Eastern and Southern Armies referred to above.

Thus there were no effective survey troops actually in India at this critical time and the available map stocks of probable operational areas were dangerously low. The only available resources consisted of the civil survey department with its printing equipment at Dehra Dun and Calcutta, and a reserve of surveyors and draughtsmen with which to form further military survey units.

During May, 1942, the War Office sent out to India an officer (Major M. O. Collins, R.E.) who had had considerable experience with the Geographical Section at the War Office in connection with the mobilization and equipping of survey units for the B.E.F. in France, and with the preparation of map stocks for operations in Europe. Having reported for duty to the Surveyor General, he was posted to the Military Circle as A.D. Survey.

In July, the Survey H.Q. and Field Survey Company from Burma were re-formed and brought up to strength and, after administrative and military training, were engaged on productive mapping work. Anti-aircraft sites, coast defence batteries and airfield sites required urgent survey work which was undertaken first by civil parties and then by military units.

Formation of Geographical Section, General Staff

In August, 1942, a Geographical Section, General Staff, was formed at G.H.Q. (I.). This was, in effect, a Survey Directorate and was headed by Colonel E. A. Glennie of the Survey of India as its Director. This officer, however, continued to be paid by the civil department, and also continued to carry out his duties in connection with the Military Circle, which rendered him responsible still to the Surveyor General. His staff was strengthened by the addition of an A.D. Survey, and two more officers who were sent out by the War Office. A small printing section was added for dealing with R.A.F. target maps and miscellaneous jobs.

Increase of map printing resources

It was realized that no further local expansion in printing output was possible so in response to India's request for more printing units the War Office organized the technical nuclei of a number of reproduction sections. Each of these units, when augmented by its Indian component, consisted of two British officers, 36 British O.R.s and 48 Indian O.R.s. They were equipped with the same type of rotary printing machines as were being supplied to standard British field survey companies. One of these mobile sections, with demy Crabtree machines mounted in lorries, was posted to the Eastern Army in September, 1942.

Survey control for Eastern and Southern Armies (January, 1943)

In January, 1943, the combined survey control of the Eastern and Southern Armies was separated, a D.D. Survey being appointed for each. The year just starting was to include the unsuccessful offensive in Arakan during the first half of the year, the 1943 Wingate expedition, and an inconclusive offensive-defensive in the Kabaw valley and the Chin Hills. During this period the Survey Service received reinforcements and was built up into an effective organization. In February a Corps Survey Directorate with one Field Survey Company (less detachments left behind at Army H.Q.) was allotted to 4 Corps which was operating in the Imphal area.

Base map production

One of the more important organizational items during the year was the build-up of a base map-production establishment near Calcutta. This, in due course, comprised the following:—

Headquarters and A.D. Survey.
Nos. 63 and 66 Indian Reproduction Groups.
Drawing Section. (Detached from 6 (Indian) Field Survey Company.)
No. 2 (Indian) Field Survey Company (from Iraq).
No. 22 Survey Park Section.

Difficulties were encountered owing to defective power plant, and were not overcome satisfactorily until the arrival of the Lister generators from the United Kingdom.

Air Survey

The technical aspects of air survey work are dealt with in Section 4. It had been appreciated early in 1942 that, without considerable air survey potential, future progress in map production for operations in South East Asia would be severely handicapped, even if not rendered impossible. By agreement with the War Office and Middle East, the Indian Field Survey Companies which had been in Iraq and Persia were transferred back to India, and were concentrated at Bangalore where they underwent military training and courses in jungle and air survey. One Indian Air Survey Company was formed early in 1943, with a second following later in the year.

Formation of S.E.A.C.

As stated in Section 1, in November an important change in higher command and control took place, by the formation of South East Asia Command (S.E.A.C.) which was responsible operationally direct to the Chiefs of Staff. The British and Indian formations operating under this Command formed the 11 Army Group, and the Eastern Army was renamed the Fourteenth Army.

Plans were worked out for the survey organization in S.E.A.C. under the new Command arrangements. Hitherto, as will be clear from this narrative, the control of all survey policy and activities had been exercised from India, where the principal military survey organizations and directorates under the control of D. Survey, India Command, were:—

G.S.G.S. at G.H.Q. (I.) (Colonel E. A. Glennie).
Survey Directorate, Eastern (Fourteenth) Army (Colonel G. Bomford).
Survey Directorate, Southern Army (Colonel J. B. P. Angwin).
Air Survey Directorate (Colonel D. R. Crone).

The main functions of these directorates were as follows:—

G.S.G.S. carried out the technical and administrative functions of a Survey Directorate at G.H.Q., kept up a map library of the areas of survey responsibility allotted by the War Office to India, and issued drawing and printing orders to the Survey of India.

The Eastern (Fourteenth) Army was engaged in operations on the Burma front. About the time of the formation of S.E.A.C., H.Q. Eastern Army moved to Comilla and became H.Q. Fourteenth Army. This army was well provided with survey, reproduction and map supply units.

The function of the Survey Directorate (Southern Army) was to train survey units, some of which had recently returned from Persia-Iraq, and to provide for the survey needs of the Southern Army, which was then the main training centre in India.

The Air Survey Directorate controlled two Indian Air Survey Companies, and two Map Reproduction Sections. It was located at Dehra Dun, and its units were spread out between Dehra Dun, Mussourie and Risalpur. Close control by the Directorate was therefore difficult. The D.D. Survey (Air), in addition to his military survey duties, had certain civil responsibilities to the Surveyor General of India.

The new proposals envisaged the creation of a completely independent survey organization for S.E.A.C. G.H.Q. Survey (I.) would then only control survey units in India which did not belong to S.E.A.C., the flow of reinforcements and stores, and the farming out of mapping programmes to the Survey of India as required by S.E.A.C. Survey co-ordination between S.E.A.C. and India was not a simple matter, more especially with regard to the planning and preparation of maps covering future operational areas. It was considered by Survey (S.E.A.C.) that, as their own H.Q. staff would be directly responsible to the Chiefs of Staff concerning the preparation of future operational plans, and might, under certain conditions, not even inform G.H.Q. (I.) of what those plans were, it would not be correct, or even possible, for D. Survey (I.) to retain responsibility for controlling the policy, planning and mapping programmes for S.E.A.C. operations. As a result of a conference in London, however, between the Director of Survey, War Office (Brigadier M. Hotine) and D. Survey (I.), it was decided that the latter should continue to retain responsibility. One of the principal arguments put forward by the War Office in support of this decision was that the technical independence of S.E.A.C. would possibly result in Indian mapping resources not being fully utilized. It was, however, well understood that S.E.A.C. should and would handle urgent and highly secret production with their own resources, and that these latter might have to be strengthened for the purpose. In coming to this decision the War Office possibly had in mind a relationship such as that which was subsequently to exist between them and S.H.A.E.F., whereby the latter was responsible for large scale map production and supply, and the former, subject to the operational requirements of S.H.A.E.F., retained general responsibility for production and supply of the medium and smaller scales. It should be remembered, however, that the War Office was always fully in the operational picture with regard to current and future operations in north-western Europe, whereas G.H.Q. (I.) was not in this position with regard to the activities of S.E.A.C.

The decision having been made, those concerned took action to regularize their procedure accordingly. As the Supreme Commander did not wish to have a large executive staff it was proposed that, with regard to Survey, there would be only a small policy directorate at his Headquarters, the remainder of the directorate to function at 11 Army Group H.Q. The proposals were approved, and the D. Survey (Brigadier G. F. Heaney) assumed duty at H.Q. S.A.C.S.E.A., his D.D. Survey (Colonel J. E. S. Bradford) being at H.Q. 11 Army Group. By March, D. Survey came to the conclusion that it was difficult for him to exercise proper control over the Survey Service in S.E.A.C. from the Supreme Commander's Headquarters. It was agreed, therefore, that he would operate at H.Q. 11 Army Group where he could exercise executive functions, and that an A.D. Survey (Lieutenant-Colonel M. O. Collins), transferred from that H.Q., would represent him at H.Q. S.A.C.S.E.A. with the following mission:—

To act as survey representative at H.Q. S.A.C.S.E.A.

To keep D. Survey 11 Army Group informed of all trends and aspects of forward planning.

In conjunction with the Joint Planning Staff to draw up survey appreciations and plans for each proposed operation, bearing in mind the technical survey policy laid down by D. Survey.

During these negotiations certain happenings occurred which are of interest to record:—

- (a) In view of the proposed move of S.E.A.C. headquarters to Ceylon designs were prepared for the erection of a factory building in Kandy to house a map reproduction plant, and the work was undertaken on a high priority basis.
- (b) By agreement with the Hydrographic Officer of the Eastern Fleet, a Hydrographic Section R.E. was raised for the production of charts and chart maps. The section was under command of a lieutenant-commander R.N.V.R., and the personnel were R.N.V.R. or Royal Marines except for lithographic tradesmen, who were Royal Engineers. The section first operated in the Survey of India's offices at Dehra Dun, but later moved to Kandy where it could work in close co-operation with Main H.Q. A.L.F.S.E.A., and later the Survey Production Centre.
- (c) In November, 1943, H.Q. Fourteenth Army moved to Comilla in eastern Bengal. Good accommodation was obtained at Maynamati, about five miles from Comilla, for the Survey Directorate and those units which would be working at Army H.Q. level. It was decided, therefore, to bring forward the units concerned from Calcutta and install them for work at this new site. Though Maynamati was very suitable for the working units, it seems probable that the directorate would have been better located alongside Army H.Q. at Comilla, where close and constant liaison with the General Staff would have been easier.
- (d) With the reopening of the Arakan offensive in January, 1944, a Survey Directorate was raised for 15 Corps. Two West African Brigade Survey Sections had joined the Army in advance of 81 (W.A.) Division in October, 1943, and were allotted to 15 Corps.
- (e) 155 (E.A. & S.R.) Survey Company had been expected in December, 1943, but was delayed and did not arrive until April. This was a large unit with 20 officers, 55 warrant officers and British non-commissioned officers, and approximately 450 Africans, but only a very small proportion of the latter were survey technicians. The unit was designed for a field role, not a static one. It contained three trig/topo sections, one drawing and one reproduction section.

In January, 1944, the Fourteenth Army Survey organization was as under:—

At Army H.Q.

Survey Directorate (Colonel G. Bomford as D.D. Survey).

No. 2 (Ind.) Field Survey Company (less air surveyors and detachment with 15 Corps).

Nos. 53 and 54 Drawing Sections.

Nos. 61 and 63 (Ind.) Reproduction Groups.

No. 22 Survey Park Section (at Dum Dum).

Combined Air Survey Section.

No. 36 Map Supply Section (less Detachment with 15 Corps).

No. 34 Map Supply Section (at Barrackpore).

With 4 Corps

Survey Directorate.

No. 6 (Ind.) Field Survey Company (less air surveyors).

No. 33 Map Supply Section.

Photo-zinco Section.

With 15 Corps

Survey Directorate.

Detachments of No. 2 (Ind.) Field Survey Company.

Nos. 3 and 4 West African Brigade Survey Sections.

Detachment of No. 36 Map Supply Section.

Photo-zinco Section.

The survey set-up at Army H.Q. was so organized that further moves could take place in two echelons.

Survey co-ordination difficulties between S.E.A.C. and India

To facilitate the control and conduct of operations, the greater part of H.Q. 11 Army Group moved to Barrackpore towards the end of 1944 and was known as Advanced H.Q. Allied Land Forces (A.L.F.S.E.A.). A small portion of H.Q. 11 Army Group went to Kandy, to a location near H.Q. S.A.C.S.E.A., and was known as Main H.Q. A.L.F.S.E.A. This separation between D. Survey (India) and D. Survey (A.L.F.S.E.A.), and the split in the latter's own headquarters made it very difficult to ensure that the senior survey officers all had the same operational picture in mind. It was by no means always easy for them to get a clear overall picture of the planning which was going on simultaneously at Delhi, Kandy and Calcutta. This difficulty was aggravated by the fact that only a few officers at G.H.Q. India were fully briefed so far as future S.E.A.C. operations were concerned, and D. Survey (India) was not one of these.

Survey organization and activities during 1944

The year 1944 covered the Japanese counter-offensive on the central front in Manipur, the siege and relief of Kohima and Imphal, the subsequent advance to the R. Chindwin, and preparations for the reoccupation of Burma.

In July, 1944, when it was clear that S.E.A.C. would be carrying out extensive campaigns during the latter half of that year and in 1945, it was agreed that in view of the probable large mapping commitments, all the survey units in the Southern Army should come under 11 Army Group control and be concentrated at Harihar, and that the D.D. Survey (Colonel J. B. P. Angwin) from Southern Army should, with a small directorate staff, take charge of their work. This was, in effect, the beginning of the Survey Production Centre which was further developed later. The units concerned at that stage were:—

Two Air Survey Companies.

Three Field Survey Companies.

One Base Map Production Section.

Three mobile Reproduction Sections.

Some ancillary units.

As future plans became clearer, a list of requirements for further reinforcements in survey units, personnel and equipment, including provision for an expansion of the Kandy map reproduction plant, was sent to the War Office. The situation in Europe at that time did not, however, allow extensive reinforcements to be supplied immediately and the War Office accepted the data supplied as a basis for planning a future supply when available.

The decision to create an advanced H.Q. of 11 Army Group at Calcutta with main H.Q. at Kandy necessitated an alteration in the dispositions of the Survey Directorate whereby D. Survey went forward to advanced H.Q. and D.D. Survey remained with main H.Q. Meanwhile the A.D. Survey who had been all this time at H.Q. S.A.C.S.E.A. remained there as the survey representative.

In September a D.D. Survey (Colonel Angwin) and an A.D. Survey were briefed for duty with the force scheduled to undertake operation "Dracula," a sea and airborne attack on Rangoon by some seven divisions. This operation was, however, cancelled in October and once more opinions appear to have varied amongst the senior survey officers as to the probability of future large scale operations. Opportunity was taken at this stage to send back to the United Kingdom the D.D. Survey who became redundant from the "Dracula" force, in order to study some of the survey lessons to be learnt from operation "Overlord" (the invasion of Normandy).

Reverting now to the survey situation in Fourteenth Army, the arrival of 155 (East African and Southern Rhodesian) Company brought a valuable accession of strength in survey resources to the army. It was apparent, however, that the unit was too large for use with any one corps under Indian conditions, and also that the proportion of non-technicians was too high. The company was therefore reorganized into the following units:—

- One small Company (No. 155).

- Two small Reproduction Sections, Nos. 67 and 68 (Type C), each with one printing press. Actually No. 68 was not raised until March, 1945, owing to the repatriation of a number of British O.R.s.

- One independent Air Survey Section (No. 17).

- One small Map Supply Section.

To simplify administration, the smaller units were provided with Indian O.R.s. instead of African and the surplus African personnel were absorbed into a Map Supply unit in Calcutta.

In July, 1944, the Survey Directorate with 4 Corps was transferred to 33 Corps when the latter took over Imphal and, at the end of November, Army H.Q. moved from Comilla to Imphal. The Survey Directorate moved with it, including all the units which had been employed on map production duties at Maynamati. All useful map stocks were moved forward, and Imphal then became the Army's main production centre and map supply base.

In November, 15 Corps was transferred from Fourteenth Army and came under the direct command of H.Q. A.L.F.S.E.A. With it went the A.D. Survey and his small directorate, the new 155 (E.A. & S.R.) Company and other units. Between December, 1944, and May, 1945, 15 Corps undertook a series of amphibious operations down the Arakan coast to assist Fourteenth Army by containing or destroying two Japanese divisions and by securing air bases. The Survey Directorate and units operating with 15 Corps had a busy time producing and supplying the necessary maps and carrying out surveys.

Survey organizational changes (S.E.A.C. and India. January, 1945)

In January, 1945, the Director of Military Survey (War Office) visited India in order to study at first hand the organizational and control problems that had been the cause of much misunderstanding and confusion during recent months. As a result of his visit several important changes were approved:—

- (a) For mapping and survey purposes S.E.A.C. would become operationally independent of India and would be answerable direct to the War Office on technical mapping matters.
- (b) S.E.A.C. would make bids on India for mapping work which it was convenient or necessary to farm out away from S.E.A.C. resources.
- (c) S.E.A.C. would bid on India for survey units and personnel when such could be made available.
- (d) All the survey units which had been concentrated in India at Harihar were to be moved to Ceylon where, with the Kandy units, they would form a Survey Production Centre under a D.D. Survey (Colonel J. E. S. Bradford).
- (e) The survey staff at H.Q. S.A.C.S.E.A. was to be slightly increased and, under a D.D. Survey (Colonel M. O. Collins) instead of an A.D. Survey, would take over all survey staff functions for that headquarters and for main H.Q. A.L.F.S.E.A. It would also deal with all air photographic and inter-service matters.
- (f) The entire Survey Service in S.E.A.C. was to be under the technical control of the D. Survey (Brigadier G. F. Heaney), even though the latter was at the time located at Advanced H.Q. A.L.F.S.E.A. In view of the great dispersion of the whole organization, a considerable measure of autonomy and direct dealing was granted to deputy directors on lines laid down in detailed instructions.
- (g) War Office agreed to the demand for reinforcements, which would be supplied as soon as available.

This recognition of, and clearing up of, the difficulties of control, together with the simplification of the S.E.A.C. survey organization, went a long way towards making the whole structure run smoothly, and eliminated the tendency towards a clash of loyalties and interests which had prevailed hitherto.

The period between December, 1944, and May, 1945, covered the advance into Burma, the destruction of three Japanese Armies, and the capture of Mandalay and Rangoon. Fourteenth Army H.Q. moved successively from Imphal to Indaingyi (January), to Monywa (February), to Meiktila (April) and to Rangoon (May). The move of the army map production and supply centre from Imphal to Myingyan took place in stages so arranged that not more than two printing presses were out of action at any one time.

After December, 1944, A.D.s Survey were withdrawn from 4 and 33 Corps and were replaced by captains with small field survey and map distribution detachments.

At the end of July, 1945, Advanced H.Q. A.L.F.S.E.A. moved to Kandy. This involved a slight readjustment of survey duties between H.Q. S.A.C.S.E.A. and H.Q. A.L.F.S.E.A. whereby the former took over all map production programmes, and the latter all distribution. This continued until the conclusion of hostilities in August.

United States Forces

The organization of the American Forces which were operating in this theatre was somewhat complicated. This is well illustrated by the following list of appointments which General Stilwell (U.S. Army) was filling at one period:—

- (a) Chief of Staff to Marshal Chiang Kai-Shek.
- (b) Deputy Supreme Commander of the Allied Forces under Admiral Mountbatten.
- (c) Commanding General of U.S. Forces in the China-Burma-India (C.B.I.) Theatre, for which he was responsible to General Marshall in Washington.
- (d) Commander of the Northern Combat Area Command. This was equivalent to a Corps Command in northern Burma consisting of four Chinese divisions, one British division and one U.S. brigade.

To cover the mapping requirements of the American Forces, a Survey Liaison Office was set up which dealt with their demands either from their own sources or by calling on British map stocks. This led to a satisfactory and efficient co-operation on survey matters between the British and American staffs. A U.S. Engineer Topographic Battalion was early available in India, with a Combat Mapping Squadron and a Multiplex Platoon (for air-photo work) following soon after. There was frequent and economical interchange of production work between British and American organizations according to what mapping potential was available. When the Northern Combat Area Command came under the direct control of H.Q. S.A.C.S.E.A., an American engineer officer joined the survey staff of that H.Q. to act as a link with the Survey Liaison Office. Later, when the staff was increased, he took over the duties of A.D. Survey.

Survey unit organization

The problem of unit organization was different under Indian conditions from that which applied in, say, Europe or North Africa. This was owing partly to a serious local shortage of lithographic tradesmen, with a negligible reserve of technical civilian personnel. The topographical conditions in Burma, with its jungles and trying climate, produced further factors which had to be taken into consideration. The following notes refer to some of the principal types of survey units which were employed:—

Field Survey Company (Indian). Out of a total of about 300, barely 50 were skilled technical tradesmen, a large number of sepoys being used in non-skilled trades such as chainmen. Map reproduction was taken away from these units owing to the shortage of Indian printers when separate reproduction groups were employed, and it was common practice to detach sections from these units to meet varying technical requirements.

Reproduction groups and sections. These consisted of a mixture of British reproduction tradesmen and Indian administrative personnel. As explained previously, they were formed by the War Office owing to the lack of Indian tradesmen, and sent out to India for completion with Indian personnel.

Some of the sections were equipped with mobile lorry-borne equipment, and some were static, involving the erection of the machines, and other plant, on some form of strong, solid flooring.

Air Survey Companies. Each of these units carried on establishment nearly 100 technical tradesmen trained in the compilation of maps from air photographs. They were more or less static, and could therefore dispense with a number of administrative personnel.

Air (Survey) Liaison Sections. These had been designed and raised in the United Kingdom to work in close liaison with R.A.F. Photographic Squadrons in connection with air survey programmes for mapping and for beach gradient determination. They did very valuable service in South East Asia, in the same way as they had proved their worth in Europe and in the Mediterranean theatres.

Survey Production Centre. This was formed in March, 1945, its major functions being briefly as under:—

- (a) To serve as a headquarter organization for controlling the brigaded mapping and reproduction units. It was capable of large intensive output.
- (b) To serve as the holding authority for all map records and compilation material, trig records and air photographs within the Command.
- (c) To serve as a link, on all matters concerning map records and production, between the Survey Service in S.E.A.C. and agencies outside the Command.
- (d) For the production of "Top Secret" and long-term planning map requirements for the Command.
- (e) For research in survey and map production methods.
- (f) For the bulk distribution of its output.

The following units were under its control:—

- Two Indian Air Survey Companies.
- Three Indian Field Survey Companies.
- Two Indian Drawing Sections.
- One Map Production Company R.E.
- One Map Reproduction Section R.E.
- Three Map Reproduction Groups (Type B).
- One Park Section.
- One Map Supply Company.

The potential of the above was reckoned to be about 90 new or revised sheets from air survey each month, and about 100 straight reproductions from existing kodelines (average run, 10,000 in four colours), in addition to normal miscellaneous requirements. This organization functioned smoothly under the control of Colonel J. E. S. Bradford during the latter part of the Burma campaign during which period preparations were in hand for the invasion of Malaya. It helped to simplify the work of the Survey Directorate at H.Q. A.L.F.S.E.A. and, with air transport as auxiliary to sea and rail, no difficulty was experienced in bulk map distribution to the various map depots.

No. 110 Map Production Company R.E. This was one of the units (see above) which was raised for the specific purpose of providing a large base map reproduction unit for service with the Survey Production Centre. It

was somewhat similar to 512 Field Survey Company R.E. in Middle East, but had no field sections. In essentials it consisted of nine officers, approximately 130 printing tradesmen R.E., 36 draughtsmen (topo) R.E. and necessary administrative personnel both British and Indian. The unit was designed and equipped to operate nine rotary machines for 24 hours a day, with a total monthly output of about 7,000,000 colour impressions. The machines, which were of sizes according to availability and not selection, included five single-colour (demy), one two-colour (quad crown), one two-colour (double-demy), and two small Harris machines for miscellaneous jobs. Being near the Equator, some of the standard sheets based on the graticule were of large size, and it was not always possible to print two up at one time on the double-demy machines. The set-up of the plant enabled "Top Secret" work to be undertaken with the utmost security.

West African Survey Sections in Burma. In January, 1943, when it had been decided to form two West African Divisions (81 and 82), arrangements were made for the raising and equipping of six brigade survey sections so that each brigade should have its own survey section. This conformed to a procedure which had been more or less routine during the Abyssinian campaign whereby each survey section was under the control of the formation commander.

By the end of April, Nos. 3, 4 and 5 Survey Sections were concentrated in Nigeria as independent units under the command of 81 (W.A.) Division and were ready to move to India.

No. 6 Survey Section started forming in January, 1943, and was soon employed on survey work in the Gold Coast. Nos. 7 and 8 Survey Sections were formed at Accra in July, 1943, and were assigned to 82 (W.A.) Division.

The original organization, as stated above, was one survey section to each brigade of the two West African divisions operating on the Arakan front in Burma. It was found, however, that the brigades were not operating independently, and the sections were therefore amalgamated to form two divisional survey sections. Each of these consisted of two officers and 30 African other ranks. These latter included four surveyors, two draughtsmen and 15 pioneers (Survey) with the necessary cooks, batmen and drivers to make the unit completely self-supporting. It was equipped for carrying out ground and air surveys, and had sufficient transport to make it semi-mobile. There were no facilities for map printing. During operations the equipment was head-loaded.

When 81 Division arrived in India in 1943 the survey organization was still on a brigade section basis.

5 and 6 Brigades were operating in the Kaladan Valley on the left flank of the main Arakan front and the survey sections accompanied them on a 200-mile outflanking march. During this 1943-44 campaign they were employed mainly on ground survey for the artillery and in mapping a new 150-mile jeep road which was constructed as a divisional supply road.

In July, 1944, the section with 5 Brigade was detached to Fourteenth Army H.Q. for 1/25,000 mapping of part of the Kaladan Valley.

3 (W.A.) Brigade was detached from 81 Division and formed one of the brigades of General Wingate's special force (Chindits). The survey section

with this brigade did little, if any, real survey work but was employed on the production of sketch maps of airstrips and camps.

In August, 1944, the three survey sections were amalgamated to form 10 (W.A.) Divisional Survey Section which was located at Rear Divisional H.Q. just behind the main Arakan front.

During the 1944-45 campaign 81 Division again carried out an out-flanking operation in the Arakan area, and the Divisional Survey Section produced a new series of 1/25,000 sheets of the Kaladan Valley. Between September, 1944, and January, 1945, this section produced ten such sheets from air photos and the printing was arranged by A.D. Survey 15 Corps. 81 Division was moving very quickly, and it was a constant struggle to maintain production so as to publish the sheets ahead of the forward troops.

In February, 1945, 81 Division was withdrawn from Arakan and moved to India to prepare for the Malayan invasion, and the Divisional Survey Section was scheduled for employment under Corps H.Q. on air-photo mapping for the forthcoming operations. In May, however, it was decided to withdraw the division from S.E.A.C. and send it back to West Africa, this move being completed early in 1946.

82 (W.A.) Division operated on the main Arakan front on the left flank amongst the foothills of the Arakan Yomas. During early 1945 the Divisional Survey Section produced eight 1/25,000 sheets and also had a field section with the advanced troops.

In May, 1945, the section was withdrawn from the division and staffed the Akyab Map Depot until September, when it closed down. The section then rejoined 82 Division at Taungap and moved with it to Rangoon.

During the early part of 1946 it worked, under A.D. Survey Burma, on the production of a new 1-inch sheet of part of the Shan States. In April, 1946, it returned to West Africa.

General Notes and Comments

There is scope for much opinion and argument on the question of unit organization. Survey tasks in S.E.A.C. were extremely variable both in nature and magnitude, depending on terrain, climate, and other operational conditions. It would be difficult, if not impossible, to devise a war establishment for any type of survey unit which would be suitable in all theatres, under all conditions and circumstances. Flexibility is a great asset. It is evident that some form of temporary local modification should be possible by some easier means than by constant amendments to war establishments. As a general rule, there is no doubt that the constant splitting of a unit into its component parts, and the placing of detachments under other people's control, is not sound from the point of view of the unit's morale and general efficiency. This occurred frequently, however, in S.E.A.C. and no doubt the varying conditions and requirements rendered it necessary so that the available resources could best be fitted to the tasks as they arose.

The fact that the military survey service was created almost entirely from the civil department of the Survey of India meant that difficulties arose because, though a man was technically competent he might fall short by military standards for promotion to V.C.O. or N.C.O. Thus promotion during the war produced a new set of standards unknown in the civil department. The attempt to ensure equality of treatment both for civil and military promotion proved

very complex and troublesome. It would have been better had dual civil and military posts and responsibilities been avoided.

It will be remembered that, although during the early B.E.F. operations in France and Belgium in 1939-40 there was survey representation with corps, the general policy thereafter was that Survey would be organized no lower than on an army basis. In S.E.A.C., however, conditions were rather exceptional, and some corps (e.g., 4 Corps at Imphal, and 15 Corps in Arakan) found themselves operating more or less independently. Under such conditions it was usually found necessary to allocate to each corps an A.D. Survey with an assistant (captain) and a small Survey Directorate; a Field Survey Company for air survey, drawing and field-work; a small reproduction unit; and a map supply unit. At other times, however, corps only had a minimum of survey representation, such as a captain at corps H.Q., with a very small drawing and record office, a small map distribution and map depot staff, and a detachment of a Field Survey Company, for such field-work as might be required.

Survey organization at army level was found to be largely dependent on the length and nature of the communications between army and army group. In S.E.A.C. it was found desirable and necessary for armies to handle all their own 1/25,000 map production and revision, and to do a great deal of whatever revision was required for the $\frac{1}{4}$ -inch and 1-inch maps. Unfortunately, the total resources in S.E.A.C. with regard to map production and revision units, did not admit of allowing Fourteenth Army to have enough of them to make its position in this respect completely secure during the advance to Rangoon. D. Survey (A.L.F.S.E.A.) had to keep a certain amount in reserve for other operations which were being planned, though many of these were, in fact, never launched.

Survey control channels necessarily vary in detail as between one theatre or command and another. In S.E.A.C. the following was taken as the general set-up:—

- (a) In accordance with accepted British policy Survey was recognized as being responsible to, and under the operational control of, the General Staff, and not coming under the Chief Engineer. It was not affiliated to any particular branch of the staff, and the Director (or D.D.) of Survey worked under the orders and direction of the C.G.S. (Chief, General Staff) or B.G.S. (Brigadier, General Staff,) making all necessary contacts with the operations, intelligence, and planning branches.
- (b) Within the army group (or army) the survey control organization at H.Q. level was as under:—

A Director (or D.D.) of Survey with directorate staff for exercising the following functions:—

Advice to the C.G.S. (or B.G.S.) on all map and survey matters.
Control of its own production, distribution, and air-liaison units.
Liaison with, and technical direction of, Survey Directorates at subordinate H.Q.s.

Army Group (or Army) Survey Troops such as:—

- (i) The Survey Production Centre, which operated under its own D.D. (or A.D.) Survey and a small staff. If the Production Centre was far away, a small group of units was assembled alongside army group or army H.Q. for drawing, printing, etc.

- (ii) Map distribution units, and Survey Park Sections (for stores). Stores sometimes passed through the map distribution organization; sometimes they were handled separately.
- (iii) Air Survey Liaison units, under the direct control of D. (or D.D.) Survey.
- (iv) Possibly some Field Survey units.

As was found in all theatres, but perhaps more so in S.E.A.C. owing to the long distances, the survey organization was complicated by the splitting of operational headquarters into advanced and main, and their wide separation. Thus there was at one time a survey directorate at H.Q. A.L.F.S.E.A. in Calcutta without local survey troops, a production centre in southern India (later in Ceylon), and a D.D. Survey at H.Q. S.A.C.S.E.A. in Ceylon. This was inconvenient but was enforced by unavoidable circumstances.

SECTION 3. MAPS AND MAP PRODUCTION

The arrangements for the preparation and production of maps for operations in South East Asia were considerably dependent on, and affected by, the survey organization which was in force in India before the war, the developments in that organization which took place during the war years, and the formation of the independent military Command S.E.A.C.

To enable the reader to get a perspective picture of mapping activities it will perhaps be well to begin with a short description of the pre-war organization and military mapping responsibilities of the Survey of India, and to trace its mapping activities during the war. There will then follow a short summary of the mapping work undertaken by the military Survey Service under the control of S.E.A.C.

PART I

THE SURVEY OF INDIA

Before the war, the Survey of India was responsible for providing such maps as the defence services might need of India, Burma, Afghanistan and Iran. In accordance with this policy, the Survey of India continued its routine programme during the field season of 1938-39 and the summer of 1939 of providing topographical maps of the above areas. As the new (post-1905) surveys of India and Burma were nearing completion, research was being devoted to the problem of revision and maintenance of the map series, and the rapid production of maps for war purposes, with special emphasis on the compilation of maps from air photographs.

The greater part of the pre-war map reproduction work was done at Calcutta, where 70 per cent of the total machine power was located. There was, in addition, a small reproduction office at Dehra Dun, with smaller offices at Risalpur and Murree. The latter dealt mainly with emergency requirements of the defence service on the North West Frontier. A small reproduction plant was also maintained at Simla to meet General Staff needs. There was no map reproduction in Burma.

The lithographic printing machines operated by the Survey of India before the war consisted of six rotary and eleven flat-bed machines. The pre-war maps were mostly printed in about six colours, and the number of copies printed of any individual sheet was usually only about 500, and seldom exceeded 1,000. It will thus be realized that at the beginning of the war the stock position, from an operational standpoint, was not a healthy one. To act as a basis for comparison with figures of production during the war period, it may be of interest to note that the number of maps printed during the 12 months from April, 1939 to the end of March, 1940, amounted to only 824,000.

The spread of hostilities in the Middle East and the possibility of war with Japan rendered communications between the United Kingdom and the East uncertain and precarious. British forces in the Middle East were, during 1940, becoming increasingly involved in the Mediterranean area. At that stage India was undertaking operational responsibilities in Iraq and, following the Survey Conference held in Cairo in the spring of 1940, and by arrangement with the War Office, India took over full responsibility for the preparation of maps of Iraq, Trans-Caucasia, a strip of the U.S.S.R. from the Caspian Sea eastwards, and a large part of Thailand, Indo-China and Yun-Nan, in addition to her previous responsibility for maps of India, Burma, Afghanistan and Iran. India also undertook to supply assistance or, if necessary, full responsibility for the printing of maps of a considerable part of North Africa, the Balkans and Turkey on the one side, and Malaya, the remainder of Indo-China and Thailand on the other, should the map production potential in Cairo and Kuala Lumpur (Malaya) be seriously reduced or destroyed by enemy action.

With increased demands being placed on Indian map printing resources the use of several colours on the maps was stopped, and during the early part of 1941 printing was limited to black and brown only, except where additional colours were essential for clarity. Later in the year, however, as a result of operational experience and criticisms from the troops, this policy was revised as the two-colour maps were found to be difficult to read. Whenever time was available thereafter a wider range of colours was adopted. The size of editions rose to an average of about 5,000 a sheet and, during the four months from April to July, 1941, over 1,300,000 maps were printed.

With changing operational conditions, certain alterations in mapping responsibility were made during the latter part of 1941.

Iraq. Middle East took over the responsibility for all mapping work in Iraq and Iran as far east as Long. 54° E.

Malaya and the Far East. The entry of the United States into the war, the loss of the Malayan and Netherlands East Indies Survey Departments, and the Japanese offensive westwards towards India, placed further responsibility on India, who now took over the preparation and maintenance of maps of Siam and Indo-China and, so far as forces based on India were concerned, of China and a portion of Malaya. Mapping material was exchanged between India and other authorities concerned, so that India could, if required, produce maps of the Dutch East Indies and the remainder of Malaya.

Ceylon. The Ceylon Survey Department produced its own maps, but India held reproduction material from which maps of Ceylon could be produced if necessary.

Within the limited capacity of the Security Press, the Survey Departments of Provincial Governments, and civil firms, attempts were made to farm out printing so as to increase production. It was first of all necessary to make duplicate printing plates, and there were delays due to the fact that the civil firms and other provincial agencies were unaccustomed to the type of work involved. The great distances between the Survey of India offices and these agencies added further difficulties, and the procedure was therefore slow in expanding.

Estimates of probable future requirements showed that the Survey of India would have to increase its drawing and reproduction resources. Arrangements were therefore made with the War Office for British technical personnel to be sent out to India, who would be held on a special military establishment attached to the Survey of India. Further printing presses were also ordered, both from the United Kingdom and from India itself.

It was also arranged that, when the modern lorry-borne demy printing equipment was available for the field units, the larger (double-demy) trailer-borne machines would be withdrawn from the forward units and used, either in the base organization in India, or to establish advanced base printing plants. With the Japanese threat from the East, and the desirability of building up a large central establishment, the bulk of the machines were concentrated at Dehra Dun instead of at Calcutta.

During the period from August, 1941, to the end of July, 1942, the Survey of India was principally engaged on the production of maps of Burma and eastern India, but their work also included maps of Iraq, Iran, Afghanistan, north-western India, China, Indo-China, Thailand, Malaya and Ceylon. A large amount of drawing was involved in respect of foreign maps, and in the gridding of the maps of India and Burma.

The output for this period of 12 months from August, 1941, to July, 1942, was:—

Number of individual maps	4,320
Number of copies printed	6,906,000
(not including those produced by the Indian Survey units in Iraq.)	

Mapping activities for the war effort during the period from August, 1942 to July, 1943, were intensified, emphasis being placed on air survey training and production. The chartering by the Indian Government of the Indian Air Survey and Transport Ltd. helped towards the acquisition of air photographs, and Colonel D. R. Crone was appointed Air Survey officer (Survey of India) to co-ordinate all air survey work and training, both civil and military, and to operate the Air Survey and Transport charter on behalf of the Surveyor General.

A photographic programme was begun in October, 1942, and between then and the end of July, 1943, over 22,000 square miles of country were photographed in various areas, from Bengal to Persia, and from Trichonopoly to the Khyber Pass, the greater part of which was for military mapping purposes. The R.A.F. and the U.S.A.A.F. also provided many photographs which were used by the Survey of India for mapping purposes.

During August, two sets of slotted template apparatus were obtained from the Fairchild Corporation and put into production and, by July, 1943, about 8,000 square miles of country had been compiled from air photographs with this apparatus.

By now, most of the maps were being printed in at least four colours, and the bulk of the production resources had been moved to Dehra Dun. The Army/Air style was adopted for the 1/M maps, and a new 1/500,000 series, primarily for air use, was introduced.

The base printing establishment at Dehra Dun issued an average of about 425,000 maps a week during the year. Its output potential for dealing with peak periods had risen to about 2,000,000 a week steady output with the prospect of a rise to 3,000,000 when all the new plant had been installed.

Production during the 12 months from August, 1942, to July, 1943, was:—

Individual maps published	3,441
Copies printed	20,575,000

In order to distinguish those maps specially prepared for war requirements from the standard Survey of India series, the designation "Hind" was applied to the former. The 1/M and 1/500,000 were samples of the "Hind" series.

During this period maps were provided for Chinese divisions operating in Burma. They were the Burma $\frac{1}{4}$ -inch and $\frac{1}{2}$ -inch maps overprinted with Chinese characters. The preparation of the overprints was organized by a Chinese officer, who recruited Chinese locally in Calcutta. Between November, 1942, and April, 1943, a total of over 250,000 such maps were overprinted, the work being done by the Bihar and Assam Government Presses.

Generally speaking, the Survey of India was, from August, 1943, till July, 1944, responsible in its capacity as a base organization for undertaking map production and printing work as demanded by the Director of Survey (India), who acted as liaison between the military forces and the Survey of India for such requirements. At this time India was responsible for producing maps of Persia (East of Long. 60° E.), Afghanistan, India, Burma, Siam, Indo-China, western and southern China, Malaya and Sumatra. The general policy was that the military survey service carried out the short-term programmes and that the Survey of India dealt with the long-term requirements.

Though not yet completely equipped, the new production establishment at Dehra Dun was now running to big capacity. The output for the 12 months from August, 1943, to July, 1944, is shown below, with the percentage increase compared with 1939-40:—

		<i>Output compared with 1939-40</i>
Individual maps published	2,281	140 per cent
Copies printed	11,787,000	1,400 per cent

These figures show a falling off compared with 1942-43. This was owing partly to the fact that maps were being printed in a greater number of colours, partly to the stabilization of the operational front, and also to the time taken to accumulate mapping material from forward areas.

A large quantity of mass production drawing was undertaken in the various drawing offices of the Survey of India. The amount completed for the production of new maps from new surveys was small, as there were few new surveys other than from air photographs, for which the drawing was principally done in the military units. Most of the drawing work was in connection with the redrawing of existing maps, mainly of Burma and overseas, for which so much new information had become available that the correction of the existing

printing plates was unsatisfactory. There was also the initiation of new map series on previously unpublished scales, and the preparation of separate colour drawings for published maps for which separate colours had not hitherto existed.

During the final period from August, 1944, to July, 1945, map drawing and printing by the Survey of India continued at high pressure. The machine position, by 1945, was as under:—

2-colour quad-demy	2
1-colour quad-demy	5
2-colour double-demy	6
1-colour double-demy	6
2-colour demy	2
Hand-feed double-demy	8
Flat-bed	4

The output for the 12 months was:—

Individual maps published	2,483
Copies printed	22,075,000
Impressions (all colours)	108,222,000

Before the war there was no central survey stores organization in India, each Circle being responsible for obtaining its own stores through various authorized channels. This method broke down under war conditions, and it was necessary to form a central organization.

The "Stores Office (Surveys)" opened in Calcutta in August, 1940, but it was a local arrangement for the Calcutta offices only. In April, 1941, it moved to Delhi, and a few months later to Dehra Dun, its role being still relatively local, and its activities confined to a small percentage of the total quantity of stores required by an organization such as the Survey of India.

Between 1942 and 1945, there was a rapid growth of the Stores Office. Eventually it served about 120 civil and military Indian, British and U.S. units in the theatre. In addition to the Survey of India, all R.E. and I.E. survey units, including map reproduction elements, obtained all their survey technical stores, instruments, machines, chemicals, etc., from the Stores Office (Surveys). In 1941 some 240 items only were under supply. By 1945 this figure had risen to some 10,000 items, and the Office was handling approximately 7,600 tons of stores a year.

The range of the stores was very wide, and included 17 different types of modern lithographic printing machines, the smallest of which would print a sheet 13 in. × 8 in., and the largest 48½ in. × 36½ in. Ancillary equipment and a multitude of spare parts were carried in order to maintain the machines in operation.

Indian manufacture was encouraged to take up production of the many survey stores, chemicals, inks, etc., required, and about 25 per cent of those held were of Indian make. Over 2,500 tons of Indian-made paper, prepared from bamboo pulp, were used annually by military and civil survey units in the theatre.

In 1941, the Stores Office had occupied a mere two bungalows. By 1945, the floor area occupied had increased to 68,000 square feet. There were two branch offices, one at Calcutta and the other at Bombay. The latter dealt with

the thousands of tons of stores which were being shipped for Survey annually from the United Kingdom, South Africa, and the United States.

PART 2

H.Q. SUPREME ALLIED COMMAND AND H.Q. 11 ARMY GROUP (LATER A.L.F.S.E.A.)

Part 1 of this section gives a brief summary of the principal map production activities of the Survey of India in connection with the operations in South East Asia. In Part 3 which follows will be found a description of the work carried out by the Survey Directorate and units of Fourteenth Army. In between these two there was the survey organization at H.Q. 11 Army Group (later known as A.L.F.S.E.A.), and at H.Q. S.A.C.S.E.A. Part 4 will cover the mapping activities with 15 Corps during the final Arakan campaign.

Mapping responsibilities and resources

The organizational development of the military survey service in South East Asia, and its relations with the Director of Survey (India), both before and after the formation of S.E.A.C. have been dealt with in Section 2. It will, however, be necessary to mention some of the main factors concerning organization during this account of mapping work.

Before the formation of S.E.A.C., India had been allotted an area of mapping responsibility by the War Office which included all likely operational areas within the theatre. On the formation of S.E.A.C., India still retained the same mapping responsibilities for the whole area, but decentralized some of the work to D. Survey 11 Army Group.

To make the organizational picture clear it must not be forgotten that the Director of Survey in the field found it advisable, for various reasons, to have his main survey directorate at H.Q. 11 Army Group, with a small directorate for forward planning, etc., at H.Q. S.A.C.S.E.A.

Early in March, 1944, D. Survey (India) transferred to D. Survey 11 Army Group the technical control of the survey directorate Fourteenth Army, and later in the month transferred control of the following units:—

Indian Air Survey Directorate.

Nos. 5 and 7 Indian Air Survey Companies.

No. 71 Base Map Reproduction Section.

No. 11 Indian Air Survey Liaison Section.

Nos. 32 and 35 Map Supply Sections.

No. 51 Drawing Section.

In addition, two-thirds of the combined survey strengths of Nos. 1, 3 and 4 Indian Field Survey Companies, which were in Southern Army, together with such of their reproduction strength as was required, were put at the disposal of D. Survey 11 Army Group. This formed the basis of his map production resources.

The air survey directorate was one of the items transferred as stated above. The air survey units, which had been widely dispersed, were concentrated at Harihar in southern India together with No. 71 Base Map Reproduction Section. To facilitate the control of these units, D.D. Survey (Southern Army) with his survey directorate was placed under the technical control of 11 Army

Group, and assumed responsibility for all the survey work which was being carried out for S.E.A.C. by the units of Southern Army.

Basic map series

The basic map series for the operational area of S.E.A.C. were, in March, 1944, as follows:—

India and Burma	1 inch to 1 mile (or $\frac{1}{2}$ inch where no 1 inch existed).
Malaya	1 inch to 1 mile.
Sumatra	1/50,000, or 1/100,000 or as planned by Washington.
Thailand (Siam)	1/100,000.
Indo-China	1/100,000.
Ceylon	1 inch to 1 mile.
Andaman Islands	2 inches to 1 mile.
Nicobar Islands	} 1 inch to 1 mile.
Cocos Islands	

Responsibility for the provision of new or revised editions of these basic maps, or maps on a larger scale, was delegated to D. Survey 11 Army Group (later A.L.F.S.E.A.).

The production of any maps on a scale smaller than the above was reserved by D. Survey (India) except in case of operational urgency.

Survey Production Centre (A.L.F.S.E.A.)

Until early in 1945, D. Survey (India) was the departmental channel of communication between D. Survey, 11 Army Group and the Director of Military Survey at the War Office, the War Department at Washington, and the Survey of India. Within the limits imposed by this chain of control D. Survey 11 Army Group had been allotted responsibility for survey planning within the operational theatre, and for initiating demands for new maps and series other than those for which production had been reserved by D. Survey (India).

In January, 1945, however, as a result of the difficulties which were experienced, it was decided to recast the working relations as between S.E.A.C. and the India Command. As a result S.E.A.C. took over responsibility from India for all military survey and mapping of their operational area, on scales of 1/M and larger, India retaining responsibility for all work other than the above within geographical limits which would be allotted from time to time by the War Office. Although thereby becoming master of its own house with regard to survey and mapping, S.E.A.C. still, of course, remained dependent to a certain extent on India for the bulk printing of certain map stocks which it could not undertake with its own resources, and for this purpose D. Survey (India) remained as the link between S.E.A.C. and the Survey of India. S.E.A.C. now assumed the task of initiating the production of maps and survey data, and it became essential to set up an adequate and efficient map production installation to deal with base mapping and other matters. The Survey Production Centre (S.P.C.) came into being in March, 1945, by forming new units and by concentrating in Kandy some existing units which hitherto had been engaged on

air survey, drawing and map reproduction in India. It was placed under the command of a D.D. Survey (Colonel J. E. S. Bradford) who was assisted by one A.D. Survey for dealing with operational matters, two D.A.D.s Survey (one for map production and one for air survey), and a number of junior staff officers. For further details about this unit see Section 2.

To understand better the status and work of the S.P.C. it is well to consider the respective functions of the Survey Directorate (A.L.F.S.E.A.), the Survey Division (S.A.C.S.E.A.) and the S.P.C. itself. Briefly, so far as mapping and production were concerned, they were as follows:—

(a) *Survey Directorate H.Q. A.L.F.S.E.A.*

- (i) Notifying H.Q. S.A.C.S.E.A. of stock requirements of survey publications, and details of their distribution, breakdown, and short-term requirements.
- (ii) Meeting the requirements of H.Q. A.L.F.S.E.A. and Ceylon Command for miscellaneous maps, and for placing orders for these on S.P.C.
- (iii) Scrutiny of demands for air photographs and map production, and passing approved demands to H.Q. S.A.C.S.E.A.

(b) *Survey Division H.Q. S.A.C.S.E.A.*

- (i) Production plans and programmes for all maps other than the miscellaneous requirements of H.Q. A.L.F.S.E.A.
- (ii) Placing all work orders on the Survey Production Centre.
- (iii) Procurement of all air photographs.
- (iv) Staff requirements of maps for H.Q. S.A.C.S.E.A.

(c) *Survey Production Centre.*

- (i) Control of all map production for S.E.A.C. not allocated to lower formations.
- (ii) Production orders on United Kingdom, India, and other agencies as directed by H.Q. S.A.C.S.E.A.
- (iii) Research into map production methods.
- (iv) Preparation of technical instructions and cartographic specifications.
- (v) Distribution to main map depots.
- (vi) Holding authority for all map records and material, trig records and air photos within the Command.

D. Survey (A.L.F.S.E.A.) laid down as policy that his prior approval was necessary before action was taken on the following:—

Programmes of map production and air photography.

Allocation of priorities for work in the S.P.C.

Specifications for standard map series.

Rejection of demands from forward formations for air survey map production, air photography, or bromide prints.

Space does not allow, nor would there be any object in giving, a detailed record of all the many mapping tasks undertaken by the S.P.C. and the other productive agencies which worked under the control of A.L.F.S.E.A. and S.A.C.S.E.A.

Extensive programmes of new 1/25,000 mapping from air photographs of parts of Burma, Malaya, Siam and other areas were carried out. The air

revision of the 1-inch maps of Burma was another of the major tasks. In connection with this work large areas were photographed by British and U.S. Air Forces, in spite of the fact that, over most of Burma, survey photography was impossible during the monsoon and preceding haze (April to October).

Photography had to be undertaken between November and March for operations which would take place the following November–March. The Air Survey Liaison Sections played a prominent part in this work, briefing the pilots for their technical tasks, and recording all the sorties as they were undertaken. They also carried out extensive programmes in connection with the determination of beach gradients, the preparation of collation maps showing beach intelligence information, surveys of airfield and bridging sites, and many other tasks of operational importance. Considerable assistance in connection with this work was given by U.S. Engineer Topographic units with their multiplex plotting equipment.

The preparation of large scale town plans was an important feature of the work of the S.P.C. and, under the future planning control of H.Q. S.A.C.S.E.A., the preparation of maps of all sorts for the proposed final assault operations in Malaya formed a mapping task of great magnitude.

With the Japanese surrender, the intensive operational mapping programmes had to be switched over, at a moment's notice, to the task of providing maps for the forces which were despatched to occupy the surrendered territories over widely dispersed areas.

PART 3

FOURTEENTH ARMY

Mapping during 1942

At the start of operations in Burma, the whole of that country and eastern and southern India had been surveyed on the 1-inch scale except for a belt covering the Chin and Naga Hills, where the $\frac{1}{2}$ -inch scale had been adopted. There were also some compiled maps on $\frac{1}{4}$ -inch and $\frac{1}{2}$ -inch scales. All these maps had been published before the war, and were mostly well printed in six or seven colours, but in some areas the survey was an old one and the maps were out of date.

The map stock situation was unsatisfactory. The normal printing order for map sheets in peace-time had numbered only 500 of each edition. Additional stocks were printed of certain areas in southern Burma and the Shan States during 1940–41 and were stored in Rangoon, but by March, 1942, that area had been overrun by the Japanese and the stocks were lost.

In March, 1942, when the Burma campaign was going badly, and India was threatened, the newly created D.D. Survey (Eastern and Southern Armies) had the responsibility of providing maps for the defence of India. As time was so pressing it seemed unwise to embark immediately on a reprint of all the 1-inch sheets, so a reprint of the $\frac{1}{4}$ -inch sheets was taken up as first priority, to be followed by the $\frac{1}{2}$ -inch, or by the 1-inch where the $\frac{1}{2}$ -inch was non-existent or inadequate. On completion of these, the 1-inch sheets were to be printed. The programme comprised 3,000–4,000 copies each of 142 $\frac{1}{4}$ -inch, 320 $\frac{1}{2}$ -inch, and 200 1-inch sheets. In addition to this, demands had also to be met until about the end of April for the army in Burma. As seven-colour printing was out of the question, the style adopted for this reprint programme was a black outline with brown contours, and one additional colour in a few special cases

(e.g., purple grid or green for forest). The task was completed by the Survey of India by the end of September.

In view of their limited printing resources at the time, the Survey of India tried to farm out some of the work to the Provincial Government presses. The Bombay Press at Poona offered to print 70 sheets a month but shortage of paper, and other adverse circumstances prevented a satisfactory use of these facilities. Under a threat of Japanese invasion the Madras Government Press was evacuated, and it was not available again until the vital need had passed. The Bihar and Assam Governments also offered their presses, but they could not be used for the printing of standard sheets, and no photographic plant was available.

With the onset of the 1942 monsoon, the arrival of reinforcements from Europe, and other factors, the immediate threat of a Japanese invasion of India receded, and the reprint of 1-inch maps of India was cancelled. A reprint of maps covering Burma and the Assam frontier was substituted, and the programme included:—

14,500 copies each of 96 $\frac{1}{4}$ -inch sheets.

14,500 copies each of 304 $\frac{1}{4}$ -inch sheets.

10,000 copies each of 800 1-inch sheets.

The printing was started by the Survey of India in August, 1942, and completed early in 1943. Two colours only, black and brown, were used.

In September, 1942, No. 6 Reproduction Group was posted to the Eastern Army. It was equipped with two Crabtree demy presses mounted in special Foden lorries, two photo-mechanical vehicles, and five 22-kw. Lister generators on trailers. There should have been camera and process lorries, but they never arrived, so Hunter-Penrose portable cameras and a portable dark room were used instead. The units carried a grainer, guillotine and arc lamps for the camera.

Map production for the 1943 operations

The operations for which maps were required during 1943 included:—

- (a) The unsuccessful offensive in Arakan during the first half of the year.
- (b) The Wingate expedition.
- (c) Operations in the Kabaw Valley and the Chin Hills around Tiddim and Fort White.

The maps of Burma available in January, 1943, comprised:—

- (a) The pre-war 1-inch series ($\frac{1}{2}$ -inch only in certain areas) which had been reprinted in black and brown. The maps were of indifferent quality in the dense jungle-covered hill areas.
- (b) A 3 inches to 1 mile air survey map of Akyab Island. This was revised and a new edition was published, for which a trace showing enemy defences was added to weekly so as to be able to produce up-to-date copies just before the assault.

Early in 1943 there were only a very small number of surveyors trained in air survey methods, so it was not possible to embark on a large 1/25,000 mapping

programme. A number of photo mosaics were therefore produced as a substitute. They were considered to be a valuable addition to the 1-inch map in the absence of large scale maps, but their quality was poor.

To supply the Wingate expedition $\frac{1}{2}$ -inch maps were flown to the force from its base at Aggartala airfield. As it seemed likely that, on its return journey, the brigade would pass through difficult country to the north of the Uyu River, where the $\frac{1}{2}$ -inch map was known to be inaccurate, a special 1-inch map was hurriedly prepared for use when crossing the watershed.

The need for the formation of a small map production organization to serve the immediate needs of Eastern Army became apparent early in 1943. This must not be confused with the base production establishments set up by the Survey of India and by A.L.F.S.E.A. Calcutta was selected as the location and the following units were available in January:—

- No. 9 Indian Survey H.Q. (with A.D. Survey).
- No. 6 (Indian) Reproduction Group (later renumbered No. 66).
- B Photo-zinco Section.
- No. 53 Drawing Section.
- Detachment from No 6 (Indian) Field Survey Company.

During June and July it was reinforced by the arrival of:—

- No. 22 Survey Park Section.
- No. 2 (Indian) Field Survey Company (from Iraq).
- No. 63 (Indian) Reproduction Group.

Production during 1943 mainly consisted of:—

- (a) New editions of $\frac{1}{2}$ -inch and $\frac{1}{4}$ -inch maps covering Arakan, Manipur, and the Chin and Naga Hills, incorporating new roads, and introducing more than the two colours of the 1942 reprint.
- (b) 1/25,000 maps, compiled by the air survey section.
- (c) New editions in colour of 1-inch maps of Arakan and the Kabaw Valley, incorporating air revision.
- (d) Target maps for the R.A.F.
- (e) Defence overprints and administrative lay-outs.
- (f) Block-plots and large scale airfield surveys.
- (g) A little half-tone work.

The standard 1-inch, $\frac{1}{2}$ -inch and $\frac{1}{4}$ -inch sheets were reproduced by various methods. In some cases the original drawings were brought up to date, in others the negatives were corrected. Each sheet was treated on its merits according to the quality of the material and the amount of correction needed.

As an improvement to the basic black-brown printing extra colours were added as follows:—

- (a) A pale red ribbon was overprinted on the existing black roads. This was not very satisfactory, but colour separation at that period was too laborious. Later, when sheets were redrawn from air survey, a separate road plate was prepared.
- (b) A pale blue filling was printed over sea areas, tanks, and double-line rivers.

- (c) Cultivated and other open areas were overprinted in yellow. This was satisfactory in northern Burma and Arakan where the country was either jungle-covered hill or open cultivation. In the drier parts of central Burma yellow was reserved for cultivation, forest being shown by black tree symbols or a green tint, and other land being left white with symbols for scrub or grass.

Throughout 1943 and most of 1944 there was a great shortage of surveyors in the Eastern Army who had been trained for air survey work. When mapping work started for the Arakan operations in December, 1942, only six were available, this number rising to about 15 in the middle of 1943. They came from various units and were combined to form a headquarter air survey section, reinforced by personnel from the Indian Air Survey and Transport Ltd.

During the early months of 1943, the work of the air survey section included:—

- (a) Photo-mosaics of Arakan, and 1/25,000 maps of the Chindwin Valley, which appeared likely to be a potential battle area.
- (b) Survey of 1-inch sheet around Tamu, and the revision of several other 1-inch sheets in the Chindwin area.
- (c) Original 1-inch survey and revision in Arakan.
- (d) An extensive programme of 1/25,000 maps in Arakan.
- (e) Photo-mosaics of rear areas for training purposes.

With a great scarcity of recognizable trig points, the 1/25,000 air surveys were based on a large number of detail points on the 1-inch map which had presumably been fixed with adequate accuracy by plane-tables. Attempts were made to obtain a near fit with a number of such points rather than a perfect fit with a few only. On average, maps so controlled were found to be correct with regard to detail position to within about 100 yards.

During 1943, few facilities existed for the provision of survey photographs. Fortunately, a large area of Burma had been photographed before the war by the Indian Air Survey and Transport Ltd. for the Burma Oil Company and, by good luck, these photographs covered areas in Arakan and the Chindwin Valley where map revision was most required. Where such photos did not exist use was made, in those early months, of low obliques taken for reconnaissance purposes.

The Indian Air Survey and Transport Company was located at Dum Dum and was of great assistance to the Eastern Army early in 1943 when survey photography by the R.A.F. was practically non-existent. Members of its staff worked with the air survey section, indexing photos and making mosaics, and they photographed also 8,000 square miles for the possible revision of 1-inch maps of Bengal before the company was taken over by the Survey of India under a charter.

Photo-mosaics were prepared on a scale of about 1/15,000, and were produced as half-tone litho prints. Before reproduction, the bromide mosaics were treated as follows:—

- (a) A grid was added by comparison of detail with the 1-inch gridded map.
- (b) Contours were drawn in black.
- (c) Roads, tracks, streams, river banks and buildings were touched up in black or white as appropriate where the contrast was insufficient.
- (d) Names were added.

Photography of the bromide mosaics for half-tone reproduction was usually done through a 133-line screen, and most of those produced in 1943 were printed by the Survey of India.

In view of the inaccuracy of the 1-inch maps in those parts of Burma concerned, the 4-inch to 1 mile photo-mosaics were appreciated in spite of their defects, and the battles of Donbaik and Rathedaung were largely fought with their guidance. The points in their favour were stated to be:—

- (a) They required less work from air-trained surveyors than 1/25,000 maps.
- (b) The photos inspired confidence in the user, who was unable to report that the map was wrong if and when he misidentified his position.
- (c) In some types of country the mosaic gave a good picture of the vegetation.

There were, however, the following serious defects in the photo-mosaics:—

- (a) Unless the original bromides were of good quality and evenly matched, and the reproduction processes free from fault, the result was usually an unintelligible smudge.
- (b) In jungle-covered hills nothing showed except what the draughtsman had drawn on the bromide mosaic, and this would have been clearer on the normal white background of a map.
- (c) The grid was distorted though not necessarily inaccurate.
- (d) For clear reproduction the scale had to be about 1/15,000, which was rather large from the point of view of distribution of the printed copies.

In actual fact, these mosaics were little used after 1943, which bears out similar experience in other theatres, where much work was put into the preparation of photo-maps, and little if any use was made of them.

Considerable use was made of block-plots. These had been used originally in the Middle East, where they were found so successful in desert country at the battle of El Alamein. The main essential was a set of overlapping photographs, each having its principal point, and those of adjacent photos, marked on it. Accompanying the photos was a gridded map, or plain piece of gridded paper, on which the principal points were plotted. Using a piece of transparent talc or kodatrace, any target which could be recognized on two overlapping photos could be cut in on the plot-sheet or gridded map, and its position fixed on the radial line principle. It was of special use in areas where there was little map detail.

Block-plots were first prepared in India in May, 1943, for the defence of Maungdaw, and in 1944-45 they were used extensively, a divisional commander considering himself ill-equipped if he had to fight without them. They were usually based on 1-inch map detail for control.

Map preparation for the 1944 Arakan operations

The Eastern Army was now known as Fourteenth Army. The failure to take Akyab in 1943 entailed extensive preparations for a 1944 offensive. Maps were required to meet the following requirements:—

Four Divisions were scheduled for the land operations, and it was estimated that they would require a total of 12,000 copies of all 1-inch maps covering the probable fighting area, and about 6,000 copies of 1/25,000 maps where they existed or could be produced.

Two Divisions were to effect sea-borne landings, for which the estimated requirements were 20,000 copies of the relevant 1-inch maps and about 10,000 of the 1/25,000. As things turned out, these projected sea-borne landings did not take place.

It having been decided not to use photo-mosaics, a series of 1/25,000 maps was put in hand extending from Bawli Bazaar (north of Maungdaw) to Akyab, comprising 22 sheets. This area was later considerably extended to the north, east, and south-east.

Before reprint, the 1-inch maps were revised from the air survey material used for the preparation of the 1/25,000 maps. In the Kaladan Valley, where only $\frac{1}{2}$ -inch maps existed, enlargements were made up to the 1-inch scale. No extra detail was added, but the larger scale was preferred in the field as it allowed room for manuscript notes and additions.

The 1944 operations (February to November)

When the Japanese opened their offensive at the end of March across the hills to Kohima, and surrounded Imphal, more than three divisions were transferred into Assam and Manipur. Heavy fighting in these areas, and the threat to areas further back for which the existing stocks were small, put a big strain on printing resources. Luckily the area was one which was covered by $\frac{1}{2}$ -inch maps. A reprint of 1-inch maps could not have been done in the short time available. As it was, 25 $\frac{1}{2}$ -inch sheets with a total of 340,000 maps were printed during April.

For the relief of Imphal, and the subsequent advance to the Kabaw Valley, a large demand arose for 1/25,000 maps and block-plots over a wide area. Nearly 60 1/25,000 sheets were surveyed between April and July. Some of this work was done under the control of A.D. Survey 4 Corps in Imphal, and the remainder by army survey units at Comilla.

As successors to the first Wingate expedition, 3 (Indian) Division, consisting of six brigades, was operating in northern Burma, together with an American Chinese force under General Stilwell, this latter forming what was known as the Northern Combat Area Command (N.C.A.C.). At the time under consideration, these formations were under the tactical command of Fourteenth Army.

Four brigades of 3 (Indian) Division were operating behind the enemy lines, and the supply of maps to the division was not an easy matter. To a certain extent their map demands were met by 11 Army Group. At a late stage in the operation they asked for 300,000 waterproofed maps which, in order to save weight, had to be trimmed to a specified size. They were mostly supplied from the Titagarh and Ranchi depots and, after being sent to Delhi for trimming and varnishing, were flown to the division's air base at Sylhet.

N.C.A.C. had its own map supply organization based on Chabwa.

In November, 1944, when Eastern Army became Fourteenth Army under General Slim, its H.Q. moved to Comilla, and D.D. Survey set up his own Survey Directorate there. Most of the remaining survey units were brought forward from Calcutta, and an army base map production organization was established at Comilla. Its main task was the preparation of air revised or modernized 1-inch and $\frac{1}{2}$ -inch maps of Burma north of Lat. 21° in contemplation of a return to that area. For current operations there were demands for 1/25,000 maps and reprints of the smaller scales. Shortage of air surveyors and

photos unfortunately prevented all the maps from being air revised. The following is a summary of the more important tasks accomplished during 1944 at Comilla:—

Completely resurveyed from air photos:—25 1-inch and $\frac{1}{2}$ -inch sheets in northern Burma.

Extensively revised, including redrawing of the whole sheet:—25 1-inch sheets.

Revised for serious changes and errors only:—49 1-inch sheets.

Modernized:—95 1-inch, and 53 $\frac{1}{2}$ -inch sheets. This modernization consisted of recasting the old double-size sheets to the normal single-sheet size, drawing communications in modern symbols, and printing about 16,000 to 20,000 copies of each in four or five colours.

Considerable extensions were made to the Arakan 1/25,000 series during the year to the north of Maungdaw, and south-eastwards towards Myebon. A number of sheets were surveyed near the Chindwin Valley round Kalemyo and Mawlaik, and work was begun on a series of 1/25,000 maps extending from Kalewa to Ye-U and beyond.

It has already been noted that, during 1942-43, there were no proper facilities for the provision of vertical survey photos in Burma. Early in 1944, however, some Mosquito aircraft, based on Dum Dum, were fitted with K-17 air cameras (9 × 9 picture with 6-inch and 12-inch lenses) and an air survey liaison section was located at the H.Q. of the photo reconnaissance unit.

In anticipation of bad photographic weather between April and November an intensive programme of 1/50,000 photography was undertaken, covering most of northern Burma between Myitkyina and Rangoon. To attain this, demands for current operational photography were kept at a minimum. The 1/50,000 photographs, when clear, were found to be excellent for 1-inch map revision. Though far from being a satisfactory substitute for larger scale photography for 1/25,000 mapping and block-plots, it was better than nothing and in many cases, where there was little detail in hilly country other than streams and contours, the 1/50,000 photos were enlarged for mapping purposes to the 1/25,000 scale.

Block-plots were provided for the 4 Corps battles round Imphal, and for the advance of 33 Corps from Kohima southwards. Only three sets of prints could be obtained from Dum Dum, so they were re-photographed at Army H.Q. and further prints taken off which, though of second-rate quality, were satisfactory. Although plans were drawn up for duplicate negatives to be supplied to Army and Corps H.Q.s, they did not materialize, and Dum Dum remained the source of all original prints.

Slotted template equipment was obtained in June, 1944. This enabled a mechanical method to be adopted for the radial line control of photographs instead of the graphical method (Arundel) which is so dependent on the individual skill of the draughtsman. It was used for controlling many thousands of square miles of photo-cover, but it was found unsatisfactory in the following respects:—

There was an absence of reliable trig data, and it was found difficult to adapt the mechanical process for the control of photos by unreliable points of map detail.

The cardboard templates softened in the damp climate, thus preventing the pins from sliding properly in the cut grooves.

At the end of November, 1944, when Army H.Q. moved from Comilla to Imphal, Survey H.Q. also moved there with its units, and Imphal replaced Comilla as the main map production centre for Fourteenth Army.

5 (Indian) Division and 11 (E.A.) Division advanced south during the monsoon and captured Kalembo. Moving through the Chin Hills 5 Division used the old $\frac{1}{2}$ -inch maps, and in addition the whole length of the road along which they moved was covered by 1/25,000 or 2-inch maps. From Tamu to within 25 miles of Kalembo 11 (E.A.) Division had no 1/25,000 maps but used recently revised 1-inch maps.

The final phase (December, 1944 to May, 1945)

This included the advance into Burma, the destruction of three Japanese armies, and the capture of Mandalay and Rangoon.

During this period the main tasks of the Survey Service included:—

- (a) Compiling and printing new 1/25,000 maps.
- (b) 1-inch revision, and reprinting 1-inch map stocks.
- (c) Map distribution.
- (d) Preparation of block-plots for battle use.
- (e) Ground surveys, levelling, etc., for airfields in forward areas.

The army map production centre moved from Comilla to Imphal during the winter. With the further advances of Army H.Q. it was found necessary to move it once more and, in April, 1945, it was transferred from Imphal to Myingyan. The survey directorate accompanied Army H.Q. successively from Imphal to Indaingyi, Monywa, Meiktila, and Rangoon, and took with it one reproduction section and one air survey section.

The 1945 operations were well covered by 1/25,000 maps which were produced as under:—

- (a) *By survey units of Fourteenth Army.* A series extending, with a few breaks, from Manipur Road in Assam to Nyaunglebin (85 miles north-east of Rangoon) and Prome, where it joined the Hind 601 series.
- (b) *By Survey Production Centre for A.L.F.S.E.A.* The Hind 601 series consisting of 188 sheets which had been prepared for a possible landing in the Rangoon area.
- (c) *By Southern Army.* 12 sheets of an area near Pakkoku-Chauk.
- (d) *By U.S. Topo Battalion at Dehra Dun.* 14 sheets covering the railway south of Wuntho.

Many of the early sheets were compiled from 1/50,000 photos enlarged up to 1/25,000, but, to the south of the Irrawaddy, and to a certain extent to the north of it also, 1/25,000 photos were available in time. Apart from a break of eight miles at Imphal, another of 15 miles north of Myingyan, and a stretch along the Tiddim road, the 1/25,000 sheets prepared between April, 1944, and April, 1945, extended from Manipur Road to Rangoon, and in May this series was extended to Moulmein and beyond as far as the Siamese frontier.

Those produced by survey units of Fourteenth Army were made under high pressure, and only just kept ahead of the advancing troops. D.D. Survey considered that, with limited resources only, it was better to work on sheets closely ahead of the advance so as to avoid, as far as possible, using his mapping

strength on sheets which might never be used. In the case of Hind 601 Series of 188 sheets, which had been planned and produced by H.Q. A.L.F.S.E.A. to cover an amphibious assault and the subsequent join-up with Fourteenth Army advancing by land from the north, the Army passed through the area against slight opposition, and if this series had been planned on the spot closer to the date of the operation, the actual lines of advance would have been covered by 60 sheets only. On the other hand, by the time that it was apparent that 1/25,000 maps in the form of a road strip would be all that was required, it is doubtful whether there would have been time to initiate and complete a 1/25,000 programme covering the roads to Rangoon. On balance it is probably wiser and safer to plan well in advance, even at the cost of covering an unnecessarily wide area. This will, of course, always depend on available resources and local conditions of time and space, and no rigid rule can be followed.

To deal with late changes of plan, help was sought from H.Q. A.L.F.S.E.A., and sheets were produced by them and the U.S. Topo Battalion. There were difficulties, however, in laying on urgent work at short notice from such a distance.

Before the advance started early in 1945, the 1-inch maps of Burma north of Lat. 21° had been put into fairly good order, though some 25 sheets still remained to be finished off. A total of from 16,000 to 20,000 copies of each sheet were printed, with rather more for those sheets which had to be supplied to the N.C.A.C. To the south of Lat. 21° H.Q. A.L.F.S.E.A. had revised and printed the 1-inch maps, and sufficient stocks were generally available. There were some critical occasions, such as the unexpectedly rapid advance to Pak-koku and Meiktila where 1-inch maps were not available to cover a full 15 miles ahead of the advance.

Until 1/25,000 photographs began to come in during 1945, block-plots could not be produced. They were not available for the operations resulting in the capture of Kalemyo and Kalewa, and the advance to Ye-U and Shwebo soon got ahead of the block-plots which were being prepared from the newly obtained photos. They were, however, available for the Irrawaddy River crossings, and for all the fighting around Mandalay and Meiktila, and for most of the advance to the south.

American enthusiasm regarding the Photo Reconnaissance Force resulted in a reintroduction of photo-maps south of Mandalay. As an insurance against the possibility of not being able to prepare 1/25,000 maps they had some value but, in actual fact, they were little used.

There was some difficulty in connection with the photo-map grid, which could not be made to agree with the grid on the 1-inch and 1/25,000 maps. An arbitrary 1-inch square mesh was therefore overprinted.

There is no doubt that, for certain purposes, especially where target identification was concerned, the supply of air photos to the troops and to the R.A.F. was desirable. To facilitate the passing of reports and messages some kind of reference grid was essential. It was a matter of argument whether this should be an arbitrary one such as a 1-inch mesh, or the theatre grid transferred to the photo. Discrepancies between grid references measured from the photos and the maps of the same area were dangerous. In S.E.A.C. it was found better and quicker as a general rule to use an arbitrary mesh.

Under jungle conditions, where enemy defences were not visible from the air, little use was made of defence overprints.

During the advance, ground survey could do nothing to improve the existing maps of the battle area, and no such work was undertaken for that purpose.

Each corps had with it a small survey detachment for carrying out the surveys of airfields, and for possible co-operation with the artillery. They were almost continuously employed on the survey of light aircraft and Dakota landing strips at scales of 6 or 8 inches to the mile.

Matters of general interest

The table below summarizes the principal mapping work carried out in Fourteenth (Eastern) Army between December, 1942, and April, 1945:—

(a) 1/25,000 sheets surveyed from air photos	377
(b) 1-inch or $\frac{1}{2}$ -inch sheets surveyed or revised from air photos in whole or part	132
(c) Standard sheets printed on scales of 1/25,000, 1-inch, $\frac{1}{2}$ -inch and $\frac{1}{4}$ -inch	1,007
(d) Other maps printed	1,255
(e) Number of copies printed	11,509,000
(f) Number of colour impressions	46,803,000

Of the 1,007 standard maps printed, 509 were surveyed or revised from air photos. The balance of 498 sheets were either modernized without air revision or reprinted without correction.

The 1,255 other maps included R.A.F. target maps, photo-maps, town plans, large scale maps of airfields and installations, and overprints showing dispositions, communications, forest boundaries, malaria belts, etc. Plans and diagrams of a non-topographical nature are not included in the totals shown above.

In addition to the 11,509,000 copies printed with Fourteenth Army, about 2,500,000 copies of maps of Burma on 1-inch and 1/25,000 scale were received from India between February and May, 1945, and about 1,000,000 of the black and brown reprints produced by India in 1942-43 were, at one time and another, sent forward from Calcutta. The total number of printed copies produced in, or received by Fourteenth Army was thus about 15,000,000, excluding the 1/M and 1/500,000 maps prepared in India and sent forward principally for R.A.F. use.

At a rough estimate, between 7 and 10 million maps were actually issued to the troops. The remainder were either superseded by new issues or remained unused in map depots at the end of May, 1945.

Experience during operations in South East Asia indicated the necessity for the 1/M and $\frac{1}{4}$ -inch (or 1/250,000) maps, and the desirability of the 1/500,000 and 1/25,000 scales.

There was considerable controversy, however, about the $\frac{1}{2}$ -inch and 1-inch scale maps. The two opposing schools of thought said respectively:—

- First produce a $\frac{1}{2}$ -inch map as the most readable overall general map. Replace by a $\frac{1}{4}$ -inch and 1-inch and discontinue the $\frac{1}{2}$ -inch. Then add 1/25,000 for specific battle areas.
- Give us a 1-inch (or 1/50,000) map and we can make do. If you have any resources left over, give us a 1/25,000 map where you can.

The answer to this controversy cannot be given as a general statement. The position must be judged independently for each campaign in the light

of the conditions prevailing. It is obvious that there are many factors which must be taken into consideration such as:—

The nature of the terrain and the probable character and speed of the operations.

The state of the mapping material already available.

The survey resources and time available for the work.

It seems to be common sense that, if operations are likely to take place anywhere over a wide area, certainty of map coverage on the smaller scale all over the battle area is better than patchy cover over limited areas on the larger, though possibly more suitable, scale. This is especially so when the Survey Service can produce 1/25,000 maps wherever serious fighting will take place.

In the thick jungle country of Burma it seems that the following two fairly firm conclusions were drawn:—

- (a) The $\frac{1}{2}$ -inch scale was too small as a tactical map on which to fight a battle.
- (b) Where there was going to be a fight, the provision of a 1/25,000 map was very desirable if at all possible. If not possible, then a 1-inch map was the next best thing.

Fortunately in Burma there were 1-inch maps covering practically the entire area outside the Chin-Naga Hills, and 1/25,000 maps could be, and were, produced wherever required. In addition, the somewhat inferior $\frac{1}{2}$ -inch map was available as an insurance against failure to print or distribute the larger scale maps. As in other theatres, D.D. Survey adopted the policy of insuring against the unexpected, and arranged his mapping policy accordingly.

The size of printing orders depended very largely on the scale of issue adopted for the theatre. This was approximately as shown below:—

$\frac{1}{2}$ -inch	1,500 for each Division (often not drawn in full).
1-inch	1,500 for each Division.
1/25,000	1,000 for each Division.

Independent brigades had about one-third of the above, and corps troops generally a little less. Divisions sometimes asked for 2,000 or 2,500. Demands for replacement of wastage were small owing to the speed of movement. It was considered that intensive operations in one limited area involving all units of a division continuously would probably have necessitated a new issue every two or three months.

Much waste occurred through divisions drawing maps of areas in which they were likely to operate according to their original orders, but to which they did not go owing to a change of plan. This was, of course, inevitable and could not be avoided.

The general rule when framing printing orders was to print such a number that, if an additional 4,000 were printed, it would be an even chance that they would never be wanted. This was based on the assumption that it involved about as much work to put the job on the machine a second time as it did to print another 4,000 in the first place. Another basis of computation was to multiply 1,500 (divisional issue for the 1-inch map) by the number of divisions which were at all likely to enter the area, then double it for spares and

wastage. In the case of the 1/25,000 scale, two-thirds of the number arrived at above was taken. In the ordinary way 4,000 was regarded as a minimum print order, and 20,000 was rarely exceeded.

The controversial subject of sheet lines arose in practically every campaign during the war and S.E.A.C. was no exception. The standard $\frac{1}{4}$ -inch, $\frac{1}{2}$ -inch, and 1-inch maps of Burma were on graticule sheet lines, *i.e.*, bounded by meridians and parallels and therefore not rectangular in shape. For a demy-size press this gave a limit in size of 1° , $\frac{1}{2}^{\circ}$, and $\frac{1}{4}^{\circ}$ respectively for the scales mentioned above.

For the 1/25,000 maps there were two possibilities:—

(a) *A graticule lay-out*, measuring 5 min. \times $7\frac{1}{2}$ min. This had the following advantages:—

- (i) A tidy lay-out.
- (ii) It afforded the possibility of a systematic nomenclature based on either the Indian or International systems. This, of course, had great advantages in regard to indexing, recording and storing.
- (iii) It led to simplification if the 1/25,000 sheets were to be compiled later into a 1-inch series. In Burma, however, the 1-inch series existed first.

(b) *A grid lay-out*, which had as advantages:—

- (i) It allowed a maximum size of sheet to be chosen which would fill the paper better than any graticule lay-out could do.
- (ii) Sheets could be staggered to fit the coast line and main communications, thus involving a minimum number of sheets.

In the case of the 1/25,000 maps produced by Fourteenth Army, a grid lay-out was adopted. The irregular lay-out enforced a type of nomenclature such as "Monya 5," where sheets were grouped into blocks of sheets, and named after a well-known and uniquely named town or other feature in the area.

Shortage of paper and the difficulties of transport made it essential to cut to a minimum the wastage of paper. One way of doing this was to ensure that the actual map detail should cover the maximum percentage of the paper area. Marginal information was cut to a minimum, and consisted principally of the sheet name, scale, and road-classification symbols. In order to reduce the tonnage which would be transported by air the Wingate Expedition insisted that their maps should be trimmed to the bare edge of the map detail, leaving only the sheet number.

PART 4

15 CORPS

Final campaign in Arakan (December, 1944–May, 1945)

In December, 1944, 15 Corps was transferred from Fourteenth Army and placed under the direct command of H.Q. A.L.F.S.E.A. for operations in Arakan. Its task was to assist Fourteenth Army in the latter's advance through the centre of Burma by destroying or containing Japanese forces in the coastal area and by securing air bases on the Arakan coast from which Fourteenth Army could be supported and maintained. The operations, which originally

had a limited objective, were enlarged in scope as a result of their success, and finally took 15 Corps to Rangoon in May, 1945.

To understand the mapping problem it is well to summarize the five phases in which the operations were conducted:—

1st Phase. December, 1944–January, 1945. The clearance of the Mayu Peninsula and the securing of Foul Point and Akyab by 25 Division, with 82 (W.A.) Division as east flank guard.

The clearance of the Kaladan Valley by 81 (W.A.) Division, which was then relieved by 82 (W.A.) Division.

2nd Phase. January–February. 82 Division advanced south from Kaladan, and 3 Commando Brigade and 25 Division landed at Myebon to cut the enemy line of withdrawal southwards at Kangdaw.

The capture of Ramree and Cheduba Islands was achieved by 26 Division in an amphibious assault mounted from Chittagong.

3rd Phase. February–March. 82 Division moved south, and 25 Division landed at Ruywa to carry out a pincer movement against the Japanese 54 Division.

4th Phase. March–April. Operations in the Taungup Pass area, to prevent the withdrawal of the Japanese 55 Division. One brigade of 26 Division landed at Letpan from Ramree and moved on Taungup. 22 (E.A.) Brigade from Ruywa moved south in support; 82 (W.A.) Division followed later and occupied Taungup.

5th Phase. May. 82 (W.A.) Division occupied Sandoway and Gwa. 26 Division captured Rangoon by amphibious assault.

The Corps Survey Directorate had under command 155 (E.A. and S.R.) Field Survey Company and 34 Map Supply Section. Each of the two West African Divisions had a Divisional Survey Section (No. 10 with 81 Division, and No. 11 with 82 Division). No reproduction unit was available at the beginning of the period. By degrees No. 68 (Ind.) Reproduction Section was formed at Cox's Bazar, and by February was in production.

Fourteenth Army had completed a considerable amount of 1/25,000 mapping in the Arakan area before December, 1944, so 15 Corps was well placed with regard to maps for the first phase of its final campaign. There was also a block of 1/25,000 mapping in the Taungup area which had been produced in India.

For all the amphibious assaults there were demands for collation maps with defence and beach information overprints or, in their absence, for 1/25,000 maps. Owing to the rapid advance, these map demands were beyond the capacity of 15 Corps Survey with its own resources. Much of the work was therefore done by A.L.F.S.E.A. survey units in Ceylon or at Bangalore, the maps being sent forward by air. Until 68 Reproduction Section was created and fully working, printing work was sent either to Fourteenth Army presses at Comilla, until they moved to Imphal, or to Advanced H.Q. A.L.F.S.E.A. at Calcutta.

Collation maps were prepared for the Akyab and Rangoon landings. The planners were located at Cox's Bazar, and it would have been desirable to have set up a complete team capable of publishing these collation maps locally, but this was not possible. The intelligence information was therefore prepared at Main H.Q. A.L.F.S.E.A. in Ceylon, where the printing also was carried out.

The following is a short summary of the mapping work completed for the final Arakan operations:—

By Fourteenth Army	1-inch new sheets	4
	1-inch revised sheets	11
	1/25,000 new sheets	59
By 155 Field Survey Company	1/25,000 new sheets	36
	1/25,000 revised sheets	1
By 10 and 11 (W.A.) Divisional Sections	1/25,000 new sheets	17
By A.L.F.S.E.A. units:—		
Arakan area	1/25,000 new sheets	97
	1-inch new sheets	2
	1-inch revised sheets	48
	Collation maps	5
	Beach maps	4
Rangoon area	1/25,000 new sheets	43
	1-inch revised sheets	37
	Collation maps	13

During 1944, block-plots were extensively used. 23 were produced for the final Arakan operations, 15 of them by Fourteenth Army and eight by 155 Company. As a rule, ten sets of photographs were provided with each block-plot, all of which were base-lined by hand. Sets of base-lined photos were also provided for the Hind 601 maps on 1/25,000 scale, the sheets of which had the principal points of the photos plotted on them.

SECTION 4. AIR PHOTOGRAPHY FOR MAPPING AND REVISION

Introduction

The development of air survey photography in the South East Asia campaign followed the familiar pattern experienced elsewhere. At the beginning there was an almost complete absence of any resources whatever for the work. Then came a period of makeshift, using various types of aircraft, cameras and other equipment which, though unsuitable for the work, had to be used, these being all that were available. Finally, towards the end of the campaign, the provision of suitable aircraft and cameras enabled the survey photographic programmes to be planned and carried out on a proper basis.

The urgent need for survey photography was plain to see, not only for the production of new maps, especially on a large scale where they did not already exist, but also for the revision of already published maps which were out of date. The eventual provision of the necessary resources was the result of continuous and urgent representation by the Survey Service backed by the Headquarters of the Command.

Weather

The incidence of the annual south-west monsoon meant that little or no photography was possible from April to October each year. Over most of the area, the flying season extended from November to March. The period between April and October afforded opportunity for planning, and for the

build-up of photographic resources which would operate during the following six months.

To allow time for the production of maps of a large area from the photographs, it was necessary that the area of probable operations should be photographed during the preceding fine weather. Survey planning had, therefore, to take account of this fact.

Survey photography before April, 1943

During this early period there were no aircraft or cameras available to the R.A.F. which could produce photographs suitable for simple, straightforward methods of map making. The Survey of India then took over the resources of the Indian Air Survey and Transport Ltd. on a charter basis. As they were equipped with Moth aircraft they were not suitable for photographic missions in operational areas. The company had, however, carried out some vertical photography in Burma before 1942, and this cover was extensive and very useful for mapping purposes. Under the charter arrangements they undertook some new photography in Bengal as an insurance against a further Japanese advance, and also in other parts of India where it was required for various purposes.

Maps of the Andaman Islands were available for a limited area only around Port Blair. The R.A.F. accepted the commitment of covering the islands, and used B.25 aircraft fitted with old-pattern cameras which were normally used for intelligence photography.

The resulting photographs, which did not conform to proper survey specification, added many complications, extra effort, and time to the subsequent operations of map production, but it did enable a series of maps at 2 inches to 1 mile to be published during 1943 covering most of the islands.

For operations in Arakan the Eastern Army was able to obtain from the R.A.F. photographs of a similar intelligence type covering parts of the Arakan area which, combined with the photo cover which had been obtained from the I.A.S. and T. Company, enabled some maps on 1/25,000 scale to be produced.

Units of the U.S. Army Air Force, using K-17, 6-inch Fairchild cameras, took a block of photos in northern Burma which, though of poor quality, enabled some map revision to be carried out in an area through which the Ledo Road was to be constructed.

Equipment considerations during the period April–November, 1943

The development of operations, and a consideration of future mapping requirements, made it perfectly clear that, unless modern-type aircraft and cameras of suitable design were made available in sufficient numbers by November, 1943, the survey programme would be very seriously prejudiced.

The U.S. Army Air Force was asked to provide a mapping squadron, and No. 24 Combat Mapping Squadron was allotted to the China–Burma Theatre. This arrived in May, 1944, and was equipped with B.24 aircraft and Fairchild cameras. These B.24s were, however, very vulnerable to enemy fighters, and could not operate in areas where enemy air opposition was expected.

The R.A.F. made several applications to the Air Ministry for the supply of K-17, 6-inch Fairchild cameras, which were of suitable type for survey photography, but were told that none were available. The Survey Service therefore took up the case with the Director of Military Survey at the War Office, with

the result that the latter was able to obtain the release of six K-17s and some K-8, 24-inch cameras for the Far East.

With regard to aircraft, six Mosquitoes had arrived, or were on their way out to the theatre by November, 1943.

Period from November, 1943 to May, 1944

During this period S.E.A.C. and 11 Army Group were both formed, and the control of all air survey photography was taken over from India by 11 Army Group until the formation of the Survey Division at H.Q. S.A.C.S.E.A. in February, 1944. After that date S.A.C.S.E.A. assumed control of forward planning. The period will be considered below in two phases, the first extending from November, 1943, to February, 1944, and the second from February to May, 1944.

1st Phase.—In October, 1943, a request had been submitted by India to the Chiefs of Staff for the provision of a Survey Flight. The Air Ministry reply was to the effect that as all reinforcing aircraft (Mosquito XVI) were fitted to take survey cameras, and the crews were trained for survey as well as for intelligence photography, a special Survey Flight was not considered necessary.

In December it was arranged that all demands for photography, including those for Survey, should go through a photographic reconnaissance (P.R.) priorities committee. As it was considered that in largely unknown areas, small scale photographic cover was often the prerequisite for defining further tasks, and that such cover fulfilled a Survey requirement, it was agreed that all demands for intelligence photography should be notified to Survey and, if they involved such tasks as the reconnaissance of an important topographical feature such as a road, the photography would be planned by Survey. This had the effect of reducing the number of sorties, and provided a more comprehensive picture. It was also arranged that aircraft should operate survey cameras when engaged on intelligence missions. Thus, on the weekly intelligence sorties to Bangkok for large scale photography of the port, the aircraft was routed each time on a new course and, by exposing a survey camera on the journey, the basic cover was considerably extended to everyone's advantage.

In January, 1944, when survey photography of the southern areas was under consideration, D.D. Survey submitted that the Cocos Islands would provide the most suitable base from which photographic aircraft could operate for covering those areas. As will be seen later, an airfield was subsequently constructed there.

Planning for future operations in areas which were at that time inaccessible for air photography resulted in a request being sent to the Chiefs of Staff for the allocation of long-range aircraft. The Air Ministry replied that they were hoping to obtain a limited number of American aircraft of suitable type, of which production was beginning, and recommended an investigation into the possible use of carrier-born photo-reconnaissance aircraft.

2nd Phase.—During this period 11 Army Group took action to intensify air photographic demands and their execution, and 147,000 square miles were covered in Burma during the flying season.

The Survey Division at S.A.C.S.E.A., in execution of its responsibilities for future planning, took action regarding the following important items:—

- (a) Expansion of the existing P.R. Force and facilities for the provision of survey photographs.
- (b) The provision of extra-long-range aircraft.
- (c) The employment of the Fleet Air Arm.
- (d) The development of new techniques.

The Air Ministry agreed to increase the number of Mosquitoes in the P.R. Force, and to provide a further squadron as soon as operations against Germany should terminate. The resulting numbers would provide sufficient aircraft to meet all requirements within their operational range but, even if Burma should be recaptured during the dry season in 1944-45, there would still be large areas which could not be reached till 1945-46 unless special means were taken. A ground survey was carried out in the Cocos Islands to ascertain the possibilities of constructing an airfield there.

With the lack of long-range aircraft the employment of the Fleet Air Arm, based on aircraft carriers, offered possibilities of development. In February, the C-in-C. Eastern Fleet was invited to make an urgent investigation into the methods by which a photographic reconnaissance of Sumatra could be obtained. Two Mosquitoes were sent to Ceylon for trials, but it was found impracticable to use them off carriers. Difficulty was found in modifying Corsair aircraft for the work and, when it was understood from a U.S. liaison officer that the Americans were using specially designed Corsairs for photographic work, the Chiefs of Staff were requested to allocate six such aircraft. They supported the request, but it was then ascertained that the U.S. Navy was using Hellcats, not Corsairs. Six of them were available, and the Admiralty accepted the offer and arranged for them to be formed into a new unit which would be raised and trained in the United Kingdom.

Owing to the paucity of ground control, it was realized that air survey in areas outside Burma would become increasingly difficult. There was an urgent need for some means of controlling air surveys without having access to the ground. It was known that experiments had been conducted in the United Kingdom regarding the use of radar for determining the position of an aircraft on a survey flight at a given instant. The Chiefs of Staff were asked to press for further research in this important subject, and the first radar-controlled unit (Mosquitoes) was ready to proceed from the United Kingdom to the Far East when the atom bombs were dropped on Japan. (For further details see Chapter XIV, Section 6.)

Period from May to November, 1944

Weather conditions during the period grounded the Mosquitoes of 684 Squadron R.A.F. No. 11 (Ind.) Air Survey Liaison Section, which worked with them, took the opportunity of tidying up its work of the preceding six months, and getting ready for the next season's photographic programme.

The principal development of this period was the raising and training of the Fleet Air Arm (F.A.A.) Squadron. It was found that Hellcats could be adapted to take a K-17, 6-inch and one other camera, whereas a Corsair could only take an F-24 camera. Work on Corsairs was therefore abandoned. The

six Hellcats promised by the U.S. Navy were despatched to the United Kingdom at the end of July.

In accordance with the existing policy of survey liaison with the R.A.F., No. 12 (Ind.) Air Survey Liaison Section was formed in July, and worked with the Fleet Air Arm during their period of training with the converted Hellcats. The first operational photography was undertaken at the end of August and covered some of the islands lying to the west of Sumatra. The work was planned by Survey, and 2,200 square miles were covered by photography. This operation formed a very successful debut to the photographic work of the Fleet Air Arm.

During September, 1,300 square miles were covered by vertical photography in Sumatra and in October, in spite of bad weather, 660 square miles of cover over the Nicobar Islands were photographed.

In October, No. 880 Squadron of six Hellcats, which had been raised in the United Kingdom, arrived in the theatre, and this brought to an end the period of dependence on locally adapted aircraft. The latter had, however, produced over 4,000 square miles of vertical cover, and had provided experience of fleet-operated photographic reconnaissance which was to prove of such great value in subsequent stages of the campaign.

During this period, a certain number of Liberators and two Mosquitoes, based on Ceylon, operated over northern Sumatra. They were equipped with Fairchild cameras, and the briefing for the work was given by No. 12 (Ind.) Air Survey Liaison Section. By this means over 4,000 square miles of vertical cover was obtained.

Period from November, 1944, to June, 1945

From November to the end of February A.L.F.S.E.A. controlled the survey photographic activities of the R.A.F. operating from Bengal. The work of the Fleet Air Arm, was, however, more of an inter-service nature, and the Survey Division (S.A.C.S.E.A.) retained a watching brief over their work and also that of 12 (Ind.) Air Survey Liaison Section, though the latter nominally remained under A.L.F.S.E.A.

There was, however, a radical change in the functions of the various survey staffs in March, 1945, and from then onwards the Survey Division (S.A.C.S.E.A.) took over complete control of all air survey photography.

The work of the period under review will therefore be considered in two phases, as represented by the above conditions.

(a) From 1st November, 1944, to 28th February, 1945.

In November there was an urgent need for basic cover in the Hastings Harbour-Victoria Point area. This work could only be undertaken by Mosquitoes but, owing to technical troubles, only six out of the 18 Mosquitoes available were fit for operations.

During November and December they were concentrated on the first priority task in the Victoria Point area which involved over 50,000 miles of flying. In order to help out the Mosquitoes, XX Bomber Command (U.S.A.A.F.), who were not then under S.A.C.S.E.A. control, agreed to take part in the work and, during their training flights, completed the task, thus releasing the Mosquitoes for urgent work elsewhere.

By December, owing to the falling off of enemy air opposition, it was possible to employ a greater amount of photographic resources of all kinds. These consisted of:—

- R.A.F. One squadron of Mosquitoes.
- U.S.A.A.F. One combat mapping squadron (B.24s).
Two photo-reconnaissance squadrons (P.38s).

The above were deployed according to the range and suitability of the tasks.

Survey demands for photographs were of two kinds:—

Small scale (1/60,000) for areas as yet unmapped.

Medium scale (1/30,000) for more limited areas where 1/25,000 maps were required.

During this period of four months the area photographed by ground-based aircraft was as under:—

	<i>Small scale (Square miles)</i>	<i>Medium scale (Square miles)</i>
R.A.F.	74,133	51,650
U.S.A.A.F.	81,650	10,640

During February, 1945, there was a unification of command of all U.S.A.A.F. and R.A.F. P.R. Forces in the theatre under a central P.R. Force H.Q. This was under the control of the Director of Intelligence at H.Q. S.A.C.S.E.A., and the allocation of work was made by a P.R. Board consisting of representatives of each service, with the Director of Intelligence as chairman. All survey demands were submitted to the Board by the Survey Division (S.A.C.S.E.A.). The Board was also responsible for co-ordinating the work of the Fleet Air Arm and other agencies.

(b) From 1st March, 1945, to August, 1945.

During this period all matters relating to photography for survey purposes were under the control of the Survey Division (S.A.C.S.E.A.). This simplification of staff control and the build-up of resources which had taken place during the preceding periods made this final phase the most successful photographic period of the campaign.

During May the new Mosquitoes (Type XXXIV) began to arrive, and a detachment was based on the Cocos Islands, where an airfield had been constructed. Even though the normal photographic season had shut down in April owing to the monsoon, activities could be continued beyond that date by using the Fleet Air Arm and the Cocos detachment. Coverage was obtained of South Malaya, South Sumatra and Java.

The U.S.A.A.F. undertook tri-metrogon photography of an area of 170,000 square miles in northern Thailand (Siam) which facilitated the production of navigational sketch maps. These were used both for actual flying and for plotting the vertical cover of the area which was planned for the next season's work.

The allocation of XX Bomber Command to S.E.A.C. also allowed small scale vertical cover to be obtained of Singapore, the Penang area,

and some of the Port Dickson-Port Swettenham area, which was well outside the range of the Mosquitoes.

From March to August, 1945, the area covered with vertical photography by the R.A.F. and U.S.A.A.F. was:—

	<i>Small scale</i> (Square miles)	<i>Medium scale</i> (Square miles)
R.A.F.	145,890	28,850
U.S.A.A.F.	44,360	72,740

The Eastern Fleet was successful in obtaining cover of the following vital areas, special Fleet sorties being planned for each operation:—

Operation "Stacey" in March. This took place in the Phuket and Kra Isthmus area, which was outside the range of Mosquitoes XVI. Vertical coverage over 30,000 square miles was obtained, and a detachment of No. 12 (Ind.) Air Survey Liaison Section assisted in the planning, and accompanied the Fleet for briefing and controlling the photography.

Operation "Sunfish" in April. The object of this was to obtain small scale cover and beach photography of the "Zipper" assault area. The Fleet was concentrated to the west of Sumatra, and the aircraft flew across Sumatra to Malaya. They obtained 5,500 square miles of much-needed vertical cover along the coast of Malaya.

Operation "Balsam" in June. As the force scheduled to take part in the "Zipper" assault operation had no large scale photo cover of the assault area for 1/25,000 map production, fleet operation "Balsam" was staged. The fleet entered the Malacca Straits and 2,900 square miles of 1/30,000 photo cover was obtained. Approximately 100 miles of beach were photographed between Port Swettenham and Singapore. To cover the beaches two of the Hellcats were equipped with split F-52 cameras with 20-inch lenses.

Summary of photographic cover

The total area covered by photography for survey purposes on all scales by the Allied Air Forces is summarized below:—

Fleet Air Arm	46,100 sq. miles
R.A.F.	290,523 sq. miles
U.S.A.A.F.	209,390 sq. miles
Total	<hr/> 546,013 sq. miles <hr/>

This total area is equivalent roughly to that of the whole of pre-war France, Belgium, Holland, Germany, Italy, Switzerland, Austria, and half of Czechoslovakia. Taking into consideration the number of aircraft available in the theatre, the delays experienced in building up resources, and the bad weather conditions during many months of the year, this was a remarkable achievement.

SECTION 5. TRIANGULATION AND FIELD SURVEYS

Introduction

The need for ground surveys of various sorts arose during the Burma campaign as in other theatres. The thick, jungle-covered terrain considerably restricted the use of triangulation methods, and in most parts of the battle zone very little triangulation was carried out. There were demands for surveys of airfield sites, base installations, roads, anti-aircraft and coast defence batteries, and so forth. There was also a need for topographical surveys in connection with the preparation of new maps and the revision of existing ones.

Provision was made, as in other theatres, for co-operation between R.A. and R.E. surveyors in connection with the establishment of control for artillery shooting, but here again a combination of factors, chiefly connected with the difficult type of terrain, resulted in very limited need or demand for such co-operation.

Surveys of airfields, triangulation, etc.

In March, 1942, urgent demands arose for the survey of airfields and base installations in Assam. The first and most urgent job was a location survey for the base at Ledo, which was to be the railhead and stores depot for the new China Road. There was also the base at Manipur Road. Both the above continued intermittently for about two years, more and more survey work being required as they developed.

Surveys for new airfields were undertaken at several sites in Assam. All this work was attended with many difficulties such as thick jungle, rainy weather, leeches, breakdown of transportation, and other adverse factors which affected progress. A number of new roads were surveyed for inclusion in revised editions of 1-inch, $\frac{1}{2}$ -inch, and $\frac{1}{4}$ -inch maps.

During 1943, 6 (Ind.) Field Survey Company with 4 Corps in Manipur carried out many medium and large scale surveys of important localities, notably 2 inches to 1 mile surveys of strips two to four miles wide along the Pail-Tamu and Imphal-Tiddim roads. These proved to be very useful later during the fighting of 1943. Some triangulation was observed round the Imphal Plain and between Imphal and Tamu which, in the absence of any existing 1-inch surveys, proved most useful as control for 1/25,000 mapping and block-plots. Other ground surveys were carried out for administrative purposes.

Surveys of airfields in Bengal and Assam continued during 1943, the largest being a 16-inch survey of the big airfields at Chittagong, Comilla, Dacca and Aggartala, a 12-inch survey of the Manipur Road Base, and much work around Ledo.

In Arakan, during the fighting in early 1944, a section of 155 (E.A. and S.R.) Field Survey Company observed a triangulation south of the Maungdaw-Buthidaung road and a 4 inches to 1 mile survey of the Maungdaw Port area was completed.

In the spring of 1944, surveys were carried out under A.D. Survey, 4 Corps in the Kohima-Imphal area for the preparation of operational maps required by the corps.

In December, 1944, 15 Corps began its final campaign in Arakan which ended in the capture of Rangoon. Trig and topographical surveys were carried out by two sections of 155 Field Survey Company. At the close of the

dry season in May, 1944, triangulation had been completed in the forward area with some intersected points further south and, with the advance of 15 Corps down the coast, the trig section was called upon to provide points for R.A. Surveyors. At any stage of the advance trig control, which was "tied in" to the Burma coast series, could have been supplied either in the Mayu Valley or along the coast. Fixes were provided for the R.A. before the assault on Akyab. After the landing at Myebon and the clearance of the enemy from the Minbya area, the section re-established its trig control there and also among the islands to the south and east of Akyab as far as the southern end of Ramree Island. No points were fixed on the mainland south of Myebon. In addition to the triangulation, surveys of some anti-aircraft sites were completed.

The topographical section of 155 Field Survey Company did some levelling for airfield sites, and also carried out ground surveys for some large scale town plans such as that of Akyab.

Meanwhile, during the final advance through Burma leading up to the capture of Mandalay and Rangoon, each corps with Fourteenth Army was provided with a survey detachment of one officer, a computer, and a few surveyors for the survey of airfields, and for possible co-operation with R.A. surveyors if so required. These small parties were found to be very useful, and were almost continuously employed on survey work at 6-inch or 8-inch scale for light aircraft and Dakota strips.

Co-operation between R.A. and R.E. surveyors

During the advance on Maungdaw early in 1944, R.A. surveyors were being employed for the first time and they carried out a certain amount of triangulation based on two primary stations which were available. Two R.E. surveyors worked in association with them at this period but the topographical and other conditions were such that R.A./R.E. survey co-operation of the orthodox kind, such as was practised in other theatres, did not appear to be profitable.

In the Manipur area during the early part of 1944, a section of 155 Field Survey Company was attached to 33 Corps during April and May to assist R.A. survey along the road from Manipur to Imphal, but they had little opportunity of doing any useful work and, as a result, it was decided to withdraw R.E. survey resources from this type of employment unless specifically asked for. During the final advance through Burma, small survey detachments accompanied each corps as stated above, but there was no call for assistance from R.A. surveyors. In Arakan on the other hand, at the specific request of 15 Corps there was a certain amount of co-operative survey work between R.A. and R.E. surveyors during the final campaign along the coastal belt.

Divisional and brigade survey sections

In poorly mapped country, such as in East Africa during the advance from Kenya into Abyssinia, the attachment of survey sections to brigade columns had proved of real value. They were able to guide the columns by locating position and direction by astronomical and other methods when no proper maps were available and, in anticipation of a battle, they were able on the spot to provide valuable sketch maps from air photos, plane-table sketches, and hasty triangulation.

In Burma, however, the position was different. The country was by no

means unmapped, and the preparation of hasty sketch maps in the field from ground survey or air photos could obviously have no advantage over maps properly prepared in the rear.

The only examples of the use of brigade and divisional survey sections in South East Asia were those of the two West African divisions in Arakan. The sections were a relic of the East African campaign where they had been so successful that, when these divisions proceeded to Burma, their commanders would not do without them. Their employment in Burma was against the considered judgment of the Director of Military Survey (War Office) who was categorically opposed to their use in that theatre. In the event it was not long before the divisional commanders themselves recommended that these sections should be abolished. The man-power released was then used for mapping work in the rear, where the demand for such work was very great.

SECTION 6. MAP SUPPLY AND DISTRIBUTION

Introduction

The operations in South East Asia, beginning with the first retirement from Burma early in 1942 and ending with the Japanese surrender in August, 1945, presented many problems in map distribution. Though many of these were common to all theatres, some of them were probably peculiar to the conditions under which the operations against the Japanese were conducted.

As has been stated elsewhere, all military survey activities in India were controlled directly by the Survey of India until about March, 1942, when a Director of Survey was appointed to G.H.Q. India, and a D.D. Survey, with a small directorate, was assigned for duty with the Eastern and Southern Armies.

At that period, when the British force was withdrawing from Burma into India, and there seemed to be a possibility of the Japanese invading India itself, the map stock situation was bad. The normal peace-time printing of any one sheet of India or Burma was about 500 only. Additional stocks of Burma and the Shan States had been printed and sent to Rangoon in 1940-41, but these were lost during the retreat. The Survey of India then undertook the printing of stocks of maps of northern Burma to try and keep pace with the withdrawal, and these were flown in, and were either used, destroyed or abandoned.

It is fair comment to state that in India, as elsewhere generally, the important task of map distribution had received little thought before the war, and all the machinery for carrying it out had to be built up as operations developed. Fortunately, there was available by 1942 a considerable amount of valuable experience on the subject of map distribution which had been gained in other operational theatres.

Early formation of map depots in India

Map depots for operational purposes were set up as under:—

At Ranchi. This was the main depot for the Eastern Army with a holding capacity of 4,000,000 maps.

At Barrackpore. A small depot with a capacity of 500,000 maps. This served 15 Corps whose H.Q. was located there.

At Bangalore. Capacity 1,500,000 maps.

At Poona. A small depot.

As maps were printed by the Survey of India they were sent by rail to Ranchi or Bangalore where they were stored, or issued to divisions and the R.A.F. Distribution to formations was by rail, or by the formations' own vehicles, or by liaison officers from Army to headquarters of corps or divisions.

Operations in Burma during 1943

The Eastern Army, which was fighting the Burma battle, was directly controlled at first from G.H.Q. (India); so also was the Southern Army, whose primary role was the defence of southern India. Maps, printed by the Survey of India, were issued by G.S.G.S. (I.) to the Armies, either from the Central Map Depot at Delhi, or direct from the printing plants.

The policy governing map distribution in the theatre was that Survey was responsible for the supply of maps down to the headquarters of formations next below that which carried a survey representative, that is to say, normally to divisions and independent brigades. For the holding of maps at divisional H.Q.s and for distribution within a division, one 3-ton lorry with one survey record keeper and one sepoy storeman were introduced into the war establishment of divisional H.Q., and these worked under the G-3 (I.) of the division.

The 1943 operations of the Eastern Army included the unsuccessful Arakan offensive, the Wingate expedition, and the fighting in the Kabaw valley and the Chin Hills. Then in November S.E.A.C. was formed, and, at the same time the Eastern Army changed its name to Fourteenth Army and its headquarters moved from Calcutta to Comilla. New map depots were opened at Imphal to hold stocks of the Manipur and Chindwin areas, and at Chittagong to hold a reserve for Arakan and to act as a local issue depot.

No. 36 Map Supply Section (M.S.S.) joined Fourteenth Army in November and opened the Comilla depot, to which all stocks of Assam, Arakan and Northern and Central Burma were brought forward.

Development of the map supply organization during 1944

In March, 1944, the Survey Directorate at H.Q. 11 Army Group was established, and the Director of Survey became responsible for all survey matters affecting that formation, a responsibility hitherto held by G.S.G.S. (I.). He was also responsible to the Supreme Commander for all survey matters in the command, and a survey liaison office was set up at H.Q. S.A.C.S.E.A. During March Nos. 32 M.S.S. (Delhi) and 35 M.S.S. (Comilla) were transferred from G.S.G.S. (I.) to S.E.A.C.

In June, a new map depot unit, No. 40 Map Supply Company, was raised in order that the main S.E.A.C. depot could be moved from Delhi to Madras, and to supply a detachment to operate a depot at Kandy. This latter was intended to supply the needs of the East Indies Fleet, the headquarters at Kandy, and the Army and Air Force units in Ceylon.

The Madras depot (No. 92) became the main S.E.A.C. depot for all maps other than those of Burma. No. 91 Depot in Calcutta, which was staffed by the East African Map Supply Company, came under the direct control of 11 Army Group, and was the main S.E.A.C. depot for maps of Burma.

Comilla (35 M.S.S.) was now the main Fourteenth Army map depot, with Chittagong feeding 15 Corps, and Imphal feeding 4 Corps. To reduce the risk of the total loss of all stocks the Imphal depot had a subsidiary depot at Patel.

The Assam lines of communication were fed by a small depot at Jorhat and, for the operations leading up to the relief of Imphal, map depots were temporarily opened at Manipur Road and at 33 Corps Headquarters.

Distribution from the Calcutta depot to Comilla, and from Comilla forward was normally by passenger train in lots of about 40 sacks (50,000 maps) conducted by a sepoy courier. During the siege of Imphal use was made of air transport.

Rail transport along the Assam lines of communication, even with couriers, was always unreliable. To make things safer, the couriers were given letters to all the intermediate movement control officers, who were asked to forward all couriers without delay, and not to separate them from their maps.

At the end of November, 1944, when Fourteenth Army H.Q. moved from Comilla to Imphal, large map stocks were transferred from Comilla to Imphal, which then became the Army's main supply base.

Reconquest of Burma, 1945

Between December, 1944, and May, 1945, the operations developed rapidly, becoming more mobile, and increasing the difficulties of distribution. This period covered the advance into Burma, with the capture of Mandalay and Rangoon. Fourteenth Army advanced from Kalewa down the centre of Burma; and 15 Corps carried out a series of amphibious operations along the coast to assist the advance of Fourteenth Army, and entered Rangoon in May. For this purpose 15 Corps was placed under the direct command of H.Q. A.L.F.S.E.A., the title 11 Army Group having been dropped.

Although U.S. troops of the N.C.A.C. came under the command of H.Q. A.L.F.S.E.A., it was arranged, at the Americans' request, that their map supply would remain the responsibility of the U.S. survey liaison officer for the China-India-Burma Theatre, whose H.Q. was at Delhi. This seems to have been an arrangement attended by many disadvantages, though admittedly N.C.A.C. and Fourteenth Army each had its own lines of communication, one leading back to Delhi and the other to Calcutta. During the period of rapid advances, which were co-ordinated by H.Q. A.L.F.S.E.A., it seems clear that the Survey Directorate at H.Q. A.L.F.S.E.A. was early aware of the C-in-C.'s future intentions, whereas the U.S. liaison officer in Delhi was unlikely to be in a position to plan his map distribution with that early knowledge which was so essential. The situation was affected by the fact that total stocks of maps were insufficient to allow both Fourteenth Army and N.C.A.C. to draw full supplies covering all their possible areas of operations. Issues had to be controlled and co-ordinated in order to make available stocks go round.

At the beginning of this period the A.L.F.S.E.A. map distribution organization was untried under battle conditions. Some of the distribution staff were inexperienced in their tasks, and the main depots were not in smooth working order. All this had to be put right in a short time, and the reorganization of working methods was carried out concurrently with supply to the forward areas, the setting up of the Madras depot, and the "cleaning up" of the Calcutta depot. No major breakdown occurred, but the strain on all concerned was a heavy one. The special arrangements for Fourteenth Army and 15 Corps are described below:—

Fourteenth Army. All the maps likely to be required for its advance into Burma were concentrated at Imphal. Until mid-April distribution

was effected by air direct to divisions, and sometimes to brigades, through the Rear Airfield Maintenance Organization (R.A.M.O.) at Imphal. The liaison survey captains at Corps H.Q.s kept the divisions informed of what maps were available, and divisions signalled their requirements direct to the Imphal depot, and to the R.A.M.O. responsible. Maps were then flown to them, generally the following day with their mail, ammunition, rations, etc. As the Army advanced, divisions began to depend more on R.A.M.O.s in Chittagong and Akyab. Supply from Imphal would eventually have been impossible but, until 20th April, when the Myingyan map depot opened, all divisions were getting supplies of some kind by air from Imphal, and there was no difficulty in sending maps with them. For the opening of the Myingyan depot, half of the Imphal stocks were moved, early in April, by road to Kalewa, and thence by river to Myingyan, the remaining stocks being moved after the safe arrival of the first half. Supply forward from Myingyan was by road transport *via* corps H.Q.s. For the Fourteenth Army advance to Rangoon a special reserve depot, holding 1,000 copies of each map, was opened at Meiktila, under 4 Corps' control, in case supply from Imphal should break down before the Myingyan depot opened. For this move, and other similar large stock transfers, special full-load Dakota aircraft were used.

Fourteenth Army was averaging the equivalent of six divisions in the line at this time, and map consumption during this 450 mile advance from Kalewa to Rangoon, was about 120,000 maps a division for each month. Put in terms of weight, between December, 1944 and April, 1945, the tonnage of maps carried to divisions and corps troops in Fourteenth Army amounted to 88 tons by air and 32 by road.

15 Corps. During this period 15 Corps was conducting a series of amphibious operations down the coast under the direct command of H.Q. A.L.F.S.E.A. in support of the Fourteenth Army advance. In December, 15 Corps was controlling map depots at Chittagong, Cox's Bazar and Maungdaw, using 34 M.S.S. and personnel from 155 (E.A.) Survey Company. Most of the printing was being done by rear formations and sent forward by air from Ceylon, Bangalore, Madras, and Calcutta. In arranging the supply of maps by air-drops to 81 and 82 (W.A.) Divisions in the Kaladan Valley, and in mounting the amphibious assaults on Akyab, Myebon, Ramree, Cheduba Island, Ruywa, Letpan and Rangoon, 15 Corps experienced and overcame a variety of map distribution problems.

The depot at Maungdaw, which had been opened in December, was closed after the initial stages of the advance had been completed because it was found easier to supply divisions by air from Cox's Bazar. This latter, manned by a detachment of 34 M.S.S., reopened at Akyab in February, 1945. The two West African divisions (81 and 82) in the Kaladan Valley were supplied by air from Chittagong.

26 Division was mapped up in readiness for an amphibious assault on Akyab but the operation in that area went so well that the assault was changed to a "ferry trip" by units of 25 Division, while 26 Division immediately prepared for the assault on Ramree. This necessitated a quick switch of map stocks over long distances.

For the Ramree assault the maps were distributed within the concentration area at Chittagong two days before embarkation. They were coded and put into bundles of 50 at Cox's Bazar Depot, and taken by survey

transport to 26 Divisional H.Q. at Chittagong, where a survey officer supervised the distribution. To deal with any last-minute arrangements that might be necessary, he remained there until the convoy had sailed. The maps were distributed to unit commanders on shore but, to preserve security, the breaking of seals and final distribution on board ship was not effected until after the convoy had actually sailed.

The Rangoon assault entailed very widely scattered arrangements under high security conditions. The mounting ports were:—

- (a) Kyaukpyu, for the main force, where a detachment of 34 M.S.S. from Akyab carried out the distribution. As the ships were widely dispersed in the anchorage, and the units were to be split up among many ships, the maps were distributed to units on shore within a sealed perimeter, before embarkation.
- (b) Akyab, for the R.A.F. and airborne troops.
- (c) Chittagong and Calcutta, for the follow-up troops. The advanced Survey Directorate A.L.F.S.E.A. was responsible, under 15 Corps orders, for the mapping up at Calcutta, and 15 Corps at the other ports. A small depot detachment was sent with the headquarters of the assault force in order to open up a beach-head depot to supply maps for the initial exploitation.

All the maps for Fourteenth Army and 15 Corps printed by base units and rear organizations passed through 91 Depot at Calcutta. Between three and four million maps a month were handled by the depot, a peak of 5,000,000 being recorded in April. Originally staffed by 158 (E.A.) M.S.S., it was reinforced in January by a detachment of 40 Map Supply Company from Madras. After the fall of Rangoon, the East African M.S.S. went to Ceylon to operate 92 Map Depot, the detachment of 40 Map Supply Company returned to Madras, and 91 Depot was then operated by 35 M.S.S. which moved from Comilla.

Final Phase

The map supply and distribution situation during the final stages of the campaign is described briefly below:—

Immediately before the Japanese surrender in August, 1945, Twelfth Army (recently formed) was operating in Burma, and Fourteenth Army was mounting operation "Zipper" for the invasion of Malaya. Map distribution activities were at their peak of activity. The map supply units comprised the following:—

40 Map Supply Company (A.L.F.S.E.A.)	Madras.
31 Map Supply Section (A.L.F.S.E.A.)	Calcutta.
35 Map Supply Section (A.L.F.S.E.A.)	Comilla.
33 Map Supply Section (Twelfth Army)	Burma.
36 Map Supply Section (Twelfth Army)	Burma.
34 Map Supply Section (Fourteenth Army)	"Zipper."
37 Map Supply Section (Fourteenth Army)	"Zipper."

In addition, the following special units were formed for map supply duties:—

A detachment of the Survey Production Centre at Kandy for running a map depot at that place.

Port depots at Cochin, Bombay, Madras, Vizagpatam, Calcutta, and Chittagong.

The main A.L.F.S.E.A. depots were No. 90 at Madras, and No. 91 at Calcutta. From these two the Army and Port depots were supplied, except in the case of very urgent deliveries which were made direct from the Survey Production Centre at Kandy, or from the main Indian printing plants under G.S.G.S. (I.) through their Central Map Depot at Delhi.

With the capture of Rangoon, the increasing interest in Malaya and the Netherlands East Indies, and the move of A.L.F.S.E.A. to Ceylon from Calcutta, 91 Depot gradually diminished in importance. It was intended, however, that air maps for H.Q. R.A.F. Burma, and maps of Burma for the ground forces, would have remained there, all other series being concentrated at 90 Depot in Madras.

At Comilla were the remains of the depot left there by Fourteenth Army when it moved to Imphal. It performed three main functions:—

- (a) It was an interim depository for all map stocks and survey stores returned from scattered points in northern Burma, until 91 Depot (Calcutta) could accept them.
- (b) It was the map depot for the L. of C.
- (c) It provided a detachment and supervised the working of the port depot at Chittagong.

92 Depot at Kandy supplied H.Q. S.A.C.S.E.A., East Indies Fleet, H.Q. A.L.F.S.E.A. and Ceylon Army Command.

For operation "Zipper," the coding of maps was done by 40 Map Supply Company at Madras, work being started in mid-June and continuing till 5th August without a break, working two 12-hour shifts, and averaging over 100,000 maps coded each day.

The port depots were opened in July and placed under the direct technical control of D.D. Survey Fourteenth Army. Their task was to break down the bulk coded stocks received from the main depots or printing units into ship or unit consignments for the launching of operation "Zipper." Their task was completed in September.

CHAPTER IX

NORTH WEST AFRICA. (OPERATION "TORCH")

The following map and plate are relative to this chapter:—

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<i>Sketch Map 9. North West Africa and the Western Mediterranean</i>	259
<i>Plate at end of book</i> } <i>27. Algeria 1:200,000</i>	

SECTION 1. SURVEY ORGANIZATION AND NARRATIVE

Historical background

From the time when the United States entered the war in December, 1941, the possibilities of an Allied expedition to French North West Africa had been considered. During 1941 and 1942 the following factors tended to strengthen the desirability for such an operation:—

- (a) The German offensive against Russia not only endangered the whole existence of the Russian Armies but involved such a deep thrust into southern Russia that it formed a dangerous threat to the Caucasus oilfields and the Middle East itself. Russia was pressing the Allies for the opening of a second front to relieve the strain.
- (b) The German and Italian forces in Libya produced a growing threat against Egypt and the Middle East generally.
- (c) The increasing difficulty of passing convoys through the Mediterranean, and the Axis threat against Malta were of serious moment to the Allies.

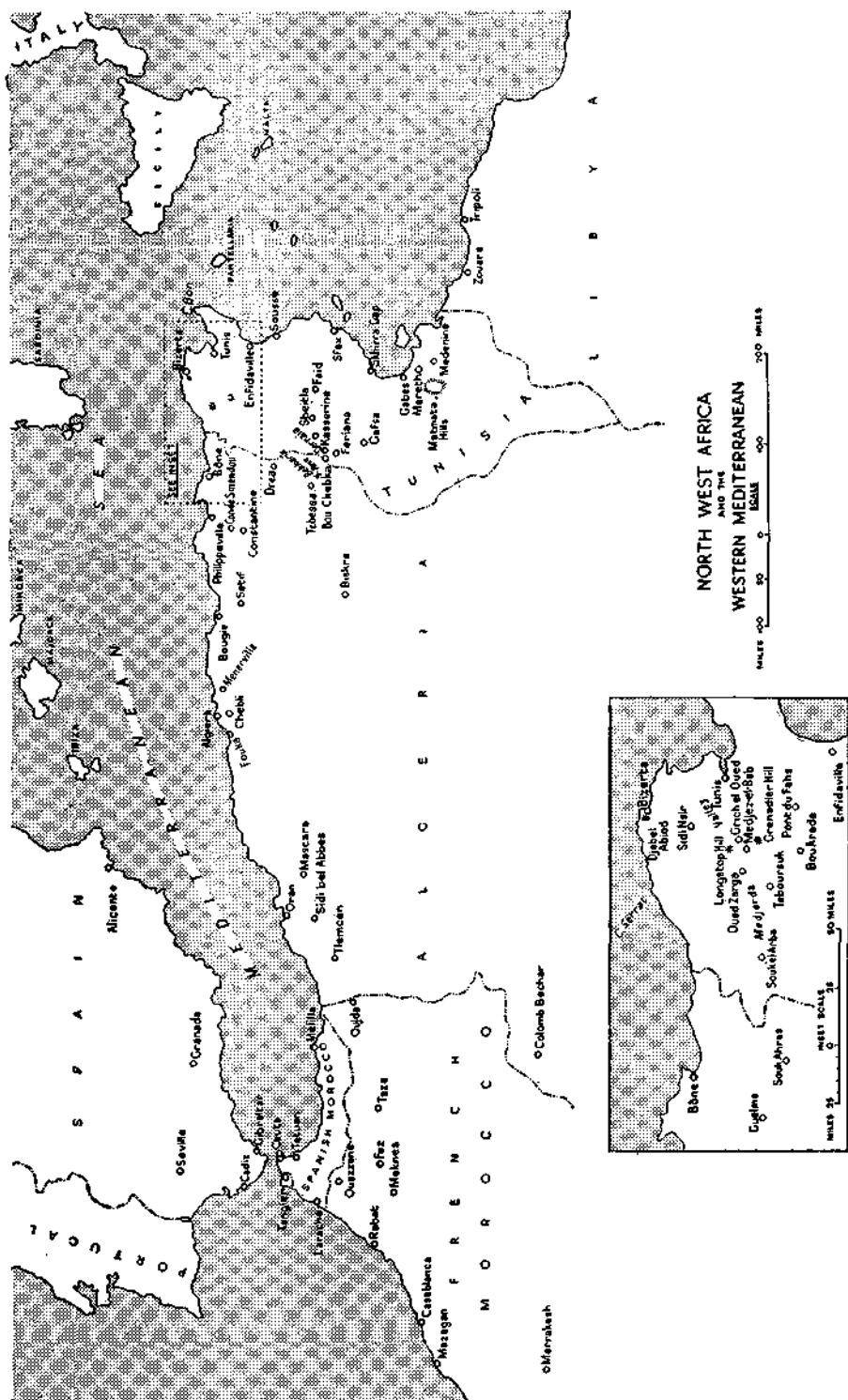
The decision to undertake a joint British-U.S. operation in North West Africa to clean up all the German and Italian forces in North Africa, to open up the Mediterranean and relieve Malta, and to relieve indirectly the strain against Russia was made by the Combined Chiefs of Staff and approved by the two Governments concerned on 24th July, 1942. The code name for the operation was "Torch."

Strategical and military considerations

Rommel's offensive against the British forces in Libya was launched in May, 1942, and by early July had reached the El Alamein area and was threatening the Nile Valley. By mid-August the enemy drive had been stopped, and the build-up of Eighth Army was being rapidly undertaken with a view to an autumn offensive in October.

The main objects of operation "Torch" were thus to secure French Morocco and Algeria with a view to the earliest possible occupation of Tunisia including its airfields, so as to help in opening up the Mediterranean for convoys, and to prevent the enemy forces in Libya from using Tunisia as a base. Indirectly it was hoped that this would relieve the strain on Russia and cause the enemy

SKETCH MAP 9



Q.R. 6512, Geographical Section, General Staff, MO 1948

to withdraw forces from the Russian front. For success it depended partly on surprise, and partly upon the degree of opposition or otherwise which might be offered by the French in North Africa. The United States, unlike Britain, had maintained relations with the Vichy Government and, for political reasons, it was considered that an initial assault operation having an American bias would meet with more local support than one in which British troops were in the van. It was arranged, therefore, that U.S. troops should participate predominantly in the assault phase, and that the British Commander of the Eastern Task Force, on which the burden of the initial fighting was likely to fall during the subsequent advance into Tunisia, should not assume command until after the actual assault phase was ended.

The plans for the landings envisaged an Eastern and a Central Task Force which should both land inside the Mediterranean, and a Western Task Force which would land in the vicinity of Casablanca in French Morocco. Originally it was intended that the landings of the Eastern Force should extend as far east as Philippeville and Bone, so as to reach Tunis as quickly as possible. The proposed landings to the east of Algiers were, however, dropped out during the planning stage in view of uncertainty as to the probable extent of air opposition against shipping in the more easterly harbours.

The final plan called for assault operations as under:—

(a) Force based on the United Kingdom.

The Central and Eastern Task Forces were to land in the vicinity of Oran and Algiers respectively. The landing at Oran was to be undertaken entirely by U.S. Forces. At Algiers one British infantry brigade group and two commando formations were to land simultaneously with the U.S. 34 Division, with a British infantry brigade group of 78 Division in floating reserve.

(b) Force based on the U.S.A.

The Western Task Force, sailing direct from the United States, was to land at Casablanca or in the vicinity.

Following the initial assault, the Eastern Task Force, under its British Commander, was to move rapidly eastwards into Tunisia to capture Tunis and Bizerta and essential airfields on the way, together with the Algerian ports of Bougie, Philippeville and Bone.

Such was the operational picture for which survey planning was required.

Survey planning

The Geographical Section (War Office) had, during 1941, put in hand the preparation of map series covering French North Africa in anticipation of possible operations in that area. These mapping programmes, which are dealt with more fully in Section 2, were initiated in 1941 as part of the normal policy of map production, as far in advance as possible, for all likely operational areas. Such a programme of map preparation over wide areas, whilst providing insurance against a sudden emergency, acted also as security cover for the mapping of areas which were definitely required for impending operations.

In 1942, when plans for "Torch" became firmer, the North African mapping programme was intensified with all due security precautions.

Allied Force Headquarters (A.F.H.Q.) was formed in August, 1942, as an integrated British-U.S. planning staff under General Eisenhower, the Commander of the Allied Forces for the operation. For the first two months all map and survey matters were handled by an engineer officer on the staff of the American Chief Engineer. This was in accordance with U.S. Army practice, whereby survey was the responsibility of the Engineer Section, there being no provision made for a separate survey staff organization. The officer concerned had one technical serjeant allotted to him as his sole assistant for survey matters. Map planning was conducted by him partly by direct contact with the Geographical Section (War Office), and partly by contact with the D.D. Survey First (British) Army (Colonel R. P. Wheeler).

It soon became obvious that map planning requirements were growing rapidly and were outstripping the powers of one engineer officer. On 21st October, therefore the War Office appointed a British officer (Colonel E. B. Elkington) to assume survey duties at A.F.H.Q. At that time there was no authorized establishment for a separate survey staff but, about 1st November, another British survey officer joined him and, in the course of the next few weeks, a staff of British other ranks was collected consisting of one serjeant, one clerk, two computers and three draughtsmen. This small Survey Directorate, though part of the Engineer Section, looked after the rapidly growing requirements of A.F.H.Q. with regard to maps for planning, and made arrangements for the subsequent bulk shipments of maps overseas in successive convoys. For some considerable time the personnel remained almost wholly British.

For the British planning of the operation First Army Headquarters was formed, which held on its authorized establishment an Army Survey Directorate. Security being of vital importance it was decided to keep the British survey staff as small as possible during planning, so work was begun at corps level, with an A.D. Survey and a Corps Survey Directorate. Later this was increased to the authorized Army Survey Directorate, but the full establishment was not filled during the planning stage, as it was considered unnecessary to have too many individuals conversant with the planning details. Four officers, with Colonel R. P. Wheeler as D.D. Survey, and Lieut.-Colonel S. G. Hudson as A.D. Survey, together with four other ranks only, were employed on planning in London, and one officer and three other ranks were employed on the assembly of the bulk map stocks at a map depot at Swindon. These latter personnel were not aware of planning details, and worked entirely in code.

For security reasons the exchange of information and instructions between the War Office and D.D. Survey (First Army) was kept almost entirely on a verbal basis. The absence of recorded data has made it somewhat difficult to piece together the survey story of the planning and early operational periods.

Colonel Wheeler attended the regular conferences of the planning staff, and was thus enabled to keep abreast of the plans as they were unfolded, and so make provision with the War Office for the supply of the required maps and other survey data.

One of the biggest problems during planning was caused by the frequent changes in plans for the tactical loading of the ships. To maintain security it was essential that the troops should not open their maps and see where they were going until they had embarked and were well out to sea with no prospect of returning to port. In the first place, an attempt was made to allocate map consignments to ships to fit the actual units which were scheduled to embark on each ship. Constant changes in the loading plans, however, made this

impossible and in the end the only solution was to give each ship a reasonable complement of maps, according to its loading capacity, irrespective of the actual units which would embark thereon.

By an agreement dealing with spheres of mapping responsibilities throughout the world between the War Office and the U.S. War Department (*see* Chapter IV), the former was responsible for all matters relating to map design, grids, and initial production for North Africa, which fell within the British sphere of cartographic responsibility. In accordance with this agreement colour pulls, kodak film negatives, and other forms of reproduction material for all maps produced by the War Office in their areas of responsibility were sent over to Washington as they were published, so that map stocks could be printed there for supply to any U.S. forces which might proceed direct to a theatre of operations without passing through British map supply channels.

The map supply planning details for the Western Task Force, which was to proceed direct from the United States to the Casablanca area, were therefore entirely taken over by Washington. In the case of American formations in the Central and Eastern Task Forces, which would proceed direct from the United Kingdom, the map supply arrangements were in the hands of the Chief of the Engineer Intelligence Division at H.Q. European Theatre of Operations (E.T.O.) in London. This officer (Colonel H. Milwit), came over to England during the summer of 1942, and worked in very close touch with the Director of Military Survey at the War Office. Having ascertained the mapping requirements of the U.S. Forces taking part in the operation, he placed his demands with the War Office, and the latter arranged for printing and bulk supply of the necessary stocks.

The first phase. The race for Tunis and Bizerta (8th November to the end of December, 1942)

The initial landings having been successfully carried through, the role of First Army was to establish a base at Algiers and occupy Eastern Algeria and Tunisia as quickly as possible. To assist in this forward rush into Tunisia, U.S. units from Oran and Casablanca were sent forward piecemeal, and were at first operating under British brigade and divisional commanders.

The British force, forming First Army, was built up slowly as convoys arrived. The initial move towards Tunis was made by 78 Division and one tank regiment. Actually 78 Division was not complete till 1st December, and 6 Armoured Division by about 15th December. The later build-up included 46 Division which arrived early in February, 1 Division during March, and 4 Division in mid-April, and one Tank Brigade. Later still, when transferred from Eighth Army there were, in addition, 4 (Indian) Division, 7 Armoured Division, and 201 Guards Brigade with their divisional and administrative troops.

For some time the French would not agree to their troops coming under British command, but eventually a French corps operated as part of First Army. The American troops were organized as the U.S. II Corps.

During this first phase German forces were reinforced in Tunisia both by air and sea. The First Army lines of communication back to Algiers extended over 500 miles, the weather was very bad with heavy rains reducing all roads to a condition of deep mud, and the race for Tunis just failed.

The British survey organization during the early part of the campaign was as under:—

- (a) *Survey Directorate A.F.H.Q. (D. Survey—Colonel E. B. Elkington).* When D.D. Survey (First Army) left London for embarkation early in November, all matters relating to his survey units and map supply which remained outstanding were handed over to the Survey Directorate at A.F.H.Q. This latter, with the remainder of the Engineer Section, remained in England till 9th December when it embarked for North Africa. It consisted at that time of two officers (British), six other ranks (British), and one technical serjeant (U.S.). The ship on which Colonel Elkington was travelling was torpedoed on 21st December off the African coast, and he landed at Oran, proceeding to Algiers the following day, where he joined up with the Chief Engineer (U.S.) and the remainder of the Engineer Section. By this time D.D. Survey (First Army) was forward at Constantine, 518 Field Survey Company R.E. and the main part of 12 Field Survey Depot R.E. also being forward in First Army area. A small rear party of the depot, had, however, been left behind at Algiers, and this rear map depot then came under the control of A.F.H.Q. and was manned by personnel of No. 12 Depot until No. 7 Field Survey Depot eventually arrived from the United Kingdom.

The Survey Directorate, as part of the Engineer Section, was accommodated at Algiers, and remained there during the whole campaign.

- (b) *First Army Survey Directorate (D.D. Survey—Colonel R. P. Wheeler).* This was of the normal type and, in addition to the D.D. Survey, A.D. Survey and D.A.D. Survey, it had three captains (corps liaison officers) to work with 5 Corps (British), 19 Corps (French), and II Corps (U.S.). A small advance party consisting of one officer and three other ranks landed with the initial assault, their primary duty being to establish contact with the head of the French Service Géographique at Algiers, and to ensure that their survey records were protected from destruction. A.D. Survey and half the directorate followed by the second convoy, arriving on "D" + 4, the remainder arriving by third convoy on "D" + 14.
- (c) *518 Field Survey Company R.E.* This unit was of the normal corps type, and was equipped with the newly supplied demy-size printing machines and ancillary equipment mounted in special lorries. One topographical section reached Algiers by second convoy on "D" + 4, the remainder arriving by third convoy on "D" + 14.
- (d) *516 Field Survey Company R.E.* Also of normal corps type. This unit, under the original shipping arrangements, should have travelled complete in convoy KM.6. Unfortunately this was altered to KM.9 without the agreement of D.D. Survey after his departure from London, and it did not reach North Africa till February.
- (e) *12 Field Survey Depot R.E.* This unit, of standard type, had the function of holding and issuing map stocks and survey stores for First Army during the entire campaign. It went out by second convoy arriving on "D" + 4.

The Army Survey Directorate controlled all survey activities, including map supply, which might be required east of Algiers by British, American and

French forces. It always worked at advanced army H.Q. and, being responsible directly to the B.G.S. was thus fully acquainted with planning and operations at all stages. D.D. Survey maintained close touch with the operational and artillery staffs at Corps headquarters.

For the first three months the only units available were 518 Field Survey Company R.E. and 12 Field Survey Depot, the latter confining its activities to map depot duties. But for the outstanding efforts of these two units, the Survey Service would not have been able to carry out its responsibilities.

Until 18 Army Group was formed towards the end of February, 1943, First Army operated directly under A.F.H.Q., and the survey directorates at A.F.H.Q. and at H.Q. First Army formed the only organizations for survey and mapping control within the theatre.

The directorate at A.F.H.Q. which, until it was augmented and integrated in February, consisted only of the original small British party, had a full-time job. It dealt direct with the War Office on all matters of survey policy, bulk map supply, and the provision of new survey units. It also effected co-ordination of map stocks and supply, both British and American, over the whole theatre extending from French Morocco to the Tunisian battle zone. It assumed control over the map production resources of the French in Algiers, and established contact with the Middle East Survey Directorate in Cairo so as to arrange for the efficient sharing of the work of preparing maps and other survey data for Eighth Army which would later be entering the Tunisian battle zone.

First Army Survey Directorate remained responsible for the survey needs of all troops under First Army command, including American and French troops, and as the U.S. forces operating in eastern Algeria and Tunisia had no survey units of their own in the field until about February, 1943, they relied on the British organization with First Army to fulfil their needs.

A.F.H.Q. was responsible for map supply to all troops and other users outside First Army. This included the Air Forces and certain requirements of the Navy.

The map situation for the initial operations is dealt with in detail in Section 2. The map series which had been prepared by the Survey Directorate (War Office) comprised those on scales of 1/1,000,000, 1/500,000, 1/200,000 and 1/50,000, the latter series being incomplete. Production of these had begun during 1941 using copies of French maps in the War Office map library as basic material. The programme was intensified and bulk printing undertaken as soon as a definite decision had been taken to stage the operation. As already stated maps had been placed on board the ships going out in convoy for issue to the troops during the voyage. Bulk stocks were also shipped to form a first reserve with 12 Field Survey Depot in Algiers and the forward depots.

The leading British formations had therefore been provided with maps of Algeria and Tunisia for their eastward move after landing. The American troops who landed in Morocco and at Oran, and who were sent east to reinforce the British 5 Corps somewhat earlier than had been anticipated, had not been issued with any maps of eastern Algeria and Tunisia. To meet this emergency French civilian printing firms in Algiers were employed to print monochrome maps, and this just saved the situation, as the reproduction sections of 518 Field Survey Company did not arrive till "D" + 14.

Contact with the French Service Géographique in Algiers was first established by the small advanced party of the First Army Survey Directorate which accompanied the initial landing. Though they were willing to co-operate, there was a feeling of inertia during the first month. Thereafter they co-operated wholeheartedly and threw all their energies into assisting the Allied Force with the somewhat limited resources at their disposal.

518 Field Survey Company, which arrived at Algiers on 22nd November, detailed one topographical section to carry out surveys for the anti-aircraft defence of Algiers, moving on to Bone at the end of the month for similar work there. The other topographical section was at first employed assisting 12 Field Survey Depot to organize the map depot and sort out the map stocks. The drawing section at once began the revision of 1/50,000 maps of the Bizerta-Tunis area from whatever air photographs could be obtained.

The reproduction sections began work on 2nd December, their first task being the printing of 1/200,000 maps of Tunisia.

After installing their main map depot in Algiers, 12 Field Survey Depot established a forward depot, first of all at Bone, using sea transport, and then at Constantine. The transport of 518 Field Survey Company was used for a map convoy service between the main depot at Algiers and Constantine.

On 23rd December 518 Field Survey Company left its location at Menerville and moved forward to Condé Smendou.

The second phase (January, February and March, 1943)

During this phase, both sides in Tunisia were building up their forces, and were engaged in an attempt to hold or seize ground features of tactical importance for future operations. The Allies were struggling all the time to maintain and improve their long lines of communication which, owing to heavy rain and mud, were very precarious. Week by week Rommel's forces were being driven by Eighth Army further and further westward towards Tunisia.

The general line of contact between the Allied and German forces in Tunisia during this period extended roughly from Cap Serrat to Gafsa, with U.S. II Corps on the right, the French 19 Corps in the centre, and the British 5 Corps on the left. During January the enemy attacked frequently, mostly in the Bou Arada and Pont du Fahs areas, and late in February they penetrated the vital Kasserine Pass held by U.S. II Corps. The situation was restored and, by March, the American Corps staged an offensive to help Eighth Army in connection with its attack against the Mareth position. By early April contact had been made between the First and Eighth Armies.

Early in February it was obvious that the small British survey directorate, which had been functioning at A.F.H.Q. since the planning stage, was neither large enough nor suitably composed to deal with the developing situation. A proposal was therefore submitted by the Chief Engineer for the establishment of an integrated survey directorate. Approval for this was not granted until 10th April. In the meantime the work had to be carried on and, from January onwards, further British and American survey officers were being absorbed into the directorate. In the absence of an authorized war establishment they were either borrowed from units or acquired in other ways. Colonel E. B. Elkington had an American officer as his deputy. Other officer appointments were for the control of map production (British), air photos (U.S.), map distribution (British), and printing (U.S.).

Early tasks of the directorate included the development of contact with the French Service Géographique so as to utilize their limited mapping and reproduction facilities, including the use of civil printing firms in Algiers. Base stocks of maps had to be built up, including imported consignments from the United Kingdom and those printed locally by all means available.

In North West Africa, as elsewhere, there was a limited demand for photo-maps. These were nothing more nor less than half-tone lithographic reproductions of photo-mosaics, touched up to intensify roads and other detail, and carrying a grid. They were prepared by U.S. topographical units in the theatre, 62 Engineer Topographical Company and 951 Engineer Topographical Company being placed at the disposal of A.F.H.Q. for this purpose. The merits and demerits of these photo-maps are discussed elsewhere, and it is of interest to note that they were poor in quality and very little used, thus confirming the experience gained in other theatres.

Towards the end of February 18 Army Group H.Q. was formed, under A.F.H.Q. control, to co-ordinate the operations of the First and Eighth Armies. This brought about certain changes in survey organization. Colonel R. P. Wheeler was appointed D.D. Survey 18 Army Group, being succeeded as D.D. Survey First Army by Colonel S. G. Hudson who had hitherto been his A.D. Survey.

516 Field Survey Company R.E. arrived from the United Kingdom at the beginning of February, and moved to Draa. One topographical section was assigned for survey duty with U.S. II Corps, as the topographical unit belonging to that corps, 62 Engineer Topographical Company, was not yet available. It there joined up with one topographical section of 518 Field Survey Company which, having been moved from the map depot to Bone for anti-aircraft surveys, was also assigned to II Corps (U.S.). These two sections remained with the corps working in conjunction with the field observation battalion until 62 Engineer Topographical Company was ready to take over, towards the end of March. No. 1 topographical section of 516 Company then went into 19 Corps (French) area, and No. 1 topographical section of 518 Company moved up into 5 Corps area along the line Beja-Medjez el Bab. Meanwhile No. 2 topographical section (516 Company) carried out surveys for anti-aircraft defences at Bougie until about the middle of March, when it was withdrawn for employment on air-photo revision. The drawing and reproduction sections of the two field survey companies were employed on map revision, the preparation of special large scale battle maps, and the reproduction and printing of large numbers of maps for the fighting troops and for staff use.

A detachment of 12 Field Survey Depot, which had moved forward from Algiers to Constantine, opened an advanced map depot at Souk Ahras early in March, with a view to the move forward to that location of the whole unit during April. Arrangements were made by A.F.H.Q. for a map depot detachment (U.S.) to be organized to take over the premises at Constantine so as to operate it on behalf of the U.S. Eastern Base Section.

Three new British survey units reached the theatre towards the end of March. No 7 Field Survey Depot R.E. took over the depot in Algiers, the rear details of No. 12 Field Survey Depot then rejoining their own unit in First Army area. Nos. 11 and 12 Map Reproduction Sections, with their double-demy printing equipment, moved out to Chebli, about 20 miles south of Algiers.

By the end of January the American topographic organization, apart from the element with the survey directorate at A.F.H.Q., was as under:—

(a) *With the Mediterranean Base Section. Oran (Algeria).*

No. 62 Engineer Topographical Company really belonged to II Corps which was forward in the battle zone. The personnel of this unit, while completing their training for survey duties in the field, were being used on various engineer survey duties. Although they had equipment adequate for field survey work, their printing presses and stores had not arrived. The unit moved forward to join II Corps in March.

The map supply depot at Oran was in good working order. It supplied the needs of Fifth (U.S.) Army H.Q., which had been lately formed, and also the 12 U.S. Army Air Force. There were no lithographic printing facilities available in Oran, either military or civil.

(b) *With the Atlantic Base Section. Casablanca (Morocco).*

No. 66 Engineer Topographical Company belonged to I (Armoured) Corps which, though still at Casablanca at the end of January, was due to move shortly. This unit was fully trained and equipped and ready for the field. The drawing and reproduction sections were engaged on mapping work of local areas, and the survey section was working on engineering surveys.

No. 951 Engineer Topographical Company (Air) formed part of 12 Army Air Force.

Maps were being supplied from three depots:—

Atlantic Base Section (A.B.S.) depot.

12 Air Force depot.

I Armoured Corps depot.

This led to a good deal of uneconomical working, so all bulk stocks were turned over to the A.B.S. Depot.

66 Engineer Topographical Company had its reproduction plant in good shape and carried sets of kodaline negatives of the local map series. There were no local lithographic printing facilities in Casablanca, though at Rabat the Institut Géographique National had three old flat-bed presses. There was a base supply depot which was in good working order, but it held little in the way of survey stores for map reproduction.

(c) *At A.F.H.Q. 649 Engineer Topographical Battalion (Army) was expected to arrive from the United States about the middle of April.*

Proposals were submitted to Washington, through the French rearmament commission, for the re-equipment of the Service Géographique in Algiers, and for the supply of expendable stores. A French officer was appointed to act as liaison officer at A.F.H.Q. so as to keep in close touch with mapping and other requirements which might be passed to the Service Géographique for execution.

During the early stages of the campaign the only photographs available were those taken on reconnaissance sorties, mainly by American "Lightning" aircraft. Some of these sorties were used for map revision purposes, but were not up to the necessary specification for new mapping. A discussion was held at Algiers on this subject which was attended by D. Survey, Middle East, and also by Colonel Milwit, the head of the U.S. Engineer topographical branch who was visiting from London. A long-term photographic programme was drawn up and requests were submitted for the provision of suitable aircraft and other equipment for air survey purposes.

The final phase (April–May, 1943)

Operational background. The final phase was a period of offensive action. Starting with the First Army counter-attack at Djebel Abiod at the end of March, it ended with the final destruction of the Axis forces in Africa in the middle of May. The month of April was occupied in achieving certain essential advances, and the capture of important features which would not only act as a strong base for the final operation of overpowering the enemy forces and capturing Tunis, but would also free certain vital lines of lateral communication. This was necessary in order to facilitate the build-up of dumps of supplies and ammunition, and to permit the regrouping of important formations from one flank to the other. Operations in the south had, as their main object, the harassing of Axis forces retreating in front of Eighth Army.

The orders for the final offensive, which was to start on 22nd April, were issued by 18 Army Group on 12th April. For this operation First Army consisted of the British 5th and 9th Corps and the French 19 Corps, with 1 (British) Armoured Division, 139 Infantry Brigade Group, 1 King's Dragoon Guards, and 51 Royal Tank Regiment in Army reserve. The II (U.S.) Corps remained under H.Q. 18 Army Group though H.Q. First Army was responsible for co-ordinating its action with that of First Army, and for issuing all necessary orders. The switching of formations from one flank to the other and the preparation for a heavy artillery battle involved Survey in extensive programmes of map supply and distribution and the carrying out of field surveys over wide areas in conjunction with artillery survey units.

Eighth Army was to attack at Enfidaville on 20th April with the intention of drawing off enemy forces from First Army.

This final operation lasted from 22nd April until 12th May by which date the Axis forces had been completely defeated.

Survey Organization.—Even though First Army itself was built up piecemeal, it grew with an increasing momentum which outstripped its survey capacity and the full survey order of battle for the force was not complete until A.F.H.Q. had obtained its base survey units and developed local printing resources. Until then First Army had to carry rather more than its own share of the survey work within the theatre. When supported by base survey units and local resources under A.F.H.Q. control, the survey strength of First Army was just about sufficient to compete with an army of four corps, but with little margin for maintenance and rest. Differences of nationality naturally added to the difficulties. The British units, in accordance with current policy, operated under army control, and the 5th and 9th Corps had no survey directorates or survey units. The French 19th Corps had no survey units at any time, but its map demands were lighter than those of British corps, being equivalent to that of about one British division. The U.S. II Corps had two survey units of its own, one being an engineer topographical company and the other a corps observation battalion of artillery. These two units only became available to II Corps during the later stages of the campaign, which meant that British units had to do survey work in the U.S. II Corps and French 19 Corps areas as well as for the British 5 and 9 Corps. Owing to losses of equipment in transit, casualties during operations and, to some extent, lack of sufficient training, II Corps was never fully self-supporting from a survey standpoint. The result of this was that the British units had to be employed in an uneconomical opportunist role, controlling and strengthening the artillery survey

work in those areas where a battle seemed imminent. Eighth Army entered Tunisia with a fully manned survey order of battle. It never had to deal with more than two corps, and there was never any doubt that its survey capacity was fully equal to compete with its tasks. On 10th April, the integrated A.F.H.Q. survey directorate, which had for some time been functioning with borrowed personnel, was legalized by the approval of its war establishment. The three new British units (7 Field Survey Depot, and Nos. 11 and 12 Reproduction Sections) had arrived and were working as base units directly under A.F.H.Q. In the absence of a proper survey stores depot, which did not reach the theatre till June, No. 7 Field Survey Depot had to handle stores as well as maps.

62 Engineer Topographical Company having moved forward to join II Corps in the battle zone, 66 Engineer Topographical Company and 951 Engineer Topographical Company (Aviation) were lent to A.F.H.Q. for map production and printing. By this time a few civilian printing firms in Algiers were being used, and arrangements were in hand for equipping the French Service Géographique with equipment and stores from the United States.

On 14th April 649 Engineer Topographical Battalion (Army) reached Oran from the United States and provided a welcome increase of mapping strength at A.F.H.Q. Its reproduction train and Multiplex plotting equipment did not, however, arrive until later. It was accommodated at Fouka.

Colonel S. G. Hudson succeeded Colonel Wheeler as D.D. Survey First Army and had at his disposal the following survey units:—

518 Field Survey Company R.E., which had been with First Army from the start.

516 Field Survey Company R.E., which arrived from the United Kingdom on 1st February.

12 Field Survey Depot R.E., which had been available since shortly after "D"-day. This was of the standard type, with one officer, 18 other ranks and one lorry only.

Owing to the needs of A.F.H.Q., the First Army Survey Directorate was always one officer short. This was a serious disadvantage, seeing that survey liaison was required with 5 (British) Corps, II (U.S.) Corps, 19 (French) Corps and, in the later stages, 9 (British) Corps as well.

Colonel V. E. H. Sanceau was D.D. Survey Eighth Army with the following units at his disposal:—

517 Field Survey Company R.E.

46 South African Survey Company S.A.E.C. This unit had the field and drawing strength of two normal British field survey companies.

20 Field Survey Depot R.E., which was of the larger type developed in Eighth Army. It consisted of about 60 all ranks and sufficient transport to provide for a main depot, a mobile forward map depot at or near Army H.Q., and a map lorry with the H.Q. of each corps and division. It had been evolved as a result of experience in Eighth Army operations, and was based on a revised conception of map-distribution responsibilities which was accepted for practically all subsequent operations in Europe.

Field Survey activities. These are described more fully in Section 3, some of the major aspects only being considered here.

One of the principal tasks during this last phase was to establish a third-order control for artillery operations during the battle which opened on 7th April to clear the enemy positions in the mountainous area Sidi Nsir-Oued Zarga-Medjez el Bab, as a preliminary to the main final offensive. To enable this work to be done, the topographical sections of 518 Field Survey Company had been moved to Beja on 15th March to establish control on the North African grid before the end of the month. This was done in the area from Beja towards the north-east as far as possible along the road to Sidi Nsir, and also between Beja and Oued Zarga. One topographical section was, for this operation, attached to each survey troop of 5 Survey Regiment R.A., and the co-operation between R.E. and R.A. surveys appears to have been admirable. The topographical sections carried the control forward to keep pace with the advancing battle in face of enemy opposition and other difficulties such as minefields.

The establishment of trig control in 19 (French) Corps area was effected by one topographical section of 516 Field Survey Company in conjunction with the Army Group R.A. On completion of this task on 9th April, this section moved into 5 Corps area to carry out preparatory surveys for the final offensive. This was completed by 21st April, when one section moved north to near Grenadier Hill and the other section went into reserve.

On the completion of the preliminary surveys along the First Army front, three topographical sections were attached to 5 Survey Regiment R.A. for work in the following areas:—

One section (518 Field Survey Company) from Medjez el Bab towards Longstop Hill.

One section (518 Field Survey Company) around Medjez el Bab and towards Grich el Oued.

One section (516 Field Survey Company) in the Grenadier Hill area.

As soon as sufficient ground had been gained by the attack begun on 22nd April, each section carried the triangulation forward, and sufficient points were established to control the great concentration of artillery used for the offensive of 5th–6th May. The advance after that date was so rapid that the topographical sections had practically no further calls made on them.

After the cessation of hostilities in Tunisia on 12th May all topographical sections were employed on anti-aircraft surveys at Bone, Bizerta and Tunis.

SECTION 2. MAPS AND MAP PRODUCTION

Preparations by the War Office

During 1941, the G.S.G.S. initiated the preparation of certain map series covering North West Africa. Although, at that time, the possibility of undertaking a landing operation on the Moroccan or Algerian coasts was in the discussion stage, there was no set plan. The production of the maps concerned offered, in any case, not only an insurance against such a possible operation in the future, but helped to draw attention from other areas of more immediate strategical importance for which maps were also being produced, thereby providing a certain amount of security cover.

When, therefore, it was decided during 1942 to plan intensively for operation "Torch," the mapping programme was already well ahead and had just to be given more priority and enlarged in scope.

The following map series were amongst those produced for the campaign in its early stages:—

- Africa. 1/2 M showing air information.
1/M based on the International Series.
- French North Africa. 1/500,000 covering all Morocco, Algeria and Tunisia.
- Algeria. 1/200,000, extending east to the Tunisian frontier.
1/50,000 (incomplete) covering a strip along the coastal region from French Morocco to the Tunisian frontier.
- Morocco. 1/200,000, covering both French and Spanish Morocco.
(French) 1/50,000 covering the whole coastal region with partial coverage inland.
(Spanish) 1/50,000 covering the whole country.
- Tunisia. 1/200,000 covering the whole country.
1/50,000 covering northern Tunisia only.
1/100,000 covering rather more than the southern half of the country.

There were also town plans of the principal ports and larger inland towns.

Comments on the above maps

The basic material from which the maps were produced consisted of copies of French maps which were held in the War Office map library. They were reproduced by a method of photographic colour separation, thus eliminating the immense labour and time which would have been entailed by the preparation of new drawings. The original French sheets had been printed in several colours and, for economy in printing time and labour, it was decided to reproduce the maps in three colours only, rising to four in certain cases.

As a result of representations from the Royal Armoured Corps, it had been decided to show all roads and tracks on the 1/50,000 series (and very nearly all on the 1/200,000 series) by adding a red road filling, however low their classification. A system of firm lines, pecks and dots was introduced to provide adequate differentiation, and this system was fully explained in the normal type of reference panel. In spite of the fact that the information was there for those who sought it, the resulting maps tended to give such a flattering picture of the road communications "at a glance" that they became the subject of bitter complaint, and the cause of faulty tactical planning. In any theatre such a policy of road classification has not much to recommend it when it is divorced from the special "Going" maps. In a theatre where communications suffer seasonal deterioration, it may be considered dangerously misleading. To the British, "red" roads mean "all weather" roads, and it takes more than a reference panel to destroy this illusion.

The 1/500,000 map was very out of date, and was not used to any extent by the Air Forces. Their tasks required them to use a larger scale map as issued to the ground forces.

The 1/200,000 map, apart from the misleading road classification, was popular, and was an excellent colour reproduction. The large number of colours on the original French sheets was reduced, for military purposes, with little loss of clarity.

The 1/50,000 map was not very popular mainly because of the poor reproduction of detail which was finely drawn on the French sheets. Also the road

information overprint placed too much emphasis on minor tracks and paths. When this map was reprinted locally by First Army survey units the red overprint was simplified so as to give a truer representation of the communications.

Early mapping activities after the landing

It did not take long to find out that many of the maps initially provided were out of date and, after arrival in the theatre, the First Army Survey Directorate took immediate steps to secure the most modern local editions of the French maps of Algeria and Tunisia.

An urgent demand for local map printing arose about "D" + 7, some days before the printing sections of 518 Field Survey Company were due to arrive. Certain American formations were sent east from Oran and Casablanca to reinforce First Army for their drive into Tunisia. They had not been issued with maps of eastern Algeria and Tunisia on board ship on their way out, and urgent action was therefore necessary to produce maps for them. Early contact with the French Service Géographique enabled civil printing firms in Algiers to be employed, and a special photogravure edition in monochrome of the relevant map sheets was quickly run off. The grid was superimposed lithographically.

518 Field Survey Company R.E. arrived on "D" + 16, and provided the only source of military map printing with First Army until 516 Company landed early in February. One of the first tasks given to 518 Company was to revise the 1/200,000 and 1/50,000 maps of northern Tunisia, using the more up-to-date French maps and any air photographs that could be obtained. The size of the unit's printing machines being "demy," it was necessary to divide the 1/50,000 sheets in two parts, and print them back to back on both sides of the paper. The 1/200,000 sheets were also printed in pairs, back and front of the paper.

Allocation of mapping responsibilities to the Service Géographique in Algiers

The printing resources of the Service Géographique were almost negligible but, at A.F.H.Q. request, they were able to arrange for various civilian printing firms in Algiers to be made available for map printing.

During March a conference was held to consider the most suitable allocation of work to the French organization, and the following was agreed:—

- (a) The Service Géographique would relieve First Army of much of the routine mapping of Tunisia and eastern Algeria, so that First Army could undertake the more special and urgent battle commitments that were becoming increasingly necessary.
- (b) The Service Géographique would undertake the production of ground/air style editions of the 1/M International series of areas in south-western Europe.
- (c) It would also undertake the revision of communications on sheets of the 1/500,000 map of North Africa and the production of a new edition.

Map production resources with U.S. Topographical Units

The shipment from the United States of some of their reproduction equipment was somewhat delayed. It was not until February that 62 Engineer

Topographical Company could be sent forward to join II Corps in the battle zone. Before that date both 62 Company and 66 Company (which really belonged to I U.S. Armoured Corps) were temporarily placed at the disposal of Survey Directorate at A.F.H.Q. for urgent mapping tasks, together with a Topographical Company (Aviation) which was operating with the 12th U.S. Army Air Force.

The 649 Engineer Topographical Battalion (Army), with its extensive mapping and reproduction resources, including Multiplex plotting equipment, only arrived in the theatre towards the close of the campaign.

On reaching II Corps in February the reproduction platoons of 62 Topographical Company were offered to D.D. Survey First Army but he was not able to make proper use of them as they were still deficient of important items of equipment, and were often wholly engaged on the production of photo-map substitutes, and in meeting the local needs of II Corps for Intelligence overprints, etc. It would have been useful, from the Army point of view, if it had been possible to brigade the reproduction platoons with the printing sections of the two British field survey units, but this was not feasible.

British map production resources

Within First Army 518 Company was available from about "D" + 16 and 516 Company from early February. To provide A.F.H.Q. with adequate map printing power 11 and 12 Map Reproduction Sections R.E. were sent out by the War Office, arriving towards the end of March.

When Eighth Army entered Tunisia, and thereafter came under the control of 18 Army Group and A.F.H.Q., it brought with it 46 South African Field Survey Company and 517 Field Survey Company R.E., both of which had mobile reproduction sections of the normal type.

Operational mapping tasks undertaken by 516 and 518 Field Survey Companies R.E.

When planning for the final offensive in Tunisia it was necessary to ensure that all essential maps for such an operation would be ready. Amongst other things this entailed the preparation of a large number of 1/25,000 maps on which to overprint enemy defences and other information.

These 1/25,000 maps of Tunisia were produced by First Army survey units. There was no existing French series on this large scale, and as no survey photography could be obtained which would be suitable for new large scale mapping, it was necessary to utilize, as basic material, the French 1/50,000 series which was of good quality. The detail was enlarged photographically, and revision was incorporated from air photographs taken for intelligence purposes. The scale of these photos varied from about 1/12,000 to 1/50,000, and there were varying tilts and overlaps, and large gaps in the coverage. A small party of topographic draughtsmen was attached to the Army Photo Centre to collect revision information from its library set of photographs.

Over 80 of these 1/25,000 sheets were produced and they were overprinted to show enemy defences. They were published in two stages. A first edition was issued somewhat in advance of the battle, bearing such intelligence information as was then available. A second edition was then usually produced immediately before the operation, containing the most up-to-date information.

In some cases third and fourth editions were produced, but these were exceptional, as time was rarely available.

The General Staff (Intelligence) at Army H.Q. accepted responsibility for all overprint information whatever the source, and no attempt was made to short-circuit the normal channels by going to corps or divisions for information.

Survey, however, accepted responsibility for the positioning of the information on the maps, and for this purpose, a small R.E. survey detachment was attached to the Photo Centre, where it had access to the latest photos.

The reproduction sections of both 516 and 518 Field Survey Companies were kept busy at full stretch on the production and printing of these 1/25,000 maps right up to the cessation of hostilities though, towards the end, the campaign was going so fast that it outran the need for maps on that large scale. Their other main task was the reprinting of the 1/200,000 and 1/50,000 series of Tunisia for stock.

When at full pressure each unit was turning out 1,000,000 or more impressions each month.

For the heavy artillery concentration in the Medjerda Valley before the final thrust it was decided to produce a "barrage overprint." An officer and a draughtsman from the Army Survey Directorate went to H.Q. 9 Corps R.A. in the evening, the draughtsman drew the overprint trace on the spot, and it was flown down to 516 Company, located further back. The required number of copies were run off on previously printed base maps and flown forward to the artillery.

Air survey photography

The arrangements, or perhaps one might say the lack of arrangements, for the provision of air-photos for mapping purposes followed the general pattern familiar in most other theatres during the early stages of operations. Resources for such work were non-existent at the beginning and, when a limited attempt was made, much too late, to provide photos for survey purposes, unsuitable types of aircraft were used. As has been stressed so many times in so many places, survey photography for use in connection with mapping is required as early as possible, otherwise there will be little or no time to utilize it for either new compilation or revision.

In the case of First Army, D.D. Survey passed his demands for survey photos to G/Air at Army H.Q. Where this demand was for new photography, the result was negligible. The demand was added to a waiting list which was sorted out into daily priorities. Almost invariably the survey demand remained in the lower half of this priority list, and there was no direct liaison between Survey and the photographic squadron.

In Eighth Army the situation was better. After obtaining approval from the B.G.S. at Army H.Q., D.D. Survey submitted his demands through the R.A.F. Wing to the survey squadron. This worked well with the minimum of delay. It must be stressed, however, that one reason for the better results with Eighth Army, quite apart from the improved routine procedure which had grown up during some months of active operations, was the fact that they had two Mosquito aircraft on the job, which were ideal for survey photographic work. First Army had no such aircraft. There is no doubt also that, as a result of their operational experience, Eighth Army were more fully conscious

of the need for, and the value of, survey photography if they were to get newer and better maps.

In First Army, practically no strip photography was undertaken for map revision, whereas, for the Eighth Army operations in southern Tunisia, successful strip photography was carried out north of Mareth, at the Skhirra Gap, and north of Enfidaville.

It was unfortunate that during January, February and March, 1943, the temporary airfields in First Army area were in such a condition owing to heavy rains that most of the fighters were grounded. The enemy had temporary air superiority by flying off the permanent airfields at El Aouina and Ste. Marie du Zit. All photography carried out by First Army had of necessity to be of the hit and run type, and even a Mosquito on strip-flying for survey photography would have been operating against heavy odds.

Air-photo revision and overprint information

As a result of the late start made regarding the supply of air photos for First Army, it was obvious that the limited air photographic resources could not supply special photos for map revision as well as for daily Intelligence needs. To make the best use of all the photo material available some survey draughtsmen were attached to the Army Photo Centre when it moved forward from Algiers and was established near Army H.Q. in the middle of March. Photography was provided by a few Lightning aircraft fitted with two 24-inch and one 6-inch cameras, operating from an airfield adjacent to the photo centre. The functions of these draughtsmen were:—

- (a) To keep up to date cover traces of the photographic sorties.
- (b) To revise the 1/25,000 sheets as photos became available.
- (c) To keep up to date defence information traces for the 1/25,000 sheets. This information was then overprinted on the maps, adopting the conventional signs in use at the R.A.F. Central Interpretation Unit at Medmenham in the United Kingdom.

The problem of interpretation from air photos for mapping purposes seems to have had its difficulties in both First and Eighth Armies. For some time the D.D.s Survey in both armies appear to have accepted, for the position of defence and other overprint detail, the map references which had been given by the personnel of the Photo Intelligence Unit in their interpretation reports. In other words they were dependent on the A.P.I.U. interpreters to give position as well as the qualitative annotation of enemy defences, a procedure which clearly could not be expected to give results up to the required standards of survey mapping accuracy.

First Army decided to detail some of their trained air-photo plotters from the survey units to work with A.P.I.U. and do the actual positional plotting. This certainly opened the door to greater accuracy of results, but it is open to some doubt whether it was the best way of attaining such a result. It is possible, for example, that it might have been preferable for a survey unit to have been located close alongside the interpretation unit so that the survey personnel could have done their work under their own officer supervision. A different method was adopted in Eighth Army. There the normal personnel of A.P.I.U. prepared the defence overprint traces and Survey acted only as a printing agency. The latter prepared the base maps, and overprinted

on them the defence information, for which they bore no responsibility for the correctness, completeness or legibility.

This question of the preparation of defence overprints, using information supplied by photo interpretation units, is one which requires careful consideration.

Photo-maps

Photo-maps, or photo map-substitutes as they were often called, were produced in large quantities by American topographical units in North West Africa to cover:—

- (a) Parts of southern Tunisia, for which the largest scale maps available were 1/100,000.
- (b) Parts of Tunisia for which there already existed maps on the scale of 1/50,000 and even 1/25,000.

The first issue included sheets covering the Gafsa-Sfax area. They provided a uniformly grey representation of wide open spaces, on which a town was almost impossible to identify, and on which roads and railways were indistinguishable. They were gridded with a fictitious grid numbered in metres but not computed from any particular origin. Except for the fact that they covered an area for which the largest scale map available was 1/100,000 they were generally considered to be quite useless.

The second lot were of better quality, but within a few days of issue, practically the whole stock had been returned to salvage by II Corps who found no use for them.

It would appear from the evidence that, although there probably was, and always will be, a need by regimental officers and staff alike for good copies of up-to-date photographs, the wholesale production of photo map-substitutes covering large areas which have already been adequately mapped and revised is a wasteful use of resources in both labour and materials.

SECTION 3. TRIANGULATION AND FIELD SURVEYS

Triangulation data

Algeria. Before the landing in North West Africa the only trig data available for Algeria were a limited amount covering the principal port areas, which had been obtained from Washington. Unfortunately the lists had been reproduced by methods which were not dependent on facsimile photographic copying, and were full of errors. After the landing the complete trig data for Algeria were obtained from the French Service Géographique in Algiers. They were in manuscript, and were more comprehensive than the American version. These data were photographed but never reproduced, as the battle zone had by then moved forward into Tunisia.

Tunisia. At the opening of the campaign the survey data for Tunisia available to First Army consisted of:—

- (a) Photographic copies of the French fascicules giving the geographical positions of trig points in grades (longitudes referred to Paris), their heights in metres, and descriptions of the marks.

- (b) A printed booklet prepared by the War Department (U.S.) containing the above data converted to degrees with longitudes referred to the Greenwich meridian, with the addition of further points on or near the coast derived from hydrographic surveys.

Full details of the Tunisian triangulation were secured by the survey reconnaissance officer who went ashore from the first convoy during the initial landing. The data were contained in fascicules giving first-, second-, and third-order points. The descriptions were poor, but there were valuable observation diagrams. The data were republished by First Army on a 1/200,000 sheet basis.

The French triangulation in Tunisia had been observed between 1888 and 1907, was well designed and rigid, and was found to have a much higher order of relative accuracy than was at first supposed. Rarely did a tertiary point fail to check up within a metre or two when included in a scheme based on higher value points. Each tertiary point had been fixed independently from points in the primary and secondary nets, though the rays so used appeared to be longer than was necessary.

The points were well marked, and could easily be located from the 1/50,000 map. The signals were in the form of tall cylindrical stone cairns, and in the case of primary and secondary stations there was a central mark consisting of a masonry pillar about three feet high and 18 inches square. A large number of "up" stations were in the form of minarets and other prominent features which were fixed by intersections, and they made admirable trig points.

The triangulation density averaged one station to 12 square miles, and was fairly evenly distributed over the whole of northern Tunisia. On the whole, therefore, the existing French control was readily available and reliable though for artillery purposes, and for large scale mapping, it needed exploitation and breaking down to more readily accessible points along the roads and valleys.

The use of the trig data in the field

In the battle zone, where operations became temporarily static on the Medjez-Gafsa line, 1/200,000 sheets were provided for the artillery and engineer survey units with the positions of the trig points clearly marked in the form of an overprint. The points were numbered to correspond with the numbering of the trig lists. Generally speaking, there was so much triangulation control, and its quality was so good, that the artillery survey regiments could resect their position almost anywhere from five or six points, and there was little demand on R.E. Survey for help, except during the final battle when R.A./R.E. Survey co-operation was most successful.

Italy, Sicily, Sardinia, and Corsica

In anticipation of subsequent operations which might be undertaken in the above areas A.F.H.Q., with the assistance of First Army Survey units, G.H.Q. Middle East, and the French Service Géographique, undertook the preparation of trig lists involving the conversion of trig co-ordinates from French and Italian lists to the appropriate military grid systems.

Grid Zones (see Diagram 2)

The theatre of operations, including Morocco, Algeria and Tunisia, was covered by the North West Africa Grid Zone, which had junction with other zones as under:—

In the north, with the Iberian Peninsula and southern Italy Zones, the line of junction being in the Mediterranean Sea.

In the north-east, with the southern Italy Zone.

In the south-east, with the Libya Zone, roughly along the frontier between Tunisia and Libya.

The co-ordinate values of points in the original lists obtained from French sources had, of course, to be converted into terms of the North West Africa grid so as to agree with the map. This work was shared by A.F.H.Q., First Army, and the Middle East Survey Directorate. The first conversions were urgently required for use on the anti-aircraft defence surveys round Algiers, Bone, Philippeville, and other ports, and for fixing naval radar direction-finding stations.

There was some confusion at first owing to the fact that two versions were current for the longitude of Paris *viz.*:—

G.S.G.S. (War Office)	02° 20' 13.95"
U.S. Value	02° 20' 14.18"

For a short time First Army used the latter, but soon abandoned it in favour of the G.S.G.S. value so as to ensure that co-ordinates obtained should be in sympathy with the G.S.G.S. map grid.

Field surveys by British units for II (U.S.) Corps

In the middle of February, arrangements were made to give survey assistance to II Corps in the areas Faïd-Sbeitla-Feriana-Gafsa, on the southern flank of the allied line. At that time the full American survey organization had not been deployed. The work required was mainly to fix medium and heavy artillery positions, to check the trig list data, and to establish a general framework control for future mobile operations.

One topographical section of 518 Field Survey Company started work in the forward area on 17th February, but had to move back to the hills north-west of Feriana-Kasserine almost at once as a result of aggressive enemy action. They then supplied position and azimuth for artillery units in the area Bou Chebka-Dernaia-Bekhara Pass.

Early in March a second R.E. topographical section reinforced the first and, with the observation battalion of the corps field artillery which had just arrived, they were grouped for surveying the positions of control points along the Kasserine-Sbeitla road to form the basis on which 1/25,000 fire control charts were constructed. These charts were printed by the U.S. Engineer Topographical unit, and were used in much the same way as the British artillery boards. Similar work was done along the Dernaia-Feriana road in preparation for an advance.

The above tasks were carried out in areas which had been recently in enemy occupation, and the survey parties were greatly hampered by anti-personnel mines, anti-tank mines, and booby traps. As testified by the American artillery commander, both sections of 518 Field Survey Company did most meritorious work.

Co-operation with artillery survey units

The R.E. survey units were first employed to assist the artillery in February, 1943, when requests were received that several divisional grids, which had been

established by 5 Survey Régiment R.A., should be put on to the theatre grid. The divisional grids had been kept true to the theatre grid bearings by means of solar azimuth observations, and required little correction for scale and position. The artillery were supplied with conversion factors to enable them to transfer their points to the theatre grid.

During the course of the work, a procedure of close co-operation grew up on the ground between the R.E. and R.A. survey units, and this was intensified during the First Army offensive during April.

The R.E. field surveys took place in three distinct phases:—

Phase I. Checking and breaking down the triangulation in the area of proposed operations, and carrying points forward as far as possible along the probable lines of advance through the valleys.

Phase II. Supplying control points and trig bases for use by artillery surveyors in areas which were not already within the divisional grid surveys.

Phase III. After the initial bombardment, when the artillery moved forward to new positions, the R.E. sections provided quick temporary fixations ahead, sufficient for immediate use, strengthening them later on by tying into the ruling triangulation, thus providing sound data for possible further advances.

During Phase I the topographical sections, up to three or four in number, worked under the control of First Army Survey Directorate. For Phases II and III one section was attached to each survey troop R.A. and one to the headquarter survey section of 5 Survey Regiment.

Procedure varied according to circumstances. Sometimes the R.E. surveyors manned the control base, and observed points ahead that had been selected and occupied by R.A. surveyors, the latter calling up by helio or lamp. The observed angles were sent by despatch rider to the R.A. computing centre. It was necessary to reduce to the minimum the movement of observing trucks owing to the heavy mining of the roads.

At other times the R.A. surveyors occupied the control base, sometimes fixing it themselves, and had a grid bearing thrown in by the R.E.

The area covered in Phase I extended from Beja through Medjez el Bab to Bou Arada, on a front of about 50 miles, and the triangulation consisted of a belt about 5 to 11 miles wide. The work of each section was carefully maintained in sympathy with the ruling triangulation. This phase lasted from about 20th March to 20th April.

Meanwhile Phases II and III were fitted in as found convenient and necessary; first of all in the Beja-Oued Zarga areas where the artillery offensive began on 7th April, and later for the Medjez el Bab offensives on 22nd April and 5th–6th May. When the swift advance of First Army took place between 7th and 12th May, survey control had been carried only about ten miles from the original front. The R.E. sections went forward with the R.A. survey units, but little work was called for before hostilities ceased on 12th May.

Though, no doubt, the expedient of attaching R.E. topographical sections to R.A. survey units was desirable in the circumstances which prevailed, it neither conformed to the basic organization of R.E. survey units nor did it absolve the D.D. Survey from his responsibilities for co-ordinating R.E. and R.A. surveys on the Army front, and for using the R.E. survey units to the best advantage of the Army as a whole.

SECTION 4. MAP SUPPLY AND DISTRIBUTION

Introduction

Operation "Torch" was the first of its kind, involving amongst others the following important factors:—

- (a) Intensive allied planning, with very limited time available between the start of planning and "D"-day.
- (b) The vital need for the highest security precautions.
- (c) The embarkation of British and American forces in British ports, and the subsequent issue to them of their operational maps for the assault landings while on voyage.
- (d) The simultaneous embarkation of American forces in U.S. ports, and their map issues, also under security conditions.
- (e) Map provision for:—
 - (i) The initial landings.
 - (ii) Formations to whom were allotted particular tasks, *e.g.*, the armoured brigade landing at Bone, and the airborne troops.
 - (iii) The development of operations eastwards into Tunisia.
 - (iv) The occupation of Morocco and Algeria in the face of possible French resistance.

Initial assembly of map stocks

As soon as a survey directorate had been established with H.Q. First Army for planning purposes, one officer and three other ranks were detached for duty at one of the War Office map depots to assist in the assembly of map stocks which would be required for the operation. Although the matter will be treated in greater detail below, it should be noted here that, during the planning period, this small party had no knowledge as to the area in which operation "Torch" would take place. They worked entirely in code, handling sealed rolls of maps as they were delivered from the printers.

Apart from those maps which were required by the planning staffs, the stocks which were assembled at the map depot were for disposal as follows:—

- (a) For issue in sealed and coded bundles to the personnel in the ships of the "Torch" convoys, for use by assault troops.
- (b) For loading on ships, packed in sealed cases, for subsequent use as formation and depot reserve stocks in North West Africa.

Security precautions during production and initial distribution

The security aspect in connection with the mapping up of any military force for an operation is of such vital concern that no excuse is offered for describing in some detail the steps that were taken, and the difficulties encountered, during the preparations for "Torch." When initiating the necessary measures for maintaining security and preventing leakage, the Director of Military Survey at the War Office kept in close touch with the Inter-Services Security Board (I.S.S.B.), and the general procedure evolved for "Torch" formed a most successful basic pattern for the remainder of the war. The following notes will be of interest.

- (a) The process of map production, supply, and distribution for any military operation is naturally fraught with considerable danger to security owing to the fact that maps, unlike most warlike stores, convey clear information of the location of the operation for which the maps are issued. About 10,000,000 maps in 700 different map-sheets were produced and distributed to ships for operation "Torch."

An extra complication, and a possible source of leakage, arose from the fact that map data and reproduction material had to be supplied to Washington so as to ensure that British and American troops should operate in combination on identical maps.

- (b) *Allied Co-operation.* In April, 1942, an officer from G.S.G.S. (War Office) went to Washington to settle the broad principles of co-operation in map supply for any large scale Anglo-American operation that might take place (see Chapter IV). It was agreed that:—

- (i) There should be a continuous general interchange of information and mapping material, so as to avoid the likelihood of drawing attention to a particular area at a particular time through a sudden increase in the transit of mapping material of any such area.
- (ii) All U.S. Army and Air Force units proceeding from, or based in, the United Kingdom should be supplied with maps entirely under G.S.G.S. arrangements, so as to avoid a sudden increase in low-grade cipher messages indicating specific areas, and to prevent sudden large bulk-shipments of a particular area from America.

The first serious threat to security in connection with Allied mapping co-operation was owing to a non-observance of the above conditions. It appears that a quasi-independent map supply organization for the Army Air Force had grown up in the United States since the date of the agreement referred to above. Although A.F.H.Q. (in London) had been fully informed of the April, 1942, agreement, and the closest technical liaison had been maintained throughout, an officer at this H.Q. ordered from the U.S. Air Force map supply organization large quantities of maps to be sent over from America for the use of U.S. Air Force units which would be proceeding to North West Africa from the United Kingdom. These maps consisted entirely of G.S.G.S. series which had been printed in the United States from reproduction material sent over from the War Office. The consignments, which arrived unheralded, were insecurely packed, and carried packing notes *in clear* in envelopes nailed to the outside of the cases. They were promptly "frozen" when they found their way, by accident, into War Office map supply channels, but not before several of the packing notes had been detached and lost. Fortunately, all the maps were on small scales. If they had been larger scale maps covering localized areas such as specific ports, the security of the whole operation might have been prejudiced. The maps were not in fact required and were not used, and A.F.H.Q. took drastic steps to prevent a recurrence.

The second serious threat to security occurred when a consignment of maps was being moved by road from a War Office map depot to an American headquarters at Cheltenham. This move was a routine one organized by the U.S. Services of Supply (S.O.S.) and the maps concerned, though covering wide areas, contained certain sheets which had been

produced under security conditions for "Torch." S.O.S. had therefore been asked to take full precautions. Unfortunately, these precautions were not complete, and a number of maps fell out of the back of the lorry unnoticed. By sheer bad luck the maps which lay strewn along the road were of Morocco, but fortunately of an inland area, and non-committal as to any precise coastal location connected with the coming assault. The maps were collected by the police, and the affair covered by the Security Board. From then on, no maps of any potential operational area were issued loose from any War Office map depot.

Except for the above lapses the arrangements for Allied co-operation regarding map supply worked admirably and preserved security.

- (c) *Security during production.* When it is considered what a large number of people in the United Kingdom were concerned with the production of maps of any area, the wide field for possible leakage will be realized. That any serious leakages did not occur, so far as is known, is a great tribute to the honesty of purpose and sense of responsibility of all those who took part in such production.

G.S.G.S. controlled its own map printing installation, but this could only deal with a small fraction of the total requirements. Much of the work was placed out with the Ordnance Survey, and through them to a number of civilian firms widely scattered over the country.

All employees in the G.S.G.S. and O.S. installations had the need for "security" impressed upon them continuously but, amongst a large crowd of people, there may always be some who find it difficult to keep things to themselves, and who feel an urge to advertise to their friends the importance of their work. Also, although carefully vetted by M.I.5, there was no guarantee that some of them might not subsequently acquire undesirable contacts.

It was therefore considered that the best course was to spread map production over widely dispersed resources, and to apply fictitious urgency from time to time to various items. To effect this it was essential to look well ahead, and to make an early start on such major commitments as maps for operation "Torch" so as to have the work interspersed with requirements for other potential operational areas. Map production for "Torch" was therefore begun on receipt of the first breath of information indicating that an operation in North West Africa was a future possibility. This demonstrates forcibly the vital importance of a Director of Survey maintaining the closest possible contact with the planning and operational staffs for whom he works, and holding their implicit confidence. Without such confidence he will obviously not be given all the information which he must have to do his job properly.

In actual fact full production was in hand some weeks before the outline plan, produced by the Joint Planning Staff, had been accepted by the Chiefs of Staff. If this had not been done, few maps of this large area, on scales larger than 1/200,000, could have been produced with full security. As events turned out, in addition to the smaller scales, revised 1/50,000 maps, and even larger scales of limited areas for the assault, as well as town plans, were produced covering all those areas for which they might reasonably be required.

Based on the table for scales of issue which were at that time current in Home Forces, an initial appreciation showed that about 30,000,000

maps would be required for operation "Torch." As a matter of interest this number was just about equivalent to the total map production for the entire British Army during the 1914-18 war. The printing of this large number in the time available could only have been attained by a system of wholesale contracting out to printing firms all over the country on a top priority basis. This would have meant flooding the country with duplicate printing plates of a "hot" area, and a stream of contacts and correspondence of a very urgent nature which would obviously have aroused suspicions. As such a procedure had never been adopted before, suspicion would have become a certainty and our intentions would have been disclosed.

It was therefore decided to base map issue scales at 30 per cent of the existing full scale. This, of course, produced a chorus of complaints from troops the majority of whom had been in the United Kingdom for some time and had become extravagantly minded with regard to map issues. They did not realize the vital security reason for this reduction in issue scale which was now applied.

One example of how security leakage was avoided when dealing with a civil firm is afforded by the following incident. A printing firm had been working on the 1/200,000 Algeria series on a long-term basis, some time before the area became a "hot" one. Acceleration of this work then became essential. To remove the job from the firm and have it completed in the War Office production installation, even if this had been practicable, would have aroused suspicion. The firm was therefore asked to complete the job quickly so as to get it out of the way *before taking up a large contract dealing with maps of Germany*. These latter were really not urgently needed at that time, but this action produced the Algerian maps quickly, and with the excuse of the German maps to cover the real reason for the urgency, tended to divert attention from North Africa.

Wherever possible high-security work was handled in the G.S.G.S. or Ordnance Survey installations. Even here, however, production tended to concentrate on North West Africa and this was corrected by feeding in maps of a "cover plan" area at intervals on a "clear the line" urgency.

The larger scales required special treatment, and were handled by the G.S.G.S. map production installation which was accustomed to such jobs. Town plans were security "covered" by arranging the concurrent production of plans of such places as Cherbourg, Le Havre and Brest, so as to convey the idea of long-term preparation. Again, some most secret air navigation charts, which were required for use by reinforcement aircraft from the United States, were given fictitious titles such as "Staff College Exercise" or "U.S. Army Air Corps, Leaflet Dropping Raid."

- (d) *Distribution security.* It had been current practice for some time before "Torch" that all maps produced by War Office for despatch to overseas theatres should be code-bundled for security. This included those for normal maintenance in established theatres, and those simply intended to be stored against future use. It was therefore not introducing any new procedure when all maps prepared for "Torch" were securely bundled with double brown-paper wrapping, and code-labelled

on the outside to indicate series and sheet. The code list was treated as a "Most Secret" document, and copies were issued only to the survey directorate concerned, and to the senior officers of the personnel ships when they received their sealed orders.

The bundles were made up in sacks for issue to the assault troops on board ship, and in wooden cases for formation and map depot reserve stocks. Both sacks and cases were securely machine-banded.

The above operations were split between several depots so as to minimize the chance of leakage. As each sheet was printed the maps were bundled in their first wrapping in a room adjacent to the machine-room. The plain bundles were then removed to another room for the second wrapping and for code-labelling with the specially printed code strips. As a rule the sacking and casing was undertaken in yet another location.

The finished sacks and cases were then removed to an intermediate "Shipping Depot," all the personnel of which were completely ignorant of the contents of the bundles and cases. None of the personnel from this intermediate depot was allowed to accompany the consignments when they were sent on to the port of shipment.

All issues to personnel ships were made by road with an officer escort and armed tail-guards to ensure that nothing fell out of the back of the lorry.

Sealed cases containing reserve stocks for subsequent use after the assault were moved by train in locked containers, and they were met at their destination by an officer who had the keys of the containers.

Precautions were taken to ensure that no code labelling tape was available at the intermediate depot for resealing. One routine check, however, indicated that a bundle had been opened. No special attention was drawn to this at that moment, but an "accidentally"(?) broken bundle taken from a cover plan area was fed through in the next consignment with just enough, but not too much, publicity. The entire staff was then assembled and given a lecture on "security." There was no direct evidence as to the individual responsible for breaking open the bundle, if indeed he did so, but the depot personnel were moved elsewhere and certain individuals were eliminated for safety.

One of the ships carrying some cased stock caught fire, and was beached before the convoy sailed. Arrangements were at once made for an immediate field security guard. Though slightly damaged by steam, no cases were missing, and none of them had broken open, so they were eventually reissued.

Orders originally issued by the Eastern Task Force were that the sacks of assault maps would be opened, and the maps issued, 48 hours after leaving British territorial waters. This was considered unsound, as a ship might easily be damaged early in the voyage and put back into port. Issues were therefore restricted at that stage to a bare minimum for planning, and general issues were postponed until 48 hours before landing.

This question of the proper time for issue in the case of an assault operation such as "Torch" is a most important one, and each such case will require most careful consideration on its own merits.

- (e) *Security in connection with map issues for planning.* Reverting to the earlier planning stage for the operation, many situations arose which tended to compromise security.

At that period there were comparatively few officers on the staff of G.S.G.S. who knew about the impending operation. The civil assistant at the map office, which G.S.G.S. maintained in the main War Office building, certainly did not know anything about it. When, therefore, a queue of strange senior officers lined up at that office, and even went direct to the map store, all asking for maps of North West Africa, it became almost impossible to preserve security. Arrangements were therefore made for all planning issues to be effected through a particular branch of the planning staff which was in the habit of drawing maps at short notice and at frequent intervals for areas widely scattered all over the world.

The improper use of a code word by an Intelligence officer of First Army nearly broke security on one occasion when he went to the G.S.G.S. map office in the main War Office building and asked the civil assistant there for "Torch" maps. When met with blank incomprehension he was barely restrained by a G.S.G.S. officer in the room who was "in the know," from explaining what it was all about!

- (f) *Disclosure of plans to Officers.* It will always be difficult to decide at what stage to disclose to selected survey officers details of any operation which is taken up for planning, and this will require constant care. Although, at first sight, it might seem better to keep the number down to a minimum, it is sometimes more dangerous to leave an officer uninformed when he will obviously draw his own conclusions, than to brief him, either partially or wholly, and make him realize the necessity for care in his conversations and dealings with others. For this reason the junior survey staff officer at G.S.G.S. who was responsible for supervising the map store in the War Office main building was, at an early date, given general information regarding the "Torch" area, but not, of course, of the planned date for the operation. Altogether there were eight officers at G.S.G.S. who were "in the picture," either fully or partially, at various stages of planning.
- (g) *Security in connection with other organizations.* The following examples are quoted to illustrate the type of situations that arose during "Torch" planning in connection with this aspect of security:—

The Inter-Service Topographical Department (I.S.T.D.) at one time asked for duplicate printing plates of certain large scale maps around Algiers so as to have the maps overprinted with enemy defences by the Admiralty Hydrographic Department. As this would have been a somewhat unusual job for a chart-producing establishment to undertake, it was thought that it might possibly provide an element of risk to security, and the request was not granted. Instead, G.S.G.S. undertook to do the whole of such work for I.S.T.D., thus obviating the need to send printing plates of the vital areas away from the central War Office printing installation.

The Intelligence Branch (G-2) at A.F.H.Q. wanted 5,000 copies each of 90 photo-mosaics of the Oran area for issue to one of the Task Forces. G-2 ordered them direct from the R.A.F. Central

Interpretation Unit. They found their way eventually into the American map distribution channels, where their handling, under security arrangements, added a considerable extra strain.

Map issues to personnel ships

When planning the map distribution details for the personnel ships, it was at first intended to make up each ship's consignment on the basis of the units and other personnel who were allocated to each particular ship. There were, however, so many changes in the order of battle, and in the plans for the tactical loading of the ships, that it was impossible to arrange distribution on such a basis.

Eventually the only possible solution was to allot to each ship a quantity of maps based simply as a percentage of the total numbers who would be carried, irrespective of the type of unit. This procedure proved to be quite satisfactory.

Special issues

Special map sets were made up and issued to formations which had been allotted particular tasks, *e.g.*, the armoured brigade landing at Bone and the parachute brigade which flew out with the mission of "dropping" in the Tunis area.

Bulk stocks

Convoys carried bulk map stocks in cases, for use subsequent to the initial landing in accordance with a prearranged programme. This programme had to be adjusted later when First Army Survey took up sheets for revision after their arrival in Africa.

Map issues to assault formations

These issues were made by O.C.s troops in each ship during the voyage out, under security conditions which have been described above. The actual times for general issue were given by signal from the convoy flagships and this was approximately 48 hours before landing. Some people were of the opinion that distribution was unnecessarily delayed, thereby prejudicing successful distribution, but security precaution had been given first priority.

Map depot activities with First Army

Only one Field Survey Depot (No. 12), which was of standard type (one officer, 18 other ranks, and one lorry) was available to First Army. Its first task was to set up a map depot in Algiers, and to receive and sort the bulk stocks as they arrived from the United Kingdom in successive convoys. The strength of this unit was at all times too small for its task, and for some months it had to do duty at the base and on the lines of communication as well as in the army area. It was bolstered up at first by employing a topographical section of 518 Field Survey Company R.E. to help with the work of sorting out the bulk stocks and organizing the map depot. Extra labour was obtained locally, including pioneers, Frenchmen and Arabs. As will be seen later, personnel of 12 Field Survey Depot R.E. continued to run the base depot at Algiers until relieved by 7 Field Survey Depot R.E. when it arrived in March.

While leaving half their personnel in Algiers, the remaining half moved forward to Bone to open up an advanced map depot for feeding First Army in the battle zone. Consignments of cased maps were ordered forward from Algiers to Bone as required. These went by sea, and were eventually moved from Bone to Constantine by lorry.

First Army H.Q. moved to Constantine early in December, and the advanced map depot also moved forward there as soon as an L. of C. area headquarters had been established about "D" + 15.

Each area and sub-area (at the ports) held stocks of maps on an agreed basis, and sent weekly stock reports to the survey directorate, who arranged for replenishment. They issued maps to all units working in their areas and, in the case of units passing through, gave them a skeleton issue, for staff use only, covering the battle area. These area headquarters co-operated wholeheartedly and efficiently, thus relieving the survey organization of much detailed map issuing.

Each corps, whether British, American or French, held agreed stocks of their own operational areas and, in addition, a 25 per cent stock of the rest of the army front. They were responsible for issues to divisions and independent brigades under their command at an agreed standard scale of issue. In the event of a sudden move of a formation across the front, a happening which frequently occurred at short notice, both the despatching and the receiving corps made a 25 per cent issue, the balance being sent forward by Army H.Q. as soon as possible.

Divisions obtained wastage replacements from the corps stocks, of which a weekly return was sent to Army H.Q. Stocks were brought up to the agreed level automatically.

The Army survey directorate retained strict control over all bulk issues as resources were limited, and as it was always in touch with the operational plan, it was able to view the picture as a whole.

The advanced depot remained at Constantine under army control until difficult communications made it necessary for it to move forward to Souk Ahras railhead. Both the advanced and rear depots were at all times controlled by the Army survey directorate.

First Army H.Q. later moved to near Souk el Arba and for the final offensive 12 Field Survey Depot, which by then had been relieved of L. of C. responsibilities and was at full strength, was installed at Souk Ahras railhead and at Teboursouk, a central position which was more or less on a level with corps headquarters.

At all times the need for a field survey depot large enough to form adequate rear and advanced depots was acutely felt. There was also the need for detachments with corps and divisions, as had been adopted by Eighth Army, and as was used later during the Italian campaign. When Eighth Army entered Tunisia towards the end of their advance from Egypt, they already had a field survey depot of the larger type which was capable of carrying out all these necessary tasks.

Had the operations not been limited geographically by the sea and other topographical features, efficient map distribution might have been quite impracticable with such slender map depot resources as were available to First Army.

Map supply arrangements under U.S. Army control

After their landings in North Africa, the U.S. forces detailed map depot detachments to operate depots as under:—

At Casablanca on behalf of Atlantic Base Section.

At Oran on behalf of Mediterranean Base Section.

In addition, 12th Army Air Force and I Armoured Corps each set up its own map depots in Casablanca, resulting in a good deal of unnecessary overlapping. The map stocks held by these two private depots were later transferred to the Atlantic Base Section Depot, 12th Air Force retaining a small map library at Casablanca to meet urgent and immediate demands for maps in small quantities.

Later on, when 12 Field Survey Depot R.E. moved forward from Constantine, the map depot there was taken over by a U.S. map depot detachment, under the Engineer of the Eastern Base Section.

A.F.H.Q. control of map supply and distribution

When an integrated survey directorate was organized at A.F.H.Q., a map supply section was formed within it to control the general policy of map supply and distribution within the theatre. Its responsibilities regarding the base depot were eased during March when 7 Field Survey Depot R.E. arrived from the United Kingdom. This released the rear party of 12 Field Survey Depot which was then able to rejoin its own unit in the battle zone.

A directive issued by A.F.H.Q. to all concerned laid down the policy to be followed regarding the following:—

- (a) The maintenance of stock records.
- (b) The control of map supply from the United Kingdom and Washington.
- (c) Map supply and distribution.
- (d) Stock transfers.
- (e) Indents, requisitions, and forecasts of future requirements.

Map supply for the air forces

A small section of the Algiers depot was lent to the air forces for use as an "Air" map library, personnel for which were supplied by the air forces. The map depot was responsible only for the bulk supply of maps to the library.

The North African Tactical Air Force experienced some difficulty in distributing maps to its forward units in the southern sector. Arrangements were therefore made for stocks of certain map series to be held for the Air Force at the Constantine depot.

During the early part of the campaign, most of the maps required by 12th U.S. Air Force were obtained from the United States and shipped to Oran. This policy was altered in March, when it was arranged that maps required by forward air force units would be obtained from the United Kingdom *via* Algiers, and that only those maps required by rear formations of 12th Air Force would be obtained from the United States.

CHAPTER X

ITALY

The following diagram, maps and plates are relative to this chapter:—

	<i>Page</i>
<i>Diagram 6. Survey organization—Mediterranean 1944–45</i>	<i>Facing 304</i>
<i>Sketch Map 10. Italy</i>	<i>290</i>
	28. <i>Italy</i> 1:250,000
	29. <i>Italy</i> 1:100,000
<i>Plates at end of book</i>	30. <i>Italy</i> 1:50,000
	31. <i>Italy</i> 1:25,000
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	33. <i>Italy</i> 1:50,000
	34. <i>Italy Road Map</i> 1:200,000
	35. <i>Italy “Going” Map</i> 1:100,000

SECTION 1. SURVEY ORGANIZATION AND NARRATIVE

Strategical background

At the Washington Conference in May, 1943, it was decided that the major offensive against the European mainland to bring about the defeat of Germany would be mounted from the United Kingdom in the early summer of 1944.

At that time operations in the Mediterranean area resulting from the allied landings in North West Africa (operation “Torch”) and the westward advance of Eighth Army from Egypt, were approaching a successful conclusion. The Combined Chiefs of Staff, who at the Casablanca Conference had instructed General Eisenhower to follow up operation “Torch” by mounting an assault against Sicily in July, now directed that, in exploitation of the capture of Sicily, he should plan operations to eliminate Italy from the war, to establish air bases from which heavy and sustained air attacks could be made against Germany, and to contain German divisions in southern Europe. The latter would not only aid the projected invasion against western Europe, but also help to weaken German opposition against Russia.

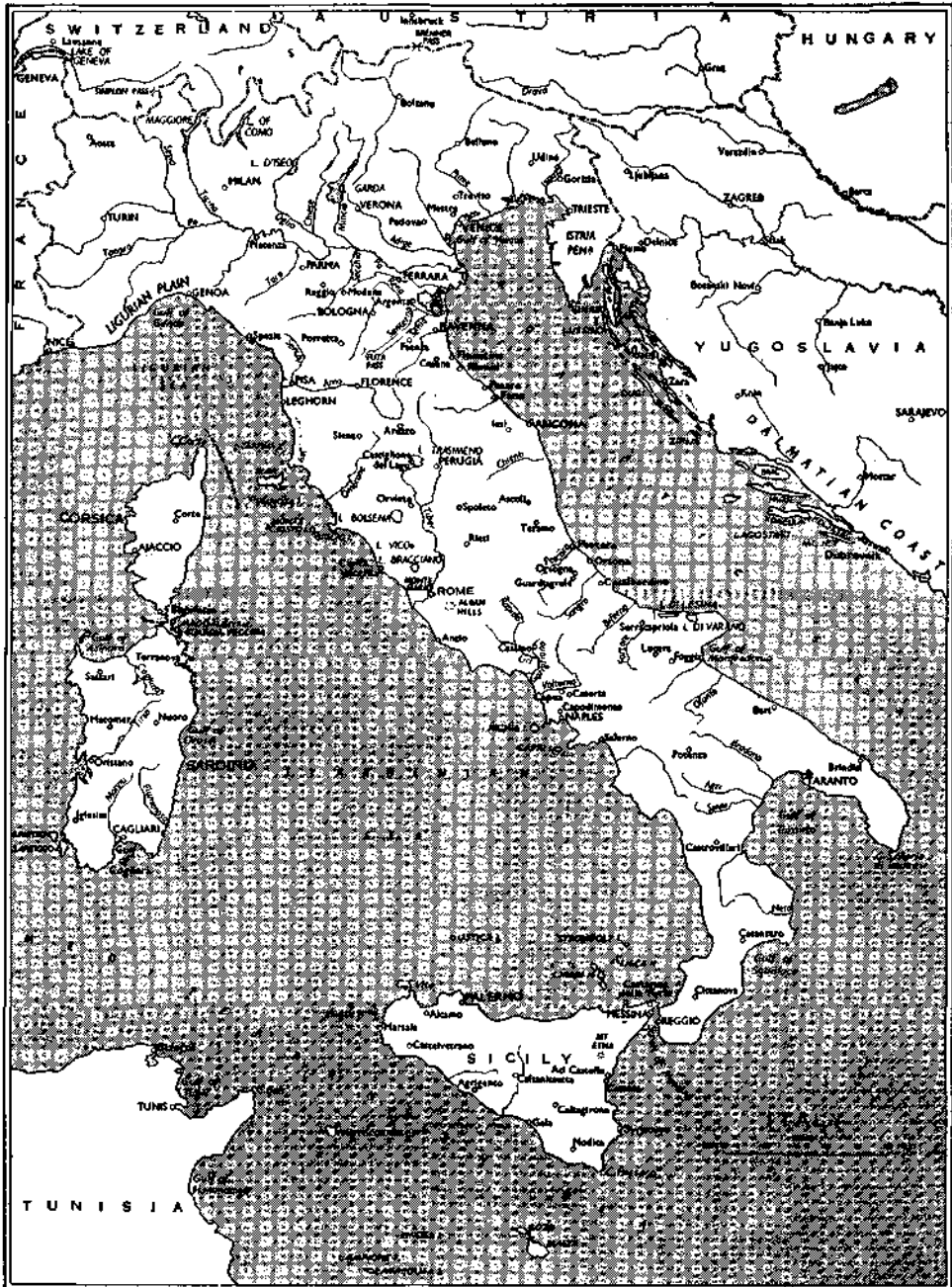
For these projected operations General Eisenhower was allotted all the ground forces in the Mediterranean area except for certain British and American divisions which were to be returned to the United Kingdom on the conclusion of the Sicilian campaign.

The operations for the capture of Sicily are dealt with in Chapter XII, Section 4, pages 496–504.

Early planning

Various alternative plans were considered. The first was to launch a sea-borne assault across the Straits of Messina to the toe of Italy so as to secure a lodgement in Calabria. Alternative consideration was given to the capture of Sardinia and Corsica, from which islands there would be a flank threat against the west coast of Italy, and also a threat against the southern coast of France.

SKETCH MAP 10



Drawn by Ordnance Survey, 1954.

The fall of Mussolini on 25th July introduced a new factor affecting policy. There now arose an urgent need to precipitate an Italian surrender, and U.S. Fifth Army was directed to plan for an assault landing (operation "Avalanche") in the Bay of Salerno, near Naples, with target date the first week in September, 1943. Meanwhile planning preparations continued for the assault on the toe of Italy across the narrow straits by formations of Eighth Army (operation "Baytown").

The course of military operations

To explain and clarify the various survey activities during the campaign, it will be well to summarize the principal operational events which took place between the first week in September, 1943, and May, 1945, when the German armies were defeated and surrendered unconditionally.

INITIAL LANDINGS AT REGGIO, SALERNO AND TARANTO

The assault across the Straits of Messina was successfully accomplished by Canadian and British divisions of Eighth Army on 3rd September. On that date the armistice with Italy was signed but not announced.

On 9th September the landings at Salerno took place, accompanied by an announcement of the armistice. The assault was carried out by Fifth Army, with a northern Task Force (British) and a southern Task Force (U.S.). On this same date elements of 1 Airborne Division (British) landed at Taranto and secured the port.

On 16th September troops of Eighth Army, having made their way up the coast from Reggio, made contact with the Salerno force, and also with the troops of 5 Corps from the Taranto area. All the allied forces in Italy now came under the command of H.Q. 15 Army Group.

The evacuation of German troops from Sardinia began on 11th September and was completed by 18th September. French units then occupied Corsica, this island being cleared of the enemy by 6th October.

NAPLES AND THE FOGGIA AIRFIELDS

By 28th September the important airfields at Foggia had been captured by Eighth Army, and Naples was occupied on 1st October. Italy declared war on Germany on 13th October with the status of co-belligerent, and there were indications that German forces intended to make a stand on a line to the south of Rome, with strong intermediate defensive lines in between that position and their contact with the Allies further south.

A directive issued by General Eisenhower on 30th September stated that the principal objects of subsequent operations in connection with the advance to the winter line were as under:—

The capture of a specified line which would make secure the Foggia airfields and the Naples area.

The subsequent capture of a line which would secure Rome and its airfields.

The unification of command of the entire Mediterranean theatre was effected on 10th December. This added to General Eisenhower's responsibilities Greece, Albania, Yugoslavia, Roumania, Hungary, Crete, the Aegean and Turkey. He was nominated as Allied C.-in-C. of the Mediterranean theatre,

but shortly after this he handed over to General Sir H. Maitland Wilson when he proceeded to the United Kingdom to become Supreme Commander for the invasion of western Europe.

During the winter of 1943-44 the operations developed into a slow, painful advance through difficult country against an enemy exploiting natural obstacles by mines and demolitions, but the allied forces were containing a large number of German divisions in Italy and, by their occupation of Corsica, were offering a potential threat against southern France. It seemed clear that the only way of frustrating the enemy's defensive policy was by exploiting amphibious landings along the coast behind his lines.

ANZIO AND THE WINTER CAMPAIGN

Planning for a landing at Anzio had been started by Fifth Army planning staff in November, 1943, the target date being 20th December. As a preliminary to this assault landing, Eighth Army opened the first stage of the battle for Rome by attacking in eastern Italy across the Sangro River on 26th November. Bad weather, floods, impassable roads and strong enemy resistance halted their advance some 25 miles short of Pescara, the objective.

An attack by Fifth Army in western Italy, forming the second stage leading up to the Anzio landing, was launched on 1st December. Progress was slow, and it became clear that the advance of the two allied armies would not be sufficient to make possible the projected landing at Anzio on 20th December. As the landing-craft situation was critical, with demands for several to be sent back to the United Kingdom for operation "Overlord," it was considered that further postponement was impossible. The operation, as originally envisaged, was therefore abandoned.

Then came the Allied Conference at Tunis on 25th December, when it was directed that the drive on Rome must be continued so as to secure depth for the protection of Naples and the Foggia airfields, and to inflict as much damage as possible to the German armies in anticipation of the allied offensive in western Europe. As a result, consideration was given to the strategy necessary to speed up the Italian campaign so as to make possible an attack against southern France in the spring of 1944. Planning was now resumed for the amphibious landing at Anzio, with 22nd January as a provisional target date. Authority was obtained for the retention of the vital landing craft for a further short period before their return to the United Kingdom. Early in January a reorganization of the Fifth and Eighth Armies was begun so as to release assault formations for intensive training.

As a preliminary to the landing, Fifth Army launched an offensive on 12th January across the Rivers Garigliano and Rapido, and the assault at Anzio took place on 22nd January. The enemy, after regrouping, stubbornly withheld the allied attacks, with the result that this phase of the allied winter offensive came to a close by the end of January.

Early in February, 1944, a German counter-attack against the Anzio beach-head was held and the bitter struggle against the strong Cassino position started, the famous monastery being destroyed by air-bombing on 15th February. The enemy again attacked strongly against the Anzio beach-head but without success.

In mid-March another allied attack in the Cassino area was staged but was abandoned, and there was a pause for regrouping. Meanwhile Eighth Army

had broken partly through the enemy's main defences on the Adriatic coast and held firm on these positions during the Anzio and Cassino fighting.

Apart from the landings at Anzio the winter campaign had not been spectacular, but it had engaged some 18 German divisions, inflicting on them considerable casualties; Italy was out of the war, the pressure against the Russian armies had been lessened, and it was obviously of great value as a preliminary to the forthcoming operations in western Europe.

With the advent of better weather, and after further preparation and regrouping, Cassino was eventually captured on 18th May, and this opened the way to an advance on Rome culminating in its occupation on 4th June.

Before dealing with the successful allied offensive which led up to the capture of Rome it will be well, at this stage, to consider the planning and operational stages of the assault invasion of southern France which was planned, mounted, and carried out under A.F.H.Q. control, and which involved extensive and urgent mapping preparations.

THE INVASION OF SOUTHERN FRANCE ("ANVIL")

At the Quebec Conference in August, 1943, the Combined Chiefs of Staff decided that a diversionary attack should be made against southern France. Later, at the Cairo Conference, it was agreed that this should be a major assault, and it was subsequently embodied in the agreement with Russia at the Tehran Conference when high-level plans for the opening of a "second front" in western Europe were drawn up.

It was originally intended that the invasion of southern France should be launched in conjunction with and coinciding with the main assault in northern France (operation "Overlord"), probably in May, 1944, while the allied forces in Italy which, it was assumed, would by then have forced the enemy beyond the Pisa-Rimini Line, were to maintain the strongest possible pressure without detracting from the French operation. No other offensives were to be undertaken in the theatre. The original plan envisaged an assault landing on the beaches in the vicinity of Marseilles and Toulon, and a subsequent advance northwards in the direction of Lyons and Vichy.

The major problem affecting the planning was the shortage of assault craft. Even though the amphibious operation which was scheduled to take place in the Bay of Bengal against the Japanese during 1944 was deferred, there were many conflicting demands for assault craft, not only between the Mediterranean and European theatres, but within the Mediterranean itself, where, owing to slow progress up Italy towards Rome, there were plans for amphibious landings behind the enemy flanks. Another important factor was the decision by the "Overlord" planners to increase the strength of their assault in northern France which entailed a further demand for landing craft.

Meanwhile H.Q. Seventh (U.S.) Army was designated as the planning and operational staff for the invasion. Uncertainty about the numbers of landing craft that would be available and the strength of the assault force, combined with the operational difficulties in Italy owing to slow progress following the Anzio landings, gave rise to doubt, during the latter part of February, whether the projected operation in southern France could take place as originally planned. This doubt was strengthened when a new directive from the Combined Chiefs of Staff gave to the Italian campaign overriding priority over all existing and future operations in the Mediterranean, and gave it first call on all resources within the theatre. At the same time, however, it was directed that alternative plans should

be prepared for an operation which, although not prejudicing the Italian campaign, would contribute towards the invasion of northern France by containing the maximum number of enemy forces. The first of such alternatives was to be an invasion of southern France by a two-division assault, building up to about ten divisions, making use of French forces to the maximum extent.

As time passed it became increasingly clear that, whatever operation was planned against southern France, it would have to be postponed till some time after the projected early June target date for operation "Overlord."

Late in March an appreciation of the situation in Italy indicated that in view of German resistance at Cassino and elsewhere which was holding up the advance on Rome, the earliest possible date for the assault in southern France would have to be deferred till mid-August. This introduced a doubt as to whether such an operation, which must inevitably weaken the allied forces in Italy, was the best way of assisting the allied invasion in northern France. It was considered by A.F.H.Q. that the available craft and forces might be better used for conducting amphibious landings and subsequent operations to further the progress of the campaign in Italy itself. One such plan envisaged a penetration through the Pisa-Rimini Line into the Po Valley and an amphibious operation against the Istrian Peninsula for exploitation through the Ljubljana Gap into the plains of Hungary, thus threatening the heart of Germany by the back door in combination with the Russian advance from the east.

These alternative possibilities and plans are mentioned here in some detail as they illustrate the extent of the mapping problems which faced the Director of Survey at A.F.H.Q. during this period. Obviously he had to be prepared to provide maps for any or all such developments.

The allied invasion of northern France ("Overlord") took place on 6th June, 1944, and a new factor now arose. General Eisenhower desired that operations should be carried out which would clear additional French ports so that allied formations might be deployed in France more rapidly and on a broader front than was feasible within the limited Normandy bridgehead. To facilitate this he agreed to divert resources to make possible an assault in southern France to capture a major port. A.F.H.Q. still considered that a continuation of the advance in Italy to the Po Valley and the Ljubljana Gap, assisted by amphibious operations against Trieste, appeared to be the best strategic policy, but General Eisenhower's requirements were accepted as decisive, and the Mediterranean Command was directed to carry out the assault against southern France with 15th August as target date, using three divisions for the assault, building up to ten, and with extra resources in the way of craft and troop carriers sent out from the United Kingdom.

It was now possible to define the objects of this operation which were:—

- (a) To contain and destroy enemy divisions which might otherwise oppose General Eisenhower's forces in northern France.
- (b) To secure a major port for the entry of additional allied forces, and to establish new lines of communication therefrom.
- (c) To threaten the southern flank and rear communications of the German forces opposing the allies in northern France.

Marseilles and Toulon were the port objectives, with subsequent exploitation up the Rhone Valley to Lyons and Dijon. It should be noted here that, at one

time, the planning staff had considered Bordeaux as a port objective. It will be realized what is involved in the way of map preparation and production when widely separated alternative objectives are selected for an assault landing with their extensive exploitation areas and subsequent lines of advance, and to what extent a major change of plan dislocates an already large mapping programme.

On 30th July H.Q. 6 Army Group was established in Corsica, which would provide subsequently a co-ordinating command and control of the American and French forces which were to land in southern France, and which would come under General Eisenhower's command when contact with the "Overlord" forces was established.

The development of allied operations in Normandy, and the break-through of American forces into Brittany profoundly affected the strategic situation, as there now appeared to be a possibility of opening up important ports in Brittany for the unopposed and rapid entry of the Mediterranean forces scheduled for the landing in southern France. It became necessary to consider the possibility of diverting these forces to the Brittany ports and this, of course, would have introduced new and unexpected complications with regard to map supply. However, the Combined Chiefs of Staff, in view of uncertainty about the progress of allied operations in Brittany, did not agree to such a diversion and, in fact, the ports were not freed till considerably later. On 10th August it was decided to proceed with the planned assault in southern France. The principal mounting ports were Naples, Oran, Taranto and Brindisi, at each of which it was necessary to assemble the requisite map stocks for issue under security conditions. An airborne division was to take off from its bases in the Rome area.

The assault took place successfully in the early hours of 15th August, rapid advances being made up the valleys of the Rivers Rhone and Durance. During the second week both Toulon and Marseilles were cleared, and organized enemy resistance south of a line from Grenoble to Bordeaux had ceased, Bordeaux itself still holding out and remaining in enemy hands for some months.

On 11th September contact was established with the U.S. Third Army which formed the right flank of the allied forces operating from Normandy. On 15th September H.Q. 6 Army Group became operational, in command of Seventh U.S. Army and First French Army, and came under General Eisenhower's command. At this stage the responsibility for map and survey control with 6 Army Group passed from A.F.H.Q. to S.H.A.E.F.

THE SUMMER AND AUTUMN CAMPAIGN IN ITALY (1944)

On 12th May Fifth and Eighth Armies launched an offensive on a wide front against the Gustav Line, crossing the Rivers Rapido and Garigliano. Cassino with its monastery was taken on 18th May, after an assault by British and Polish troops, and the Allies advanced towards the Adolf Hitler Line, the Fifth Army attack in the Anzio beachhead synchronizing with the Eighth Army attack further to the east.

After a rapid pursuit the battle for Rome started on 30th May, in the Alban foothills, Eighth Army advancing along Highway 6. Rome was entered on 4th June and, with the Germans retreating, there was a further advance along the whole allied line. Civita Vecchia was taken by Fifth Army on 8th June, Eighth Army capturing Orsogna, Pescara and Perugia.

On 30th June a further offensive was launched along the whole front and

French troops occupied Siena. Fifth Army then broke through and entered Leghorn on 19th July, and Eighth Army advanced through Arezzo and captured Florence on 11th August. By the end of August the enemy was back on the main Gothic Line, but this position was breached by Fifth Army in the west, and by Eighth Army in the east later in the month.

Bad weather in October slowed up movement across the Po Valley. There was a change in command towards the end of November when General Alexander was promoted Field-Marshal and appointed Supreme Commander in the Mediterranean, and General Mark Clark, from Fifth Army, became C.-in-C. 15 Army Group.

THE WINTER OF 1944-45

Progress during the winter months was slow, owing to stubborn enemy resistance, heavy rain and bad road conditions, but Eighth Army took Ravenna early in December, New Zealand troops entering Faenza on the road to Bologna a few days later. Towards the end of the month the Canadians thrust towards the R. Senio and Fifth Army withdrew slightly following a German attack in the valley of the R. Serchio.

THE FINAL STAGE

In April, 1945, the Allies once more resumed the offensive, Fifth Army executing a surprise attack in the mountains dominating the Ligurian Plain, and Eighth Army making a further advance from the Senio bridgehead, assisted by a sea-borne landing behind the enemy line. On 12th April Eighth Army crossed the R. Santerno in strength, and Fifth Army began a new assault south of Bologna four days later.

Bologna was freed on 21st April and both armies advanced and crossed the R. Po. By the end of the month Verona, Genoa, Milan and Venice had been occupied, and Mussolini had been executed by his own countrymen. On 1st May New Zealanders crossed the R. Isonzo and made contact with Marshal Tito's forces. Other troops entered Udine, and Fifth Army were advancing along the Gulf of Genoa.

On 2nd May the German forces in Italy surrendered.

Survey planning

In accordance with the normal survey policy of looking well ahead and, for security reasons, spreading the mapping programmes over wide areas, the production of maps of Italy had been taken up between G.S.G.S. (War Office) and the Survey Directorate Middle East as early as 1941.

As soon as plans for operation "Torch" were put in hand, it was obvious that in exploitation of such an operation, combined with a successful advance by Eighth Army from Egypt, the way would be open for the capture of Sicily, Corsica and Sardinia, and allied landings in Italy itself. Priorities for hastening the production of Italian maps were therefore raised, and after the initial landings in North West Africa the Survey Directorate A.F.H.Q. took over a large share of the work. Particulars of the map series involved, their production and revision, and the preparation of triangulation data will be found in Sections 2 and 3.

Survey organization

In its main essentials, the survey organization for the Italian campaign was a continuation of that which existed for operation "Torch" and for the Eighth Army operations from Egypt into Tunisia and the subsequent campaign in Sicily. In supreme control of survey and mapping within the theatre was the A.F.H.Q. Survey Directorate, which remained at Algiers until June, 1944, when it moved to Caserta, near Naples.

Shortly after the initial landings in Italy in September, 1943, the allied forces on the mainland came under the command of H.Q. 15 Army Group which was later known as H.Q. Allied Armies in Italy (A.A.I.) and finally, in December, 1944, was reconstructed with its original title of H.Q. 15 Army Group. A small Survey Directorate at this H.Q. controlled the survey and mapping work carried out by the allied survey units of the Fifth and Eighth Armies. With the British Eighth Army there was a normal Army Survey Directorate, and with the Fifth (U.S.) Army, which was under American Command, survey control was exercised, in accordance with U.S. Army practice, by the Army Engineer. The latter always had one, and at times two, British survey officers and some British O.R.s in his engineer section at Army H.Q.

Survey units, either British, American or Polish, were available at all the above levels, *i.e.* at A.F.H.Q., H.Q. 15 Army Group and with the two armies in the field. U.S. Corps also had their own Engineer Topographical Companies. When a British corps was sent to Greece to restore and maintain order at the time of rebel disturbances, a small survey directorate and a field survey company R.E. accompanied the force.

The general set-up of the survey organization within the Mediterranean theatre is shown diagrammatically in Diagram 6 and consideration will now be given to the various echelons:—

A.F.H.Q. Survey Directorate (D. Survey—Brigadier R. L. Brown)

This was originally formed in the planning stage for operation "Torch" when it consisted of two British and two American officers and a few other ranks and enlisted men. Complications due to differences between American and British methods of staff control quickly became apparent and so, with real Anglo-Saxon compromise, the Survey Directorate was organized as part of the Engineer Section A.F.H.Q., but with a British chief as Director of Survey who was given direct access to the Chief of Staff and to all the various staff branches. This somewhat mongrel and quite unorthodox arrangement continued throughout the campaign till the end of hostilities and proved to be a thoroughly efficient and happy one.

It may be noted that this was a different arrangement from that adopted in the case of S.H.A.E.F., also an integrated British-American headquarters. There the Survey Directorate, headed by a British Director of Survey, and composed of British and American personnel, formed the Map and Survey Section of the Operations (G-3) Division and, though responsible directly to the Chief of the Operations Division and not to the Chief of Staff, the Director of Survey had direct access to all staff divisions and to the air staff, and dealt direct on technical survey matters with the Director of Military Survey (War Office), and with Directors of Survey in other theatres when necessary.

At the start the Survey Directorate at A.F.H.Q. was a small one, but it was always foreseen that, with the development of operations, a large increase

would be necessary. What was not foreseen was the delay that would occur in effecting such necessary increases.

By April, 1943, when the operations in Tunisia were drawing to a close, the directorate had four British and five American officers, and had under its direct control one U.S. engineer topographical battalion, two map reproduction sections R.E., and one field survey depot R.E. Operations in North Africa ceased on 12th May, and on 18th May Brigadier R. L. Brown assumed duty as Director of Survey, an appointment which he held until the end of the war. It was now evident that the directorate, and the survey service generally, needed expansion and reorganization to meet an increased commitment and to prepare for new projected operations. Extra topographic officers and enlisted men were obtained from the United States, and the American quota then became six officers and four enlisted men who, in the absence of an authorized establishment, were mostly held on an "expediency" basis. Meanwhile one New Zealand and four South African survey officers were unofficially added, raising the British quota to 10 officers and 17 other ranks. The directorate remained at this approximate strength for the remainder of the war and, together with two map depot teams (U.S.), operated throughout as a single integrated team, more or less on the British system, serving the needs of all ground and air forces. Its *de facto* status was never properly legalized but, as everything worked so smoothly, matters were allowed to remain undisturbed.

The chief function of the A.F.H.Q. Survey Directorate with the survey units under its direct control was to ensure and control the preparation and supply of maps and triangulation data for all operations that might take place. Some of the maps were newly compiled, others were old ones brought up to date by revision, and they were supplied either as bulk stocks, or in the form of reproduction material for use by army survey organizations serving the Fifth and Eighth Armies and their supporting air forces. The strategic and independent air forces in the theatre were served directly by A.F.H.Q. Survey Directorate.

For purely land operations it is usually possible to complete a mapping programme at the base, or at least to carry it to a stage when it can be handed over to army groups and armies, who then assume responsibility for subsequent mapping tasks in their areas of immediate and prospective operations. This was in fact done all the way up Italy, responsibilities for mapping and revision being decentralized and modified, where necessary, to conform to the progress of operations.

In the case of amphibious operations, however, a G.H.Q. survey organization is often very closely concerned with the assault force and its intimate needs for maps and survey. Sometimes these amphibious operations are mounted at short notice, and the survey units of the assault force, though of course vitally interested in the mapping programme concerned, may have little time or opportunity to study and prepare for the operation and its requirements. They are probably more immediately concerned with the problems of embarkation and working out plans for the survey tasks they will have to undertake after landing. Under such conditions a G.H.Q. survey organization should be in a position to hand over to an assault formation the results of any survey planning and production that has already been done, and resources in the way of survey units far in excess of its normal allotment.

Survey Directorate A.F.H.Q. supplied such direct assistance for the invasion of Sicily (in conjunction with Middle East), the Salerno landings, the occupation of Sardinia, Corsica and Elba, and the invasion of southern France.

For the landings at Anzio the mapping up of the assault force was controlled by the army concerned.

The survey units under direct A.F.H.Q. control at the beginning of the campaign in Italy were as under:—

British

516 and 518 Field Survey Companies R.E. (late of First Army).

11 and 12 Map Reproduction Sections R.E.

2 Air Survey Liaison Section R.E.

10 Field Survey (Stores) Depot R.E.

7, 12 and 26 Field Survey (Map) Depots R.E.

U.S.

649 Engineer Topographical Battalion (Army).

Atlantic, Mediterranean, and Eastern Base Section Map Depots.

2611 and 2697 Engineer Map Depot Detachments.

In February, 1944, extra mapping strength was added when 30 Engineer Topographical Battalion (G.H.Q.) became available at A.F.H.Q. It did not, however, stay long as it was redeployed to the Pacific during the summer. Further map depot detachments were added, also two American model-making detachments.

On the British side "B" Air Survey Liaison Section was formed and took the place of No. 2 Section when the latter went to South East Asia Command. Towards the end of the campaign 13 and 19 Field Survey Companies R.E. came directly under A.F.H.Q. control, and 11 and 12 Map Reproduction Sections were amalgamated to form 650 Field Survey Production Company R.E. No. 524 (Palestinian) Field Survey Company R.E. and two further Palestinian field survey depots also operated under A.F.H.Q.

Preparations for the invasion of southern France delayed the move of A.F.H.Q. from North Africa to Italy. The Survey Directorate was then at its peak strength of 17 officers, with 1,800 technical personnel (British and American) under its direct command in A.F.H.Q. survey units, and a further 1,200 in the Middle East. Algiers was, however, much too far from the scene of operations, and the Survey Directorate moved to Caserta in June as part of the general move of A.F.H.Q., just before the invasion of southern France. The A.F.H.Q. survey units also moved to Italy with the exception of 30 Engineer Topographical Battalion which went to the Pacific, and 649 Engineer Topographical Battalion, which was assigned to Seventh Army for the French operations.

Apart from Africa, the area of the survey directorate's responsibility for mapping amounted to some 880,000 square miles. The number of individual map sheets for which the directorate held and maintained reproduction material was nearly 18,000. The number of maps produced for the theatre was over 134,000,000, more than four times the total number produced for the First World War.

The production of maps is, however, of little operational value unless they are distributed to the ground and air forces at the right place and time. The commendations which were received by the Director of Survey from both air and ground commanders were adequate proof, if any was needed, of the satisfactory manner in which the mapping requirements of the allied forces were met during the campaign.

On the termination of active hostilities in May, 1945, the responsibilities of A.F.H.Q., from a survey point of view, naturally lessened. There was a demand for the American officers to be redeployed to the Pacific theatre and the reduction of the survey directorate started in earnest. Brigadier R. L. Brown, after six years' service in the Mediterranean, gave up his appointment as Director of Survey and returned to the United Kingdom.

H.Q. 15 Army Group (D.D. Survey—Colonel K. M. Papworth; later—Colonel V. E. H. Sanceau)

While awaiting the authorization of an establishment for a survey directorate at this H.Q. when the Italian campaign started, Colonel K. M. Papworth was attached as D.D. Survey from a pool of officers held at A.F.H.Q. known as the Survey Planning Increment. This served many uses and kept the wheels turning when delays due to war establishment procedure would otherwise have held up the appointment of officers to essential posts. Two captains, one British and one American, were sent as his assistants, and No. 16 Field Survey Depot R.E. carried out map depot duties.

The establishment, when authorized, provided for a D.D. Survey (Colonel), two A.D.s Survey (Lieutenant-Colonels), one of whom was on permanent loan to Fifth Army, a D.A.D. Survey (Major) and a captain. For most of the period 517 Field Survey Company R.E. was under the direct control of H.Q. 15 Army Group, and at various times and for short periods, 13, 19 and 514 Field Survey Companies R.E. were also available to meet special requirements together with extra field survey depots and map depot detachments.

15 Army Group comprised the Fifth (U.S.) and Eighth (British) Armies with the usual allocation of army group troops. The survey directorate was responsible for:—

- (a) Controlling and directing the field surveys, mapping and map supply within the army group.
- (b) Supplying the special mapping needs of the various staff branches at army group H.Q. (Operations, Intelligence, etc.).
- (c) Supplying maps direct to army group troops.
- (d) Supplying maps to strategic air forces based on the Italian mainland while A.F.H.Q. was back in North Africa. This responsibility reverted to A.F.H.Q. when the latter moved over from Algiers to Italy.
- (e) Supplying maps to the Second Tactical Air Force, which worked in co-operation with the army group.

In accordance with A.F.H.Q. survey policy the responsibility for new mapping and revision, and for printing map stocks of certain series, was delegated by A.F.H.Q. to 15 Army Group on an area basis. These area responsibilities were altered as operations progressed northwards. 15 Army Group in turn decentralized responsibility to the two armies in accordance with their current and immediately prospective operational areas, retaining for execution by its own unit or units, certain tasks which were not of immediate operational interest to the two armies.

In April, 1944, Colonel Papworth was appointed D. Survey at G.H.Q. Middle East and he was succeeded by Colonel V. E. H. Sanceau as D.D. Survey 15 Army Group. The latter remained in this appointment for the remainder of the war.

Eighth Army (D.D. Survey—Colonel V. E. H. Sanceau; later—Colonel S. G. Hudson)

The survey directorate crossed over to Italy in September, 1943, with Colonel V. E. H. Sanceau as D.D. Survey. The units at first operating with Eighth Army were 13 and 517 Field Survey Companies R.E., 7 General Survey Section R.E., and 20 (Army) Field Survey Depot R.E. In December, 517 Company, after 14 months' valuable service with Eighth Army from Alamein to Tunisia, Sicily and Italy, passed to 15 Army Group command, and was replaced by 514 Field Survey Company R.E. from Middle East. Then, in March, 13 Field Survey Company was assigned for duty under A.F.H.Q. control, its place being taken by 49 South African Survey Company. In March also the Polish Survey Directorate joined Eighth Army and assumed control of the work of 12 Polish Field Survey Company and 312 Polish Field Survey Depot. They remained with Eighth Army throughout the campaign.

When Colonel Sanceau was appointed D.D. Survey at H.Q. 15 Army Group he was succeeded by Colonel S. G. Hudson, who retained the appointment of D.D. Survey Eighth Army till the close of hostilities.

20 (Army) Field Survey Depot was redesignated 29 Field Survey Depot and, in the late summer of 1944, 514 Field Survey Company, after nine months of strenuous and efficient service with Eighth Army, was withdrawn, being replaced by 518 Field Survey Company from A.F.H.Q., one of the two original units with First Army during operation "Torch." Together with 49 Survey Company (S.A.E.C.), 7 General Survey Section, and 29 Field Survey Depot, 518 Company remained with Eighth Army till the end of the war.

The technical activities of the Eighth Army survey units are referred to in the appropriate sections which follow. That their work was appreciated as playing a worthy share towards final victory is shown by the following message received by D.D. Survey from the Army Commander:—

"I want to thank and congratulate all ranks of the Survey Service for the splendid work you have done throughout the whole Italian Campaign, especially during the last great battle, and since the end of hostilities when you have been as busy as ever. Your success in providing whatever maps have been required has only been achieved as the result of the greatest forethought, energy and hard work on the part of all concerned.

"During the planning stages and during the mobile phases, the pressure has been intense, and the strain on your organization has been great. But with the best possible will you have surmounted every difficulty and you have never failed to meet the most far-reaching demands, often at the shortest notice.

"Well done indeed; you have played an essential part in the final defeat of the enemy."

Fifth Army (Senior attached British Survey Officer—Lieutenant-Colonel A. H. Dowson, R.E.)

As Fifth Army was predominantly American, under American command, the survey organization was basically in accordance with normal U.S. practice. This meant that survey control was exercised by the Army Engineer at Army H.Q. A topographical engineer officer (Lieutenant-Colonel J. G. Ladd) had, however, been appointed to deal with survey matters, and he carried out the functions of what, in the British Army, would be those of a D.D. Survey,

Two British officers were attached from the A.F.H.Q. Survey Planning Increment as his assistants. Lieutenant-Colonel A. H. Dowson R.E. was the senior of these, and he remained at Fifth Army H.Q. for the duration of the campaign.

There was no engineer topographical battalion with Fifth Army but the following units were available throughout practically the whole period:—

66 Engineer Topographical Company (Corps).

46 Survey Company (South African Engineer Corps).

Detachment of 3059 Engineer Model-Making Detachment.

1710 and 1712 Engineer Map Depot Detachments.

The first two of the above units provided strong map-printing resources, and the survey groups of 46 Company carried out most of the field survey work that was required along the army front.

A second engineer (corps) topographical company was available for part of the campaign, but these corps units were under the control of the corps engineer, and it was only by mutual agreement between the army and corps engineers that they were made available for use at army level. Their functions were primarily to fulfil the local needs of the corps they served.

As in the case of Eighth Army, programmes of mapping and revision were delegated to Fifth Army by the Survey Directorate 15 Army Group in accordance with current survey policy laid down by A.F.H.Q.

SECTION 2. MAPS AND MAP PRODUCTION

Italian mapping policy

MEDIUM AND LARGE SCALES

The pre-war national mapping policy of Italy, which was controlled by the Istituto Geografico Militare at Florence, appears to have been concentrated principally on the covering of the whole country on the 1/100,000 scale and also on *either* the 1/50,000 *or* the 1/25,000 scale. The latter covered the towns and more densely populated areas, and the 1/50,000 covered the more open and less densely populated parts of the country. The three scales between them formed the medium and large scale tactical maps of the whole country, including Sicily and Sardinia, and were based on good original surveys. They were on corresponding sheet lines based on the graticule, each 1/25,000 sheet being one-quarter of a 1/50,000 sheet, each of the latter being one-quarter of a 1/100,000 sheet.

The series will now be considered in more detail:—

- (a) 1/50,000 and 1/25,000. The date-range of the copies of these maps available to the War Office just before the war extended over a wide period (1863–1937). Generally speaking, modern revision was concentrated in the north, but in Sardinia nearly all the sheets were dated 1931. In Sicily the 1/50,000 sheets were mostly pre-1900 in the north and dated 1923–37 in the south, but the dates of the 1/25,000 maps varied over the whole island.

Thus the probable current accuracy of these two series, which formed the original basis of all other Italian topographical maps, varied largely from area to area. In some few cases the 1/25,000 originals were enlargements of the relevant 1/50,000 maps.

The Italians published the 1/25,000 maps in black only. For the 1/50,000 series the earliest editions were printed in black only, but later military editions were in five colours with a sales edition in three.

- (b) 1/100,000. This series formed the official *Carta d'Italia*, covering the whole of Italy, Sardinia and Sicily, and varied in date from 1907 to 1937. Early editions were in black only, but later editions were in three and four colours. Here again much of northern Italy and the toe in the south was dated post-1930, Sardinia was wholly 1931, and in Sicily, while all sheets were post-1920, the majority were dated between 1930 and 1937.

SMALL SCALE (1/250,000)

The whole of Italy and Sicily was covered by a 1/250,000 series known as the "*Carta d'Italia del Touring Club Italiano*," dated between 1929 and 1937. This was published on graticule sheet lines on the same basis as the larger scales, and each small scale sheet covered the same area as six of the 1/100,000 sheets referred to above.

War Office mapping programmes

The Directorate of Military Survey (War Office), using its own map production resources and those of the Ordnance Survey, undertook the initial preparation of map series covering the Italian theatre, including Sicily, Pantellaria, Sardinia and Corsica, and the mainland up to the junction with other series either in existence or in contemplation in France, Switzerland, Austria and Yugoslavia.

The following brief notes indicate the scope of such production which began on low priority late in 1941 with the colour-separation reproduction of the 1/100,000 series and the copying of the 1/50,000 and 1/25,000 sheets.

The prime objective was the preparation of reproduction material in the form of kodalines or colour pulls for despatch to the Middle East, and later to A.F.H.Q., so that local printing of stocks could be undertaken when required in case of emergency. The next step was to produce better and more up-to-date editions by incorporating revision, adding colour plates, and sending out fresh kodalines or colour pulls. Considerable use was made of the photo library which was built up at the Central Interpretation Unit (C.I.U.) at Medmenham, where arrangements were made for revision traces to be prepared from available air-photographs. These traces were used either in the United Kingdom for map revision by G.S.G.S. or Ordnance Survey agencies, or they were sent out to the Middle East or A.F.H.Q. for use there.

Priorities for production were subjected to frequent alteration in accordance with changes of strategic plan and forecasts of probable future operations. Sicily, Pantellaria, Sardinia and Corsica had early priority, and the mainland of Italy was naturally taken up from south to north.

In June, 1943, available drawing resources in the United States were offered, and advantage was taken of this by allotting to the Army Map Service, Wash-

ington, the production of new 1/50,000 sheets in northern Italy where almost complete 1/25,000 cover existed, but where 1/50,000 mapping was very limited. The resulting sheets naturally differed in style from those in southern Italy and elsewhere which were direct reproductions from the Italian series (Plate 33).

With the completion of map series on various scales, including a certain amount of revision and improvement done in the United Kingdom, and the despatch of reproduction material to the Middle East and A.F.H.Q., the responsibility for further revision and improvement, and for any new mapping required, was delegated to A.F.H.Q. during 1943 when the War Office was becoming heavily committed on map production programmes for operation "Overlord."

The principal mapping projects will now be considered:—

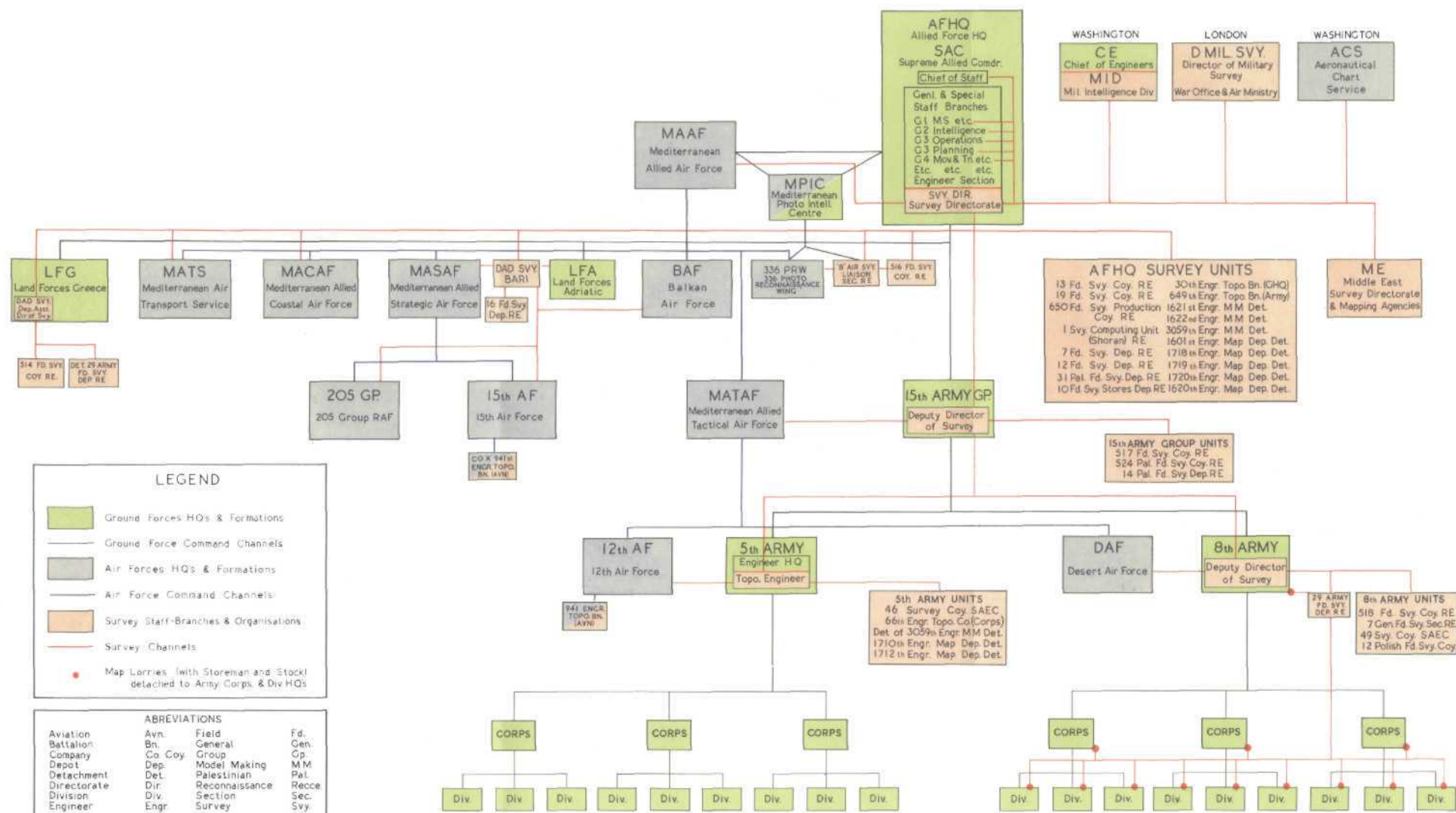
(a) *Small scale.*

- (i) *GSGS 2758. 1/1,000,000 (Europe).* This general series, whose primary use was for topographical "form at a glance" by both Army and R.A.F., covered the whole theatre. By 1943 these sheets were in process of being converted from their original form to Army/Air style.
- (ii) *GSGS 4072. Europe (Air) 1/500,000.* Essentially a flying map which was compiled during 1941–42 and covered the whole Italian theatre.
- (iii) *GSGS 3982. Europe (Air) 1/250,000.* Also an air map and fairly up to date, being compiled, so far as Italy was concerned, mainly from the 1/250,000 Carta d'Italia.
- (iv) *GSGS 4230. Italy 1/250,000 (Plate 28).* Started in November, 1942. It covered Sicily and the Italian mainland, but not Sardinia or Corsica, and was copied by photographic colour-separation from the 1/250,000 Carta d'Italia (dated 1929–37). It was published by G.S.G.S. in Army/Air style with red road fillings, purple layers, green woods, and water in a prominent blue. In the north the series was extended to join, without overlap, the adjacent G.S.G.S. series at the same scale of France, Germany and Yugoslavia.
- (v) *GSGS 3982 (Military).* This was an adaptation of the air map (see (iii) above). It incorporated fuller detail from the Carta d'Italia, and was published in Army/Air style to cover Sardinia and Corsica.

(b) *Medium scale.*

GSGS 4164. Italy 1/100,000. This was a direct reproduction of the Italian 1/100,000 sheets. It suffered in quality owing to the muzziness of the contours and the thickness of the names and basic detail on the Italian originals. Work of reproduction began in the south, and by mid-1943 sheets were available for Sicily, Sardinia and Corsica, and for the mainland as far north as Naples. The first monochrome edition was quickly followed by a second which carried a revision of communications, road classification being shown by red filling, and for Sicily a certain amount of revision was incorporated from air photos. Work continued steadily over the northern areas so as to provide complete coverage at this scale for the whole of Italy.

MAP & SURVEY ORGANISATION MEDITERRANEAN THEATRE OF OPERATIONS 1944 - 1945



(c) *Large scale.*

GSGS 4229. *Italy* 1/50,000 (Plate 30).

GSGS 4228. *Italy* 1/25,000.

The mapping material available consisted of record copies of Italian maps on these scales of which the 1/25,000 sheets covered practically the whole of northern Italy, the majority of Sicily, and odd patches over the remainder of Italy and Sardinia. The 1/50,000 material covered all southern Italy, the greater part of Sicily and Sardinia, and isolated blocks in northern Italy.

The first edition published by the War Office was a facsimile reproduction in black from the Italian sheets with the addition of the British military grid. A second edition was taken up with priority to Sicily, Sardinia and southern Italy. This incorporated some revision, and was made into a coloured edition by emphasizing certain classified roads with a red filling and showing water features in blue. For clarity the basic detail, which included also the contours, was usually printed in brown and, with the overprinted roads and water, it was known as a "griblet"* edition. The revision for Sicily and Sardinia, which was given early priority, included a careful comparison between sheets on all scales so as to get the benefit of whichever one was the most modern. Air-photo revision was also used. In spite of the care taken many errors were found and, in the case of Sicily, which had first operational priority, revision detail was sent to A.F.H.Q. for the local production of third editions.

By mid-1943 the situation was as under:—

Sicily.—Second (coloured) editions of both series had almost completely replaced the first editions. Seven 1/25,000 sheets were completed in a third edition, and several new 1/50,000 sheets were under production so as to complete 1/50,000 cover of the island.

Sardinia.—The second (coloured) edition of the 1/25,000 series had superseded the first edition in the south and in a few other areas, and was approaching completion for the whole island. New 1/50,000 sheets were in preparation so as to cover the island completely at this scale except in the south-west corner.

Italy (mainland).—The first edition had been completed as far north as Rome. Work was continuing on sheets further to the north.

Thus, at the beginning of operations in Sicily and Italy in 1943, A.F.H.Q. was in a position to supply subordinate formations with reproduction material for 1/100,000, 1/50,000 and/or 1/25,000 sheets of operational areas for field printing, and had printed bulk stocks of smaller scale maps either by its own units or through the agency of the survey directorate in the Middle East.

It then became a question of drawing up programmes of further new mapping, revision and printing, and decentralizing responsibility for portions of such work so as to conform to the progress of operations. This was an A.F.H.Q. responsibility as, by the middle of 1943, the War Office was fully committed in the production of map series of western Europe for operation "Overlord."

* Originally the detail was printed in a grey-blue (French "gris-bleu"). Hence the bastard form "griblet."

Mapping preparations in the Mediterranean theatre

The War Office mapping projects for covering the central Mediterranean theatre including Italy were, as mentioned above, of a nature sufficient to provide an initial map coverage which was both adequate and essential to meet an emergency. In the late spring of 1943, however, with the probability of early operations in Sicily, Sardinia, Corsica and the mainland of Italy, it now devolved on the local survey organization within the theatre to amplify and improve the map series which had already been provided.

At an early stage of operations in the Middle East, the survey directorate there had called for photographic coverage of selected priority areas, not only for revision but also for the production of new 1/25,000 sheets, including Sicily where there were gaps in the Italian series. During the spring of 1943 A.F.H.Q. was fully occupied in conducting the closing stages of operation "Torch," but after the victory in Tunisia in May, 1943, D. Survey A.F.H.Q. assumed mapping control for future operations in the central Mediterranean, and the extensive resources of the survey service in the Middle East were placed at his disposal to augment those already under his control.

SICILY, SARDINIA, CORSICA AND SOUTHERN ITALY

The work of preparing maps of Sicily was about equally divided between North Africa and Egypt, planning and control being vested in A.F.H.Q. In general the work carried out by A.F.H.Q. was for American forces, and that done in Egypt was for use by Eighth Army. By means of interchange of visits and other means of co-ordination the production programme went well ahead.

Further preparation and printing of map stocks for the coming operations in Sicily continued. This included the production of several new 1/25,000 sheets covering gap areas, and the revision of others previously published. This work was done largely by 649 Engineer Topographical Battalion (U.S.) and 516 Field Survey Company R.E. Difficulty was experienced in interpretation owing to the fact that small scale photographs had to be used for 1/25,000 revision. A few of the new 1/25,000 sheets were produced by enlargement from existing 1/50,000 maps and incorporating revision from air-photos.

The presence of American troops, who were accustomed to the use of special road maps, led to the preparation of a 1/500,000 road map of Sicily and Sardinia, and also to the production of a large number of 1/25,000 photo-maps. Defence overprints were compiled and printed on maps of Pantellaria and Lampedusa, the former being at 1/25,000 scale, and the latter at about 1/16,000.

The short campaign in Sicily during July, 1943, showed that mapping preparations had been satisfactory (see Chapter XII, Section 4). It now became necessary to intensify the projects required for coming operations on the mainland of Italy, in Sardinia, and in Corsica. At an early stage of planning the possibility had been considered of capturing the latter two islands as a prelude to landing on the mainland. The task of amplifying and revising the maps of Sardinia and Corsica had therefore been undertaken with fairly high priority.

The military edition of the 1/250,000 Air Map (GSGS 3982) covering Sardinia and Corsica was revised, and the necessary material was sent home to the War Office so that a new edition could be published. The French Service Géographique in Algiers revised the 16 newly drawn G.S.G.S. sheets

of Corsica at 1/50,000 scale from a set of modern 1/80,000 maps which they had available. Survey units at A.F.H.Q. undertook a rapid revision of the 31 1/100,000 sheets of GSGS 4164 covering Sardinia and also produced photo-maps of parts of the island.

In the case of the mainland in southern Italy a revision programme for the 1/50,000 sheets had been in hand with Middle East for some time, and this was now hastened. At the same time A.F.H.Q. was examining the sheets with a view to the production of a third edition, and air-photos and other revision material were allocated to Eighth Army for a block of sheets in their future operational area. During August 12 third-edition sheets of the mainland were completed, 200 were in hand with Middle East, and 17 with Eighth Army. In preparation for the impending landings at Salerno and Reggio early in September, the survey units at A.F.H.Q. and with Fifth and Eighth Armies were kept busy printing stocks for the operation.

It has already been noted that over a considerable part of northern Italy there were no 1/50,000 maps. The War Department in Washington asked that this gap should be filled, and in June, 1943, it was agreed that the Army Map Service would take up the production of newly compiled sheets covering practically the whole of Italy lying to the north of Lat. 42°20'. These sheets, which were based on the existing Italian 1/25,000 series and included revision from air-photos where such were available, were published in colour. They naturally differed in style from the existing sheets of GSGS 4229 in southern Italy which had been reproduced from the Italian maps direct. Thus, with the exception of a few isolated areas, the whole of Italy was eventually covered by 1/50,000 maps.

Many miscellaneous mapping tasks of a special nature were undertaken in preparation for the landings and their exploitation. Sheets of the 1/250,000 series were overprinted with road information. Water supply data were overprinted on 1/500,000 maps. Sheets of the 1/50,000 series in the toe of Italy were, after revision of the basic detail, overprinted with enemy defences, beach detail and other topographical information supplied by G-2 (Intelligence).

On the larger scale (1/25,000), of which there was only a very limited amount of original Italian mapping in southern Italy, revision had been in hand with Middle East and, during August, A.F.H.Q. organized a revision programme for a third edition and for the overprinting of defence information on selected sheets.

When the invasion of the toe of Italy was undertaken by Eighth Army, it was understood that its advance would not proceed further than the Catanzaro neck. The German resistance at Salerno caused a change in plans, and Eighth Army was instructed to push forward at all speed to effect a junction with Fifth Army. Owing to the original instructions, and the fact that the 1/50,000 sheets were being revised, only small planning stocks had been printed of the unrevised 1/50,000 sheets in that area. It now became necessary to provide full bulk stocks for use by Eighth Army during its advance northwards. During the month of September, 13 Field Survey Company R.E. moved ten times from one location to another and, during the remaining 20 working days, it managed to print on its mobile equipment well over 1,000,000 copies of these maps, which was an effort well worthy of record.

General mapping and revision policy for the standard map series

As soon as the campaign on the mainland had been launched, A.F.H.Q. was faced with the problem of ensuring that the allied armies fighting their way

up through Italy should be adequately supplied with essential maps in sufficient numbers and as up to date as it was possible to make them in the time available.

The initial production and revision work of the War Office and the Middle East had given an excellent start. The general controlling policy of D. Survey A.F.H.Q. was to decentralize mapping and revision responsibility for the 1/100,000 and larger scales to the survey organizations in the field for those areas which were of immediate tactical interest to them. For such areas A.F.H.Q. handed over to 15 Army Group all available material which was required for the work, such as air-photographs, revision correction traces where already made, and so forth. D.D. Survey 15 Army Group then sub-allocated tasks to Fifth and Eighth Armies, retaining some of the work to be done by survey units under his direct control. The armies were primarily concerned with the revision and production of maps covering their current operational area and the areas immediately ahead. As sheets of the larger scales were revised, the revision of the corresponding 1/100,000 sheets was taken up. In addition to the air-photos and other material supplied by A.F.H.Q., the armies obtained further photo-cover through army channels, and made use of captured maps and other acquired material.

15 Army Group, with its two armies, was responsible generally for the battle-zone itself and for the areas immediately ahead of and to the rear of it, while A.F.H.Q., with Middle East assisting, assumed responsibility for other areas within the theatre, both inside and outside Italy. Whenever the survey units in the field were in a position to undertake any work surplus to their own army group or army requirements, tasks were allotted to them from A.F.H.Q.

As the armies moved north there was, in consequence, a constant change in the allocation of spheres of mapping responsibility between A.F.H.Q. and subordinate formations. In Italy, as in other theatres, the survey directorates with the field armies, who bore direct responsibility for the day-to-day provision of maps to the fighting troops and planning staffs, were often apprehensive about whether the revision and supply of map material for areas ahead of the current battle-zone would be available from behind in time for them to get the stocks printed. The tendency was, therefore, for them to conduct their own revision of all tactical maps which were likely to be required in the near future.

Field formations were, in general, responsible for the printing of their own stocks of medium and larger scale maps, and bulk stocks of the smaller scales were printed and supplied by base installations. In this connection Middle East carried out a great amount of work for A.F.H.Q. on an agency basis.

It has already been noted that the first editions of the G.S.G.S. reproductions from Italian medium and large scale maps were in monochrome only. The task of producing revised editions included not only the revision of the basic detail but also the preparation of colour overprints for roads, woods, etc., in order to clarify the somewhat crowded detail and make it more legible.

Early mapping preparations for the invasion of southern France

The landing of an allied force in the south of France to assist General Eisenhower's main assault in Normandy had been considered during the early stages of planning. D. Survey A.F.H.Q. had therefore taken early steps to initiate a programme of mapping for those areas which seemed most likely to be concerned. Mapping projects for the major operation in western Europe

("Overlord") had been in hand with the War Office since 1942 and sheet line systems and map design for the whole of France had already been laid down by G.S.G.S. Within this general scheme, therefore, D. Survey A.F.H.Q. assumed responsibility for the preparation of maps covering those parts of southern and south-central France through which an allied invasion force from the Mediterranean would most likely operate. The whole programme was co-ordinated by the Survey Directorate (War Office) and, with their agreement, D. Survey A.F.H.Q. farmed out much of the work direct to American mapping resources in the United States.

Early references indicate that as far back as August and September, 1943, revision work was in hand at A.F.H.Q. for certain of the prospective 1/50,000 sheets of southern France, as well as for the French 1/200,000 series. Some of the results of this work were sent back to the War Office to assist in the production of the regular series.

As time went by, and the target date for the operation was postponed, mapping programmes were amended to fit in with other requirements. Later on, when a definite decision was taken to undertake the operation, the work was again intensified.

Mapping activities during the autumn and early winter of 1943

After the breach of the R. Sangro position in November, heavy rains set in and movement was slowed down. This eased up the map-printing situation (the printing "run" for 1/50,000 maps was temporarily reduced in Eighth Army to 5,000 for the two corps), and this enabled personnel to be given a rest and machines to be overhauled. In December these numbers were raised again to 12,000 for the 1/50,000 scale and 20,000 for each of the 1/100,000 sheets.

Fifth Army produced defence overprints on 1/50,000 base maps for the planning and execution of the Anzio assault operation. Relief models and photo-mosaics were also included.

By the end of September the maps of southern Italy had either been completed or handed over to field formations for them to revise and put into "griblet" form. A.F.H.Q. then became heavily engaged on revision programmes for maps of northern Italy, Middle East taking over a large share of this work. All work at A.F.H.Q. on maps south of Lat. 42° 20', except in the Naples area, then stopped. Bad weather during November prevented systematic photography, and many gaps in northern Italy still remained uncovered.

In December an "improvement" programme was started by A.F.H.Q. for the 1/50,000 series extending from just north of Rome as far as Rimini. For some sheets better quality original Italian material was obtained from G.S.G.S. and new reproductions were made. In other cases existing kodak negatives were improved by extensive touching up and photo-writing. In the case of the newly produced U.S. Army Map Service (A.M.S.) sheets the Canadian type of grid "ladder" numbering was added.

During the winter of 1943-44 there was a demand for a layered edition of the 1/100,000 sheets. Layer plates were prepared for printing in brown and green, with white for the bottom layer up to 100 metres altitude. In many of the coastal and valley sheets of low altitude this meant that there was no layer-colouring at all, a fact which considerably eased production. Requests were frequently made throughout the campaign for the layering of 1/50,000 sheets

and even of the 1/25,000. In a few cases of special importance this was done, but it was beyond the capacity of the survey service to take this on as a regular programme except to the detriment or even cancellation of other much more vital work.

The U.S. Army, during its training, had been accustomed to the use of special road maps for road movement as distinct from the normal type of topographical map. They therefore produced a 1/200,000 road map of the mainland which was good and clear, and was much used for movement purposes. It became a best seller (Plate 34).

Eighth Army mapping activities early in 1944

In January, 1944, revision responsibility for an area just north of Florence-Rimini was passed to Eighth Army. Revision of 1/25,000 sheets started in the Ancona and Pesaro areas, followed by that of the 1/50,000 and 1/100,000 scales. During January Eighth Army fought along the Ortona-Guardiagrele front where the 1/50,000 maps were found to be very inaccurate. They had been revised in October from incomplete, small scale photo-cover, but it was clear that the original survey was of inferior quality, and more accurate and legible maps were requested by the artillery. The following work was then taken up by survey units of Eighth Army:—

- (a) The revision of the 1/50,000 sheets using photos of larger scale.
- (b) The production of 1/25,000 "key" maps for artillery use.
- (c) The production of a limited number of new 1/25,000 sheets of areas in front of its present position.

Owing to the inaccuracy of the 1/50,000 maps in this particular area, a rapidly produced type of skeleton 1/25,000 map known as a "key" map was produced to satisfy the minimum needs of the artillery in the shortest possible time. It was essential to reduce to a minimum the amount of detail to be plotted, and the R.A. quoted as essential the showing of streams (which ran in deep and very steep-sided ravines), tracks and track-junctions. It was agreed that plotting errors not exceeding 50 metres relative to the grid would be tolerable.

A trial sheet was produced by a topographical section of 514 Field Survey Company. The detail was plotted in the field in pencil from 6-inch (focal length) vertical photographs which had already been block-plotted and enlarged to 1/25,000. The compilation took a few hours only, and the pencil drawing was then sent back to the unit for fair drawing and reproduction. This trial sheet aroused considerable interest in both corps, and other sheets were produced. The idea was to improve these "key" maps in two stages, first by adding more detail and then by adding form lines so as to provide large scale maps for "set-piece" attacks by all arms. The average time of production was four days for the "key" map in skeleton, and ten days for the improved version. They were widely used.

Some new 1/25,000 sheets were made following the general style of GSGS 4228, but omitting unimportant detail. The master-control was laid down by slotted template, the detail being compiled from enlarged 6-inch vertical photos and large scale obliques. Contours were obtained by two methods. In one case height control was obtained from the coast-line, spot heights, and trig heights on the 1/50,000 maps, supplemented by parallax readings from 6-inch

enlarged photos, contouring being done under the Fairchild stereoscope. In the other case contours were taken from the 1/50,000 sheets, and adjusted to the actual ground shape as indicated by photos under the stereoscope.

"Going" overprints were produced to assist movement by armoured vehicles, and they illustrated lines of approach and natural obstacles based on interpretation from air-photos. Quick ground appreciation was almost impossible from the very fully detailed Italian-type maps in their original form (Plate 35).

Eighth Army penetrated the enemy defences on the Adriatic coast during January, 1944, and then, during the rest of the winter of heavy rain and bad weather conditions, held firm in their newly gained positions while the fighting round Anzio and Cassino was going on further to the west. Little photography of survey quality was coming in at this time owing to the bad weather, though a certain amount of gap-filling reconnaissance photography was obtained, and revision continued of forward areas where there was now an increasing demand for 1/25,000 maps.

Arrival of 30 Engineer Topographical Battalion (U.S.)

This unit, with its extensive mapping resources including multiplex equipment, became available for work at A.F.H.Q. during February, 1944, and was employed without delay on the following types of work:—

Improvement and revision of 1/50,000 maps of Italy.

Collation maps of Italy (1/50,000).

Block-plots in Fifth Army area.

Revision and improvement of 1/25,000 maps of eastern France.

Town plans in southern France.

A.F.H.Q. was asked to prepare block-plots covering areas in advance of the actual Fifth Army front where there was little trig control, and where the available photos had excessive tilts. The photo-centres were located by multiplex methods to facilitate radial line plotting, and the multiplex equipment was also used to bridge the gaps between available control.

The spring and early summer of 1944

Various changes and exchanges of survey units took place between A.F.H.Q., 15 Army Group and the two armies during the spring. In March, Eighth Army took over part of Fifth Army front, but the latter's revision of the maps concerned was up to date, and the former was able to embark on a long-term revision programme. The production of new 1/25,000 maps from air-photos was also initiated where, hitherto, only enlargements from the 1/50,000 had existed. With better weather more photography was coming along to aid these projects.

During April, when conditions on the front were more or less static, two important developments occurred, namely, the demand for and provision of gridded large scale vertical photos, and a large increase in the demand for 1/25,000 maps.

An alternative strategical plan, which might have involved possible operations in northern Yugoslavia, made it necessary to prepare mapping cover of that part of the Balkans. New multiplex mapping of Yugoslavia at 1/25,000 was therefore started, and the A.F.H.Q. revision programme of Italy on

1/25,000 scale was now confined to the area of Milan and the north-west, with Middle East concentrating on the revision of north-eastern Italy round the Gulf of Venice. For southern France the revision of GSGS 4411 (1/25,000) was nearing completion for the limited areas taken up, and revised kodelines were sent home to the War Office. The 1/50,000 maps of eastern France (GSGS 4471), which had been reproduced direct from modern French sheets, were too large to be printed on the American mobile field presses, and were therefore modified in size.

During May, in connection with the allied offensive towards Rome, the main mapping effort at A.F.H.Q. was the production by multiplex methods of new 1/25,000 sheets in an area to the north of Rome. The control framework was dense and good, and blocks were laid down by slotted template. As events turned out the rapid allied advance during June and July outran much of this new work, comparatively little of it being available in time, but the project afforded valuable lessons in technique and training for the personnel of 30 Engineer Topographical Battalion.

The field armies, as a result of their northward advance, now approached close to an area covered by a large block of modern Italian 1/25,000 mapping which had been extensively revised.

As good-quality survey photography had been obtained over southern France, A.F.H.Q. started the production of new 1/25,000 sheets. They also sent over to A.M.S. Washington the original negatives and other material for a block of sheets in the Upper Rhone Valley so that production could be undertaken there. By the end of July complete 6-inch cover existed over southern France south of Lat. 46° and east of the Paris meridian. It was generally found, however, that 6-inch photos taken from 30,000 feet were unsatisfactory for mapping on 1/25,000 and 1/50,000 scales unless they were supplemented by larger scale photos for identifying control and interpreting map detail.

In July, Eighth Army was busy preparing for an advance along the axis Florence-Bologna through the Gothic Line. Then in August there was a change of plan involving a thrust along the Adriatic coast through Pesaro and Rimini to Faenza and Ravenna. This necessitated another big programme of gridded photos and defence and "Going" overprints, and the building up of map stocks for 14 divisions. With this change of plan, Eighth Army was able to hand over to Fifth Army large stocks of maps covering the axis Siena-Florence-Bologna, thus avoiding an overlap of effort and waste of resources.

Map records

Survey branches with all the major formations, *i.e.* at A.F.H.Q., H.Q. 15 Army Group, and the two armies, found the need for establishing Map Record Sections. This was generally done by allocating to one particular unit the responsibility for receiving, holding, indexing and issuing the material required for the carrying out of revision and new mapping projects. This included library-record copies of maps, air-photos, captured maps and other acquired material. Thus the holding and control of such material was centralized and properly organized in each formation and, as responsibility for areas changed, it became necessary to transfer the map-record material from one formation to another. By July, 1944, the armies held all available map-record material for the 1/100,000 and 1/50,000 series right up to the north of Italy,

with 1/25,000 material up to about 46°, and reproduction material for the latest edition of the 1/50,000 maps of northern Italy was received from Washington in August and passed on to both armies.

Relief models

The production and use of relief models on various scales was a regular feature in the American Army. They had trained and provided special model-making detachments for this purpose and, whenever conditions became static, or there was planning for a staged offensive, models were usually constructed of the enemy positions. In June, for example, models at a scale of 1/25,000 were made of the Pisa-Rimini Line.

Italian Military Geographical Institute

The Italian national survey organization had its headquarters in Florence. During German occupation it had been employed on cartographic work for the benefit of the German forces in Italy and, when the enemy was driven out of Florence, most of the equipment was stripped, though the buildings remained intact. Much of the original staff still remained in Florence and was collected together. Survey records had mostly been removed by the Germans, but a certain number of printing plates of Italian series and some original drawings were still held.

By degrees the Institute was restored to a workable basis under its own control and, under allied supervision and direction, it was eventually used to assist in map production work of various sorts.

Final mapping preparations for the invasion of southern France

The date finally fixed for the assault invasion of southern France by Seventh (U.S.) Army was 15th August, 1944.

Survey planning was now intensified by A.F.H.Q. and was divided into two phases. During the first phase which ended on 7th July, Survey Directorate A.F.H.Q. was located alongside H.Q. Seventh (U.S.) Army at Bouzarea in North Africa, and all the resources of A.F.H.Q. survey units were made available. Much help was also given by the Survey Directorate Middle East.

The second phase started on 7th July, when A.F.H.Q. and H.Q. Seventh Army moved to Naples. From then until "D"-day the Survey Directorate maintained a detachment of two survey officers and four other ranks at Seventh Army H.Q. to assist in their mapping problems. A drawing section was also attached to G-2 (Army) to prepare their Intelligence and collation overprints. During this phase two Field Survey Companies (13 and 516) worked under the survey detachment at Seventh Army H.Q. under the strictest security conditions. 19 Field Survey Company was released from 15 Army Group to work under A.F.H.Q. control, and the resources of 30 and 649 Engineer Topographical Battalions were available.

From 10th July till 15th August the three British field survey companies mentioned above worked exclusively on special mapping projects for the operation, including collation maps, special overprints, "Going" maps, beach panoramas, the layering of 1/50,000 maps, and the preparation of a "Gee" lattice chart for radar navigation control of aircraft. All the work was conducted under the strictest security, no passes being allowed till after "D"-day.

Officer couriers were used for escorting map material between the survey directorate and units doing the work. Armed escorts were employed, and follow-up vehicles were arranged for in case of a road crash.

649 Engineer Topographical Battalion produced a number of annotated photo-mosaics, and over 50 relief models were constructed for the operation. During August 30 Engineer Topographical Battalion completed 42 new 1/25,000 sheets by multiplex in the Rhone Valley, and A.M.S. Washington was working on a block of 1/25,000 sheets further to the north. Many new town plans were prepared by A.F.H.Q. units, and the revision programme included 45 sheets at 1/25,000 and 54 at 1/50,000. Bilingual (English-French) marginal data were prepared for all 1/25,000 and 1/50,000 sheets in the area, and bulk stocks of these series were printed. There were, in addition, many miscellaneous maps, diagrams and other special productions to meet the requirements of the Navy, Army and Air Force staffs. In all, over 15,000,000 copies of maps were issued for the assault and establishment of the bridgehead.

The subsequent rapid advance of Seventh Army up the Rhone Valley brought about many changes in the A.F.H.Q. mapping programme, and it was necessary to switch resources rapidly from one job to another as old needs were cancelled and new ones arose. During September, machines were working at full capacity printing the 1/100,000 and 1/250,000 series of eastern France and southern Germany. 19 Field Survey Company was running five machines three shifts a day and supervising the work of two civilian printing firms.

By October Seventh Army had advanced so far that all uncompleted work on the mapping programmes of southern France at A.F.H.Q. and at A.M.S. Washington was cancelled.

The autumn and winter (1944-45) in Italy

By the end of August, 1944, as a result of the allied offensive following the capture of Rome, the enemy was back on the main Gothic Line, but this was broken through during September by Fifth Army in the west and by Eighth Army in the east. The large scale map situation from now on was good, as there was complete 1/25,000 coverage ahead right up to the northern Italian frontier.

Bitter fighting between Pesaro and Rimini and beyond slowed up progress and enabled the revision programme to be brought well up to date. By the end of September, Eighth Army had examined and corrected practically all the 1/25,000 sheets as far as Venice, and the new A.M.S. 1/50,000 sheets north of the R. Po had been checked over. Opportunity was also taken to carry out a revision of communications (*i.e.* roads and railways) on both the 1/50,000 and 1/100,000 sheets before printing.

46 South African Survey Company and 66 Engineer Topographical Company, who were serving the mapping need of Fifth Army, were constantly engaged on the revision and stock-printing of the standard series and of the many miscellaneous tasks required of them.

There was now a big demand in Eighth Army for large scale gridded photographs. Two sections working two shifts turned out an average of 20 a day. The gridding was done from 1/25,000 maps with an accuracy, it was claimed, of 25 metres in close, and 50 metres in open country. These gridded air-photos were used by forward infantry and their supporting artillery as a quick and sure means of identifying small but important target detail which was often very obscure or not shown on the maps. Description started with the photo-serial num-

ber, then the grid "square," after which the description was worded the same as if the ground itself were being viewed. The photos were indexed on the maps.

The withdrawal of German forces in all parts of Europe during September, 1944, led to an increased potential demand for maps covering all the approaches into Germany, thus giving urgency to many A.F.H.Q. mapping liabilities. Work was intensified on map production for northern Yugoslavia and southern Germany in case of a sudden German collapse. A large printing programme of 1/100,000 maps of southern Germany, Austria and Hungary was undertaken, and several town plans along the southern approaches to Vienna were compiled. Between September and December the Survey Directorate at H.Q. 15 Army Group concentrated on an extensive revision programme of the Yugoslav 1/25,000 and 1/50,000 series. Action was also taken for Middle East to supply small quantities of all available large scale maps of the southern Balkans and the Aegean Islands.

Early in September, Sixth Army Group (Seventh U.S. and First French Armies) passed beyond the A.F.H.Q. theatre boundary in France and thereafter came under S.H.A.E.F. control, but A.F.H.Q. continued to assist by printing and supplying road maps and 1/250,000 scale maps of eastern France and southern Germany.

In October, 30 Engineer Topographical Battalion was under orders to leave the theatre for duty elsewhere and their cessation of work was a great cartographic loss to A.F.H.Q.

On Eighth Army front progress was slow during October in the flat, wet country between the Rimini-Bologna road and the Adriatic. Map revision kept well up to schedule, and was extended beyond Venice along the general line Padova-Gorizia.

Revision of 1/25,000 maps of Italy

It may be of interest to note some features of the technical specification issued by Survey Directorate Eighth Army in connection with 1/25,000 revision from air-photos. Generally speaking a complete and thorough revision of everything of military importance was required. Examples of items which were *not* considered to be of military importance, and which were not to be included for revision were the following:—

- Footpaths and mule tracks in flat country.
- Minor corrections in shape.
- Very small buildings, especially in built-up areas.
- Semi-permanent buildings, such as huts.
- Vegetation, except where it had a definite pattern and was a landmark.

All illegible, thick, and weak parts of the basic detail were to be clarified and improved. It was found that from seven to 21 man-days were required for each sheet for compiling the correction trace, and from seven to 14 man-days for correcting the kodak film, of which from one to seven man-days were required for the clarification and improvement of the existing detail on the film. The work was normally classified as second and third priority, and quality was given precedence over speed except when the time factor was paramount to meet operational requirements. A full 100 per cent check of all work was required, and every use was made of small scale photo-cover, especially for revisions covering a large area, in connection with road and rail communications, lakes, coastlines, woods, etc.

Revision of communications

This type of revision was sometimes undertaken on all the three larger scales before printing when opportunity offered. The main task was the adding of new communications detail for roads, railways, etc., and the deletion of old detail where it no longer existed on the ground according to air-photo or other evidence. In the absence of other information, the classification of new roads had often to be determined from the photos alone. It was necessary to make a careful study of the system of road classification which was given in the "Notes on G.S.G.S. maps of Italy," published by the War Office. When compiling their own series G.S.G.S. translated the Italian functional classification into terms of width and surface. This was quite arbitrary, and gave a good approximation in average country, but did not apply in exceptional types of country such as in Alpine areas. It was a generally accepted rule that the classification of roads shown on the map and still existing should never be altered as a result of photo-study alone unless there was some quite definite evidence of a change of function. The final authority for position in all cases was, however, the air-photo.

Fifth Army revision activities during 1943-44

The normal allotment of topographical units to a U.S. Army was one engineer topographical battalion and three engineer topographical companies (one for each corps). There was never at any time a topographical battalion with Fifth Army, and for most of the period under review there was an average of only two survey units available, the 66 Engineer Topographical Company and the 46 South African Survey Company (S.A.E.C.), together with part of a model-making team and engineer map depot detachments.

The topographical units were kept at full stretch. Their main task was the preparation of revision models and the actual revision correction of the kodak films for all three scales, 1/100,000 and larger. The following figures give a summary of their revision output from August, 1943, to November, 1944:—

General revision from air-photos	459 sheets
Wholly redrawn	35 sheets
Straight photographic enlargements	19 sheets
Newly compiled and drawn from air-photos	3 sheets
General revision from captured sheets	45 sheets
Redrawn for clarity	5 sheets
	—
Total	566 sheets
	—

Mapping in Greece

When 3 Corps was sent to Greece to deal with the rebel rising there a small survey directorate and 514 Field Survey Company R.E. accompanied the force. Various mapping jobs were undertaken in addition to the task of helping to put the Greek Military Topographical Service on a working basis. Four new 1/25,000 sheets were completed in the Patras area, and one new 1/50,000 sheet round Athens. A new 1/500,000 road map of Greece was also produced. Revision work on the 1/100,000 series was hindered by the interference of rebel activities.

Liaison with the Greek Military Topographical Service was established in January, 1945. They co-operated well, contributing accommodation, equipment and air-photos. With assistance from Middle East a new mapping programme was then initiated in connection with the rehabilitation of the Topographical Service, including:—

- A complete 1/100,000 series of the whole country with Greek characters.
- The overprinting of Greek characters on the existing 1/250,000 series.
- A bilingual edition of the new 1/500,000 road-map.

Mapping preparations for the spring offensive (1945) in Italy

By the end of 1944, the probable form of the final operations in Europe began to take shape, and the mapping situation became more or less clarified. The reconstruction in December, 1944, of H.Q. Allied Armies in Italy as H.Q. 15 Army Group as an operational and tactical headquarters only, involved the transfer of certain mapping programmes and units to A.F.H.Q. The latter then took over responsibility for all mapping outside northern Italy, for which purpose any spare productive capacity of 15 Army Group units was placed at A.F.H.Q. disposal. The new A.F.H.Q. mapping programme now centred mainly on Austria and northern Yugoslavia.

During December, 1944, A.F.H.Q. had been studying the map situation for Austria. There was an existing Austrian series at 1/75,000 from which A.F.H.Q. produced two pilot sheets in "griblet" form, at a scale of 1/50,000. The intention was to cover the whole country first of all with a monochrome edition by direct photographic copying from a library set of the Austrian 1/75,000 sheets obtained from the War Office. This was to be replaced north of Lat. 47° by a second revised edition in "griblet" form. Concurrently arrangements were made to send over original 6-inch negatives to Washington where A.M.S. would compile by multiplex about 80 new 1/25,000 sheets of selected areas south of Lat. 47° for publication at 1/50,000 scale. A similar programme of another area was arranged with the Chief Engineer E.T.O.U.S.A. in Paris under the topographical control of D. Survey S.H.A.E.F. A.M.S. also undertook the compilation from Austrian map material of further 1/50,000 sheets where no photo-cover was available. These would eventually replace corresponding "griblet" sheets of the originally produced A.F.H.Q. 1/50,000 series (Med. 4). A further programme was undertaken by the War Office whereby they would produce a number of 1/50,000 sheets by colour separation from Austrian originals. These were to replace sheets of the original Med. 4 series. G.S.G.S. also undertook the reproduction by colour separation of all available Austrian 1/25,000 sheets for publication as GSGS 4529.

To meet 15 Army Group needs, A.F.H.Q. modified selected sheets of the 1/100,000 series (GSGS 4416) in Germany, Austria and Hungary by introducing certain colour changes including those for road classification. Middle East prepared layer plates on the brown and green system already used for Italy.

The programme of 1/25,000 production and revision for northern Yugoslavia, which had been started by 15 Army Group, was continued under A.F.H.Q. control. The 1/100,000 and 1/50,000 series were also under revision, and town plans for the same area were compiled so as to be ready for possible operations there.

Several special maps for air use were produced including Radar Navigational Charts. A novel form of relief map at 1/M scale was issued in negative form

in which the normal detail appeared white on a black ground. This was found useful for navigational purposes. Sheets of the Europe "Air" series at 1/500,000 in south-eastern Europe were overprinted with flak information.

516 Field Survey Company R.E., working under A.F.H.Q. control in support of 336 Photographic Reconnaissance Wing, was employed largely on the production of lithographic photo-mosaics, communication overprints, and other intelligence maps.

Target fixation and the plotting of enemy defences

No. 7 General Survey Section R.E. was attached to the Mediterranean Air Intelligence Unit (M.A.I.U. West) for several months. Its principal tasks were the fixation of targets for the counter-battery organization (C.B.O.), a check of the plotting of the Italian trig points on the maps, the calculation of grid constants, and the plotting of enemy defences, which had been located on reconnaissance photos by the M.A.I.U. interpreters, for subsequent incorporation in defence overprints.

The fixation of targets was effected by first of all transferring their positions from reconnaissance photos to survey photos, the grid co-ordinates of whose principal points had already been determined and plotted on a skeleton block-plot. By means of radial line methods of intersection, the position of each target was fixed and its co-ordinates measured from the grid. The programme was a continuous one, each move forward introducing a new set of targets whose positions were required by the C.B.O.s so that concentrated artillery fire could be directed on to them if required.

During static periods a dense system of such targets was established on the enemy front. Between May and September, 1944, over 1,200 such fixations were determined, and with the advent of bad weather conditions 7 General Survey Section was then temporarily removed from M.A.I.U. for other urgent work, returning again in time to carry out further target fixations before the spring offensive. This target fixation work eventually came to an end late in April, 1945, when the enemy forces had been defeated and were retreating. Ground checks on 42 targets fixed on the Senio front showed that the mean point of impact of shells was on the target in 25 instances, and in only three cases was it more than 50 yards off. Assuming perfect gunnery this represented a very satisfactory result.

The need for the determination of grid constants was brought about by the fact that, over various parts of the Italian mainland, variations were found in the relation between the list co-ordinates of trig points and their plotted positions on the map relative to the grid. As the gun positions were as a rule fixed by survey methods in terms of trig co-ordinates, and the targets were often fixed cartographically by direct measurement from the grid on the map, it was essential that the two should be in sympathy. For each sheet, therefore, a constant was determined which would put one lot of co-ordinates in sympathy with the other. The chief users of these grid constants were the C.B.O. staffs.

The constants were required to be accurate to about 25 metres, and experiments determining the values indicated that they lay generally within this margin. Although giving a good indication of the accuracy of the overall projection plot, the constants did not take into account random errors in cartography. It is of interest to note that the standard of cartography apparently fell towards the north of Italy.

Controlled photo-mosaics

American artillery units had been led to expect, during their peace-time training, that their engineers would produce controlled photo-mosaics for them. Consequently, in the early stages of the Italian campaign, particularly in the Liri Valley, they made repeated demands for them. Most of their training in the United States had been over relatively flat country where the production of these mosaics offered little difficulty. Italy, on the other hand, was extremely mountainous, and this fact, coupled with the inadequacy of the air-photo cover available, the lack of sufficient trig control, and the shortage of survey resources, made it impossible for the Army Engineer to meet the artillery demand. In spite of this, controversy went on for some time and culminated in a compromise by which survey resources were devoted mainly to the production of new or revised large scale maps, but were also used for compiling what were termed "semi-controlled" mosaics. These were made usually from large scale low oblique photographs which had been approximately rectified, and were laid down more or less on large scale map control. Warnings were issued that they were not as accurate as the maps, and therefore could only be considered a supplement to, and not a substitute for them. They were lithographed and were very variable in quality.

The final period (January-May, 1945)

The relatively static nature of operations during the rains and fogs of January, February and March, 1945, afforded an opportunity for much progress in mapping preparation both at A.F.H.Q. and with the field formations.

In Eighth Army two new features arising in January were the layering of a few selected 1/25,000 sheets for a special purpose, and the preparation of a new type of topographical overprint on 1/25,000 maps for selected defended areas (Plate 31). The special information was overprinted in red and blue on a brown base, and presented in clear form to the user valuable information regarding roads, bridges, waterways, crossing places for tanks and infantry, flooded areas, etc. In the case of the waterways, sections of the banks and the widths were shown by marginal sketches. These topographical overprints were in great demand. During February, Eighth Army produced a block of eleven such sheets, and also a number of defence overprints in the battle area. In March a large programme of gridded 36-inch air-photos was taken up covering most of the immediate battle zone.

The planning staffs were now urgently asking for maps of Austria in anticipation of future movement northward, so practically all the drawing resources with A.F.H.Q. were concentrated during February on the preparation of the first monochrome edition of the 1/50,000 (Med. 4) series covering the whole of Austria. Concurrently, revision models were in preparation for the second "griblet" edition which was to replace the monochrome sheets north of Lat. 47°.

A special road map at 1/300,000 scale was put in hand to cover Austria and north-western Yugoslavia by the colour separation of an existing motoring map. Meanwhile 15 Army Group and its two armies continued their programmes of revision and printing of the maps of northern Italy on scales from 1/25,000 to 1/100,000, and were also doing revision work of areas outside Italy on an agency basis for A.F.H.Q. The mapping situation for northern Italy was now well on in the course of preparation for the coming allied offensive.

Fifth Army, in addition to its extensive revision and printing commitments, was continuing to turn out relief models of enemy positions for planning and briefing purposes, and was also producing a number of semi-controlled photo-mosaics at 1/12,500 scale.

In April the Allies delivered their full scale assault. The success of the mapping and survey arrangements during this battle was largely due to the excellent initial provision of maps by the War Office, the early acquisition of properly taken survey photographs, the forethought, good organization, skill and industry of the survey staffs and units at all levels, the complete and harmonious working together of the allied surveyors, and the time that was available for revision and printing. Apart from the regular series much value was gained from the defence overprints, topographical overprints, gridded photos, semi-controlled mosaics, and the target fixations.

In western Europe the Allied Forces under General Eisenhower were, by April, moving rapidly into Germany in pursuit of the defeated German armies and this, combined with the rapid advance of the Allies in Italy and the Russians from the east, stretched survey resources to the limit. Previously planned programmes had to be recast, and it seemed probable at one time that troops of General Eisenhower's 6 Army Group would enter Austria from Bavaria before those of 15 Army Group could cross the frontier from Italy.

Arrangements were therefore made between the Directors of Survey at A.F.H.Q. and S.H.A.E.F. whereby all available reproduction material for maps of Austria should be flown over from Italy to S.H.A.E.F. for immediate printing of stocks in Paris. Meanwhile all hastening action was taken by A.F.H.Q. to complete the first edition of Med. 4 (1/50,000) all over Austria. Towards the end of April the mapping situation with A.F.H.Q. was as under:—

- 1/50,000 (4229) Italy. An extra block of sheets which had been produced by A.M.S. to complete the series in northern Italy was received from Washington, and all sheets were handed over to 15 Army Group control.
- 1/50,000 (AMS 702) Yugoslavia. Kodelines were received by A.F.H.Q. from Washington and were passed to 15 Army Group with responsibility for further maintenance.
- 1/50,000 (Med. 4) Austria. 191 sheets of the unrevised monochrome edition were completed, printed and distributed. There were 75 sheets under revision for the "griblet" edition.
- 1/50,000 (AMS M771) Austria. 81 sheets were being compiled and newly drawn by A.M.S. for four-colour printing. Of these 36 were based on multiplex compilation from air-photos, the remainder being from map plus photo material.
- 1/25,000 (4228) Italy. All sheets had been handed over to 15 Army Group up to the Austrian frontier.
- 1/25,000 (4528) Austria. 73 sheets of the modern Austrian 1/25,000 series had been colour-separated by G.S.G.S. and were available in kodeline form. Revision was in hand.

Thus it will be seen that, immediately before the surrender, the armies in Italy were fully equipped with maps for operations leading up to the frontier and the mapping situation was well in hand for Austria itself. After the surrender there was little opportunity for immediate relaxation of pressure. All work in hand for Austria was continued as the maps were required for occupational purposes. In addition, the Yugoslav occupation of Venezia

Giulia introduced a new situation and, so as to be able to meet any eventualities, Eighth Army had to undertake urgent mapping preparations for that area.

Conclusions

After the cessation of hostilities in Italy, a conference was held at A.F.H.Q. with the object of discussing and collecting the needs and experiences of map users, based on the varied operations which had been carried out in the Mediterranean Theatre, while people's ideas were still accessible and fresh in mind. Amongst those attending this conference were representatives of the H.Q. staffs of armies, corps and divisions, the R.A.F. and U.S. Army Air Force, engineers, armoured forces and infantry, and of course officers of the survey service.

The following brief summary of the main conclusions which emerged are quoted as they may be of future interest:—

(a) *Scale.* The 1/25,000 map was regarded as essential, the importance of accurate contours being stressed. There was also a definite requirement for both 1/50,000 and 1/250,000 maps. It was stated that the 1/50,000 map was needed by infantry and artillery in pursuit operations and the artillery could shoot off it in emergency if it was of good quality. Armoured units and the Tactical Air Forces also needed it. If one of the large or medium scales had to be given up it was considered that this should be the 1/100,000.

(b) *Colouring.*

(i) *Monochrome.* Black monochrome was preferred to brown, but monochrome maps in general had not proved satisfactory.

(ii) *Additional colours.* Where additional colours were possible the order of preference for coloured detail was:—Roads, water, contours, woods, layers. In a minority recommendation the Tactical Air Force considered that woods and layers were of paramount importance.

(iii) *Layers.* Brown and green was found more satisfactory than the purple layering in spite of the disadvantage that the former made difficult the use of a green tint for woods.

Except possibly under very static conditions, the layering of 1/25,000 maps was impracticable, and this applied generally to the 1/50,000 also.

(c) *Detail.*

(i) *Woods.* Stress was laid on the importance of representing wood shapes correctly, this being of special importance from an air force point of view. It was suggested that, where possible, there should be some method of differentiation between various types of trees.

(ii) *Marginal data.* It was generally felt that too much marginal information was provided. There was, however, no agreement as to the minimum requirements.

(iii) *Magnetic data.* Artillery staffs suggested that the magnetic data should be expressed relative to grid north.

(iv) *Contours.* The importance of accurate contours was stressed, also of making the contour interval such that they were not too close in hilly country. The adequate numbering of the contours and their accentuation at regular intervals was regarded as important.

- (d) *Road Maps.* The opinion was expressed that there was a definite need for a road map as distinct from a small scale topographical map.
- (e) *Scales of Issue.* The following scales of issue were found generally satisfactory:—

Scale	Area	Issue to Corps H.Q. and Corps Troops	Issue to Divisions (Each)
1/25,000	Corps area	1,000	1,000
1/50,000 } 1/100,000 }	Corps area	1,500–2,000	1,500–2,000
1/250,000 (or similar scale)	Army area	600	200

- (f) *Air photographs.* These were considered as being an essential supplement to maps. Basic photo-cover should be gridded and should carry some reference to enable the photo to be related to the map.
- (g) *Trig data.* Artillery staffs required a standard distribution of trig lists to artillery regiments.

SECTION 3. TRIANGULATION AND FIELD SURVEY

Historical foreword

The fundamental geodetic network in Italy was started in 1859 with the measurement of a base at Foggia, and was continued until its completion towards the end of the 19th Century. There were eight measured bases, six of them in Italy itself, one in Sicily, and one in Sardinia. The development of the triangulation followed in the wake of each base measurement as it was completed.

The work was undertaken for the dual purposes of map-making and, in collaboration with the surveys of other countries, of measuring the shape and size of the earth. The fundamental meridian of the map was established as that one which passed through the geodetic point of Monte Mario at Rome.

Triangulation data originally available to the Allies

Before the landings in Sicily and on the mainland in July and September, 1943, the only trig data available consisted of the Italian Primary Triangulation, records of which had been published by the Royal Italian Geodetic Commission in “*Elementi della Rete Geodetica Fondamentale*” in two parts:—

- (a) North of the Rome Parallel dated 1908.
- (b) South of the Rome Parallel dated 1919.

The longitudes of trig points were referred to Genoa (1908) which constituted the Italian datum, and bearings and distances of the sides were also quoted. The first task was to convert these geographical co-ordinates to rectangulars based on the North and South Italy grid systems which had been adopted for use by the Allies. The Survey Directorate at A.F.H.Q. then published its first trig lists as under:—

- No. 1. Sicily.
- No. 2. Sardinia.
- No. 3. Italy, south of Lat. $43^{\circ} 10'$.
- No. 4. Italy, north of Lat. $43^{\circ} 10'$.

With the progress of operations, further material was captured or acquired, and the trig lists which were compiled therefrom were brought into sympathy, where necessary, with the Italian Primary Triangulation on the Genoa datum by means of correction graphs or blanket corrections.

Acquisition of supplementary trig lists for coastal areas

At the outset, when the lists of primary points formed the only trig data available for Italy, Sicily, and Sardinia, the problem of ground control was acute as it was not dense enough for air survey purposes. Fortunately a further list of trig points was acquired during the early stage of operations which gave co-ordinates of points along the coasts of Italy, Sicily, Sardinia and the north-eastern Adriatic. This list had been published by the International Hydrographic Board (I.H.B.) and the trig points were related to a number of independent origins whose longitudes referred to Greenwich.

It was obvious that this supplementary list must be made use of at all costs, as it supplied a fair density of points along the coastal areas where it was probable that local air-photo mapping would be required. A preliminary examination showed that the points were not in sympathy with the Italian primary system, so a detailed investigation was undertaken to determine a method whereby they could be properly related to it. There were about 400 points in this I.H.B. list in addition to those which were common to both systems.

The values of the common points were compared, and the Italian primary co-ordinates were accepted as standard. The value of the longitude of Genoa which was used to convert the I.H.B. points from Greenwich to the Italian origin was:—

Genoa— $08^{\circ} 55' 15.93''$ E. of Greenwich.

All conversion work was carried out using longitudes referred to Genoa.

The I.H.B. list, as received, was divided into seven zones, each zone being the result of an individual survey based on its own particular origin.

Certain of these zones were subdivided by A.F.H.Q. into groups, making a total of 12 groups, and a mean correction was calculated and applied to each group to bring it into sympathy with the Italian primary network. The range of variation from this mean correction was such that practically all the points could be used for air-photo control, and some could be used for triangulation purposes in connection with ground surveys where approximate results only were required.

On completion of the adjustment and conversion of the geographical co-ordinates to rectangular co-ordinates on the military grid, A.F.H.Q. published the values as A.F.H.Q. trig lists, copies of which were sent to armies in the field.

Capture of further trig data

With the capture of Sicily, and progress up the Italian mainland, further trig data were acquired from various sources such as military headquarters, university libraries, local government offices, etc. Where these included the

results of secondary, tertiary, and lower-order surveys they were of great value as they offered the extra ground control which was urgently needed for target fixation and artillery surveys and for air-photo mapping.

Grid Zones

Italy was covered by two grid zones known respectively as the North Italy and South Italy Zones. (See Diagrams 2 and 8.) Their junction was along the 43rd parallel, roughly 100 miles to the south of Florence.

As in other theatres, where the inconvenience due to a change of grid within the operational area had to be faced, all necessary preparations were made to facilitate the change-over with its attendant alteration of grid co-ordinate systems. When it came to the point, however, the armies were going ahead fairly fast when they reached the junction between the two zones, and the change-over was effected with little inconvenience or dislocation.

Methods of publishing trig lists

Trig lists were, in general, of two types:—

- (i) Those originally produced by A.F.H.Q. on an area basis rather than by map sheets.
- (ii) Later editions produced by A.F.H.Q. and by armies in the field compiled on a 1/100,000 map-sheet basis.

The original data consisted of acquired or captured Italian or German trig folios in which the points had been listed alphabetically. Their geographical co-ordinates were given and the points of origin varied generally between Genoa, Rome, and Castanea delle Furie in Sicily. The following procedure was adopted in preparing the allied trig lists:—

- (a) All geographical co-ordinates were first adjusted to the Italian trig datum and longitudes referred to Greenwich.
- (b) The adjusted co-ordinates were then converted to rectangular grid co-ordinates on the British military grid for the theatre (North or South Italy Grid).
- (c) Trig lists were then compiled on a 1/100,000 map-sheet basis in order of "eastings," listing the serial numbers, classification of the point, grid co-ordinates, elevation, sketches and descriptions. A monochrome copy of the 1/100,000 map concerned was included at the back of the booklet, on which the positions of the points were indicated by means of a red overprint. A preface was included to explain what adjustments had been made to the original data, and the source of that data.
- (d) Errata and addenda were compiled from field reports and other sources and were entered up on a trig-list record copy held at A.F.H.Q.

Early field-work in Italy

In connection with the Eighth Army operations in southern Italy two topographical sections of 13 Field Survey Company landed on 3rd September to work with the composite batteries of 3 Survey Regiment R.A. operating with 5 Division and 1 Canadian Division. Owing to the rapid advance they passed quickly through the small area for which minor trig data were available, but this

was compensated for by the fact that practically no survey data were required during that early stage by the artillery.

In general, check observations showed that the primary trig was very good. The minor points in the south, however, had suffered many changes and the results appeared to be of doubtful quality. As progress continued northwards the quality of the minor triangulation improved.

As winter came on, bad weather and difficulty of movement slowed up the advance. The Eighth Army front was contracted, and the requirements of the artillery survey were considerably reduced. The 3rd and 5th Survey Regiments R.A. each had only parts of one battery working forward, and it was found unnecessary to have more than two topographical sections R.E. in the field. Their work consisted almost entirely of checking the existing minor trig, and it proved satisfactory in most areas.

On the western flank with Fifth Army, Survey Group A of 46 South African Survey Company was operating in support of 10 Corps. Plentiful fixations were made, and all the artillery was soon put on the theatre grid.

Preparations for the invasion of southern France

In anticipation of the assault operation in the south of France A.F.H.Q. Survey Directorate, by arrangement with G.S.G.S. (War Office), took over responsibility for the conversion of trig values in parts of southern France from geographicals to rectangular grid co-ordinates. This work continued through the autumn and winter into the spring of 1944, and trig lists were prepared for issue to the U.S. Seventh Army when the operation was launched in the summer of 1944.

Discrepancy between trig-list values and the map co-ordinates of trig points

Shortly before the landings in Sicily, when the plotting of the primary trig points in Sardina and Sicily was being checked on large scale maps, it was noticed that there was a discrepancy between the trig-list values of the points and their values, as measured on the map, referred to the Monte Mario graticule which had been superimposed on the face of the map as a consequence of the Monte Mario meridian having been adopted as the fundamental meridian for mapping. Investigations into this problem were extended systematically over the whole of Italy, and it was found that the discrepancy was not constant all over but differed in various parts of the country. As a consequence it was decided to prepare a table of grid constants, one for each sheet, which would enable corrections to be made to measured map grid co-ordinates so as to put them in sympathy with the values obtained by ground survey which were computed from trig-list values. This action was especially necessary for the artillery, as they might well have their guns positioned by ground survey and their targets measured from the map, and it was essential that the respective co-ordinates should be in sympathy.

Trig library at H.Q. Allied Armies in Italy

During March, 1944, a trig library was set up with 19 Field Survey Company R.E. This dealt with bulk stocks of trig lists and arranged for their distribution to armies as required. It also maintained records of the field surveys, original record documents, original computations and records of trig lists.

German trig lists

Many German military trig lists were captured during the campaign. They had adopted the German Gauss Kruger grid for their military maps, and their trig lists gave co-ordinate values on this system. They had therefore to be converted to the North or South Italy grids before they could be issued to and used by the allied forces. Rapid methods for this conversion were evolved which eliminated the intermediate stage of conversion to geographicals.

A particularly satisfactory haul of German trig lists was made during June, 1944, by which date all the known Italian trig folios north of Lat 43° and most of the German lists had been obtained.

The Germans accepted the Italian geodetic triangulation as the datum for their trig work in Italy. The latitudes were accepted without correction, and the meridian of Monte Mario was defined as 12° 07' 12.000" E. of Greenwich.

Field surveys on Eighth Army front in the spring of 1944

Taking advantage of a comparatively static operational period the topographical sections of 49 South African Survey Company and 12 Polish Field Survey Company reobserved and recomputed a close network extending over the whole of the Eighth Army front. This included a large number of intersected points in enemy territory, and the network so provided formed a sound basis for an extension forward when the advance was renewed.

Capture of further records of the Italian triangulation

On 15th June, 1944, the capture in Rome of complete records of the Italian lower-order triangulations supplied details of a control which gave between 160 and 240 points on each 1/100,000 sheet. In most areas this now supplied a network sufficiently dense to allow the artillery survey observers to resect their positions and obtain satisfactory bearings without the need for further triangulation on the part of engineer survey units.

As the original Italian triangulation had been carried out in the middle of the 19th century, it was to be expected that some of the stations would have been destroyed, rebuilt, or covered up by new buildings. The engineer survey parties were therefore instructed to check the existence and identification of Italian points in areas likely to be used for artillery deployment, and to restore or amend any that were found destroyed or in error. It was satisfactory to find that about 85 per cent of the old stations still existed in good order. In many of the cases where stations were found to have unreliable values it is probable that the errors were due to faulty proof-reading or transcription when the original Italian publications were produced.

In some areas, where the hill-tops were thickly wooded and where the country was of an exceptionally difficult type, it was found necessary to supplement the listed points by fixing a number of new stations.

More valuable trig data were captured during August in Florence. It mainly consisted of records of modern work, amongst which were the results of the readjustment of the geodetic network reoriented on Rome. It included also the extension loop along the Dalmatian Coast from Trieste to Foggia.

Field survey with Fifth Army during 1944

On Fifth Army front surveys in the field were controlled by Group A of 46 Survey Company S.A.E.C. augmented by survey platoons of U.S. and British

units. The work of checking the existing triangulation and providing new points extended over large areas of extremely rough and difficult terrain. The mountain-tops were often mined and booby-trapped and under enemy artillery fire. Between October, 1943, and October, 1944, the following work was completed:—

Italian trig stations verified	264
Italian trig stations amended	305
New trig stations established	624
Stations found destroyed	83

Field surveys with Eighth Army during the winter of 1944-45

The task of meeting field survey requirements on Eighth Army front was successfully accomplished by 49 Survey Company S.A.E.C. and 12 Polish Field Survey Company during this period. Weather conditions made survey work difficult in the Po valley, and this was aggravated by dense cultivation and the systematic destruction of high buildings and towers which might have served as trig points.

Throughout the advance on the Adriatic sector, it was possible to maintain a check of the control ahead of the advancing troops. This was done by the co-ordination of forward observations on all corps fronts, though, on the left flank of the army sector, the enemy's habit of holding out to the last in the hills denied the full use of valuable points in that area.

The first experience of conditions in the Po Valley north of Rimini indicated that, although it was still probable that control checks would keep in advance of artillery requirements, forward rays were likely to be considerably more restricted, involving the need for fixing a greater proportion of new stations. A new technique was evolved for checking existing trig points in forward areas by the stereoscopic examination of air-photos but, although this undoubtedly provided useful advance information, the use made of these annotated photos hardly justified the time and labour spent in their preparation and distribution.

Operations were more or less static during January, February and March, 1945. Mist and fog greatly hampered field observations but it was possible to build up ample trig cover along the army front.

The final stage

The allied full scale assault on the enemy positions in northern Italy was launched in April, 1945. The success of the artillery action during the opening stages of the battle undoubtedly owed much to the completeness of the survey preparations which had been going on during the preceding months.

Up to the crossing of the R. Po on 26th April, the topographical section of 518 Field Survey Company was able to keep the R.A. survey units supplied with trig information well forward in the battle-zone. From then on, however, the retreat turned into a rout, and movement was so rapid that field survey control could not keep pace with it. The need for survey, however, fell away with the collapse of resistance, so both topographical sections were withdrawn and put on to other work.

Special survey training for bridging operations

In February, 1945, a topographical section of 49 Survey Company S.A.E.C. underwent a training course on the Volturno River near Capua in connection

with surveys for anticipated bridging operations across the R. Po. The task of the section was to be as follows:—

- (a) The accurate determination of the water gap.
- (b) The marking of the centre line of the bridge.
- (c) Drawing a profile of each bank on the centre line, and also of the river bed.
- (d) The fixing of levels at the roller sites for launching the Bailey sections.
- (e) Fixing levels for the approach roads.
- (f) Taking soundings along the anchor line, 250 feet upstream from the centre line.

On 22nd April, the section came under command of C.R.E. corps troops. The preliminary reconnaissance was carried out at 0230 hours on 26th April. At about 0400 hours the enemy blew one of the remaining pillars of the demolished railway bridge near by, and by 0700 hours the far bank was reckoned to be clear of the enemy and the survey proceeded. By 2000 hours on 27th April, the last floating section was being put in place and the section's task was complete.

Somewhat similar work was done by a section of 49 Survey Company (S.A.E.C.) for C.R.E. 13 Corps Troops, and in addition they did the survey for the bridging of the Rivers Adige and Piave.

Modern adjustments of the Italian primary triangulation

Amongst the data obtained by the allied survey service from Italian and German sources were the results of modern observations, including a new chain down the Dalmatian Coast, and new adjustments of the primary trig nets. This material seems likely to have a considerable effect on future trig lists of Italy, and on those trig lists of the Balkans which fall along the Yugoslav and Italian frontiers.

Amongst this new material were the following:—

- (a) The 1940 adjustment of the Italian first-order triangulation, together with the adjustment of the 1941–42 Italian survey along the Dalmatian Coast.
- (b) The German adjustment of part of the Italian primary network for the publication of co-ordinate lists based on the Einheits system.
- (c) The German investigation into the triangulation in the area of the Italy-Yugoslav frontier.
- (d) The German adjustment of the Yugoslav primary triangulation to the Italian system.

On the Italian mainland, the 1908 adjustment, as published in the "Elements of the Fundamental Geodetic Net," was known to contain errors, and it did not cover Venezia Giulia and Venezia Tridentina, which parts of Italy were previously included in the Austrian first-order net. From the material acquired during the war, data became available for adjusting all the trig lists of Italy to a net of Italian first-order triangulation, and also for determining a sounder connection between the Italian and Balkan systems.

SECTION 4. MAP SUPPLY AND DISTRIBUTION

Introduction

No matter how much care, forethought and labour are expended in the design and production of maps for the use of ground and air forces, they will be of no avail unless proper steps are taken to store, issue, transport and deliver the right maps at the right time to those who require them, whether at a headquarters for planning, on the lines of communication, or amongst the fighting formations.

Unlike other commodities such as rations, ammunition, etc., which are appropriate to any part of the theatre, maps are of an ephemeral nature only, and require continual change and replacement as troops move from one area to another. The more rapid and fluid the operations the greater are the difficulties of distribution. It is essential, therefore, to have in being an organization which is capable of continuous and efficient action to ensure proper map storage and distribution.

Initial organization

For the operations in the Central Mediterranean the Survey Directorate at A.F.H.Q. was responsible for exercising a general control over map supply and distribution. Map stocks were obtained from the following main sources:—

- The United Kingdom (G.S.G.S. War Office).
- The United States (Army Map Service, Washington).
- Survey Directorate, G.H.Q. Middle East (who produced and printed maps on an agency basis for A.F.H.Q.).
- Survey units (British and American) under the direct control of A.F.H.Q.
- French Service Géographique at Algiers.
- Survey units under the direct control of H.Q. Allied Armies in Italy (15 Army Group).
- Survey Units with Fifth and Eighth Armies.

During the early part of the campaign, base stocks of maps were assembled and stored in British and American map depots situated at Algiers and other parts of North Africa. At the end of May, 1943, following the successful termination of the operations in Tunisia, the units available for map depot work were as follows:—

- British* 7 Field Survey Depot R.E. Algiers (A.F.H.Q.).
 12 Field Survey Depot R.E. Tunis (First Army).
 20 Field Survey Depot R.E. (Eighth Army).
- U.S.* Atlantic Base Section (A.B.S.) Map Depot (Casablanca).
 Mediterranean Base Section (M.B.S.) Map Depot (Oran).
 Eastern Base Section (E.B.S.) Map Depot (Constantine).
 Two Engineer Map Depot Detachments established with Seventh Army for the receipt of coded stocks for the Sicily operation.

10 Field Survey Depot R.E. arrived from the United Kingdom in June, 1943, and took over stores depot duties, thus releasing No. 7 Field Survey Depot for map depot duties only. These were heavy in consequence of preparations for the invasion of Sicily (operation "Husky").

Map distribution arrangements for "Husky" are described elsewhere in the notes on that operation. (See Chapter XII, Section 4.)

Preparations for operations in Italy

In preparation for operations on the mainland of Italy subsequent to the occupation of Sicily, map stocks were assembled at Algiers on arrival from overseas and from local printing resources, and they were gradually split up between there and Tunis. For planning purposes open stocks were supplied to H.Q. 15 Army Group, to 5 and 10 Corps and, later, to U.S. Fifth Army. The map stocks in Algiers were divided into operational and non-operational stocks. The former remained in the A.F.H.Q. depot operated by 7 Field Survey Depot and the latter were stored in a depot run by 649 Engineer Topographical Battalion. 12 Field Survey Depot (ex First Army) continued to operate the map depot in Tunis. Maps for use by the air forces were transferred to the Island Base Section map depot at Palermo and the Eighth Army map depot at Syracuse.

For the mapping up of forces taking part in the landing operations at Salerno (operation "Avalanche") stocks were shipped to Oran, Tunis and Tripoli. A.F.H.Q. Survey Directorate sent personnel to Tunis and Tripoli for the detailed distribution of maps to British units taking part in the assault and follow up. Reserve stocks in large quantities were prepared for shipment to Fifth Army map depot by an early follow-up convoy.

On 24th August, a conference was held at Algiers which was attended by the officers of the various map depots, engineer intelligence officers from the U.S. Fifth and Seventh Armies, representatives from British survey units, and representatives from the North African Air Force. Their respective responsibilities with regard to map distribution were clarified, and details of the coming operations were discussed so as to foster efficient co-operation within the theatre. Assistance was given to Fifth Army by A.F.H.Q. in organizing and equipping two engineer map depot detachments for service at Salerno.

Turning now to Eighth Army, 20 Field Survey Depot R.E. had been organized during the desert campaign as an "Army type" unit, with a main and rear depot, and with sub-sections equipped with specially fitted map lorries for attachment to the headquarters of corps and divisions. The rear depot (Palestinian personnel) moved by air from North Africa to Sicily on 26th August to join the main depot. Efforts were now concentrated towards preparations for landing on the Italian mainland across the Straits of Messina. Maps were issued from Syracuse direct to formations.

The opening of the Italian campaign (September, 1943)

Although all formations taking part in the initial landings were adequately mapped, the margin of safety on most deliveries was uncomfortably small. After completing its work in Tunis 12 Field Survey Depot moved to A.F.H.Q. and joined No. 7 at Algiers.

Officers from A.F.H.Q. had helped to map up the troop ships leaving the ports of Bougie and Philippeville for Salerno, and a topographical section of 518 Field Survey Company R.E. did the same at Bizerta and then rejoined its unit at A.F.H.Q.

An advanced map depot (A.M.D.) which was formed from 20 Field Survey Depot crossed over to the mainland on "D" + 3 and set up at Reggio. It

held reserve stocks of sheets already issued to Eighth Army formations, and also carried sheets of more forward areas. Syracuse now became unsuitable as a base map depot for Eighth Army so stocks of the mainland were moved to Aci Castello whence consignments were despatched daily to the A.M.D. on the Catania ferry.

As operations developed, map distribution became more difficult. The advancing troops were moving rapidly to effect a junction with the Salerno bridgehead and road transport up the toe of Italy became very precarious owing to broken bridges and damaged roads. As bulk stocks arrived by ferry from Sicily they were sent forward to advanced map depots which were continually being opened and closed as it became necessary to move forward. The British wing of 20 Field Survey Depot acted as the A.M.D., and the Palestinian wing took over and wound up these depots as they were left behind. At this stage of the campaign only 13 Corps, consisting of two divisions, was concerned, and all stocks for the divisions were delivered in bulk to Corps H.Q., the latter preferring to assume full responsibility for distribution to the troops under its command.

5 Corps then landed at Taranto and, though not yet under Eighth Army command, it was supplied by the latter with maps at A.F.H.Q. request from an A.M.D. opened up at Taranto. This was relieved by the Palestinian detachment at the end of September, and the freed A.M.D. went on to Bari where it started to open up a base map depot.

After the capture of Naples, U.S. forces established there a Peninsular Base Section Map Depot operated by 2634 Engineer Map Depot Detachment. Arrangements were also made for 16 Field Survey Depot to move from Taranto to Bari to operate the base map depot for H.Q. 15 Army Group.

Meanwhile 26 Field Survey Depot was newly formed to work in conjunction with Nos. 7 and 12 at A.F.H.Q. in Algiers. Stocks were being received from the United Kingdom and the U.S.A. by convoy. Those from America were chiefly air maps and road maps of Italy.

During early October, map distribution with Eighth Army became less difficult, and the British and Palestinian wings of 20 Field Survey Depot were concentrated at Bari. But when Main Army H.Q. moved forward, the main depot transferred to Lucera to form an A.M.D. The detachment of No. 20 which had been operating with Fifth Army then returned to Eighth Army. Big consignments of 1/250,000 maps were being received by air from A.F.H.Q. and Middle East, and the situation regarding stocks was now easier. Further consignments of air maps were received and were added to the Bari stocks. The supply of maps to the Desert Air Force was the responsibility of Eighth Army.

The winter of 1943-44

With the slowing down of operations owing to weather and bad communications, opportunity was taken to build up stocks of forward areas in the A.M.D., making use of large consignments taken over from Fifth Army and also those received from the Middle East. The front of Eighth Army was split by mountain ranges which ran down the middle of Italy, and this resulted in poor lateral communications between the two main axes of the Army's advance. The A.M.D. was moved forward from Lucera to Serracapriola, and a mobile A.M.D. was attached to H.Q. 13 Corps moving along the inland axis.

16 Field Survey Depot, which had been established at Bari, now took over

from No. 20 the stocks of special air maps held there, and also the bulk stocks of all sheets covering the area behind the rear boundary of the army.

A.F.H.Q. was sending over continuous supplies of maps to Naples and, during December, these included maps of the Balkans. Space was assigned near Naples for 12 Field Survey Depot which, on arrival from North Africa, was given the task of handling British survey stores and certain categories of maps under the direction of 15 Army Group.

In December there were changes in the spheres of operational responsibilities between the two armies, and the A.M.D. which had been attached to 13 Corps was moved into 5 Corps area, where it became a general A.M.D. serving all the forward troops of Eighth Army.

No. 20 was reorganized during January, 1944, which resulted in a saving of transport and personnel. The Palestinian personnel, who now formed a separate unit, remained responsible for operating the base map depot. The A.M.D. with its maps and stores moved forward from Serracapriola to Casalbordino, and large map consignments were received from A.F.H.Q. including road maps and first instalments of the revised 1/25,000 series. On the arrival of the Canadian Corps a new corps sub-section of the field survey depot was formed.

In February, there was a readjustment of depot responsibility at Algiers. 26 Field Survey Depot opened a new depot to handle new operational stocks arriving in the country. 7 Field Survey Depot was made responsible for handling 1/M maps and all smaller scales, all maps for air forces only, all maps of Italy, Africa, the Iberian peninsula, and areas east of 30° E., together with all maps of general interest.

February also saw the closing down of the Eastern Base Section map depot at Tunis, its bulk stock being distributed between Algiers, Naples and Palermo. Shipment of bulk stocks to Italy was speeded up, and opportunity was taken to send to salvage all used and obsolete maps.

The spring and early summer campaign of 1944

When the Polish Corps became operational, its map supplies were issued by 312 Polish Field Survey Depot, bulk transfers being effected from 20 Field Survey Depot of sheets covering or adjacent to the Polish area of operational responsibility. The role of the depot was identical with that of an A.M.D. attached to a corps.

In North Africa the Atlantic Base Section map depot was in process of closing down in March, and its stocks were distributed to Oran, Algiers, and to salvage. The shipments from U.S.A. which, in the past, had come to Casablanca, were now diverted to Oran.

In preparation for operations in southern France, the engineers of the Northern Base Section in Ajaccio established a small map depot there to which consignments of maps, mainly for use by the air forces, were shipped from A.F.H.Q.

By April the map depot situation with H.Q. Allied Armies in Italy was showing steady improvement, comprising 12, 16 (Palestinian), and 27 (Palestinian) Field Survey Depots together with U.S. Engineer Map Depot Detachments 2634 and 2658 which were assigned to the Peninsular Base Section. With Eighth Army 20 Field Survey Depot, which had in March become No. 29,

opened up at Varriano during May. Two new sub-sections had been formed for incoming divisions and were equipped with map lorries racked on an improved system, a third sub-section being held in reserve.

The allied armies were advancing rapidly northwards in June and July towards Florence and the Gothic Line. A.F.H.Q. moved over from Algiers to Caserta early in July, and 16 and 12 Field Survey Depots were transferred from H.Q. 15 Army Group to A.F.H.Q. command. In replacement 14 Field Survey Depot (Palestinian) was moved from Middle East to H.Q. 15 Army Group and took over the Varriano map depot from 29 Field Survey Depot (Main), the latter moving forward with Eighth Army. No. 14 then moved on to Rome, its main function being to hold stocks of all maps of Italy north of Rome, and small stocks covering the area between Naples and Rome. By the end of June, two weeks after its arrival, it had taken 8,000,000 maps into stock and issued over 1,000,000.

In mid-July 29 Field Survey Depot (Rear) moved from Bari to Rome to take over the survey stores, leaving No. 14 to deal only with maps. A small port detachment was left at Bari to look after incoming shipments.

For the first seven months of the Italian campaign, the map distribution personnel with Fifth Army consisted of one map depot detachment only. A second one was assigned in June, 1944, and these two units (each of one officer and 12 enlisted men) handled the following quantities:—

Received from A.F.H.Q. for distribution on "D"-day	1,580,000
Received from higher H.Q.s after "D"-day	12,500,000
Received from new printing by army survey units	10,520,500
	<hr/>
	24,600,500

During the early summer 1712 Map Depot Detachment operated a forward map depot which carried only combat stocks of forward areas. 1710 Map Depot Detachment operated a rear depot which carried general stocks and also took over stocks which were left behind by the forward depot as it moved forward.

Operation "Anvil" (Invasion of southern France)

H.Q. Seventh Army (U.S.) moved over to Italy with A.F.H.Q. early in July, and preparations for mapping up the allied invasion force went ahead. The following map depots were employed for map distribution duties in connection with the operation:—

Oran	1620 Engineer Map Depot Detachment (U.S.).
	1711 (later 1719) Engineer Map Depot Detachment (U.S.).
Algiers	26 Field Survey Depot R.E. (British).
Naples	1709 (later 1720) Engineer Map Depot Detachment (U.S.).
	1713 Engineer Map Depot Detachment (U.S.).
	12 Field Survey Depot R.E. (British).

There was also a security breakdown depot in Naples which was operated by 661 Engineer Topographical Company (U.S.). The numbers of maps issued by the survey service for the assault and for the establishment of the bridgehead were:—

Standard maps	14,833,000
Collation maps	135,350
Going maps	50,250
Layered maps	57,500
Panoramic beach sketches	84,000
Miscellaneous printings	110,900
	<hr/>
	15,271,000 copies

In addition there were issued:—

Contact photo prints	1,900
Half-tone litho prints of air-photos	101,000

Subsequent to the assault large consignments were sent to Seventh Army in France from North Africa, Italy and Middle East, much of this going by air. By early September the "Anvil" operation forces had passed beyond the theatre boundary of A.F.H.Q. but, by arrangement with S.H.A.E.F., A.F.H.Q. continued for a while to supply Sixth Army Group with road maps and also 1/250,000 and 1/100,000 topographical maps of Germany.

The summer and autumn of 1944

During August there was a change of plan which involved Eighth Army in a main thrust along the Adriatic Coast instead of along a more central axis. As Fifth Army thereby took over the western end of Eighth Army front, the latter was able to hand over to the former nearly half a million maps covering the Siena-Firenze-Bologna axis.

29 Field Survey Depot (Adv.) had moved early in July from Orvieto to Castiglione del Lago, moving on two weeks later to Arezzo where it remained till the end of August when it was transferred across to Iesi on the Adriatic coast in conformity with the new operational plan. Since landing in Sicily in June, 1943, this depot had moved once every three weeks, each move involving the loading and unloading of up to 3,500,000 maps. These always had to be ready for issue within a few hours of arrival at the new destination. Within four days of its arrival at Iesi over 750,000 maps had been issued.

In anticipation of future operations northwards, H.Q. 15 Army Group organized a detachment of 14 Field Survey Depot in Rome to handle bulk stocks of areas ahead of the current battle-zone. This enabled large consignments for the two armies to be assembled and issued promptly, and also separated the bulk stocks from the smaller stocks which were held in the main depot for 15 Army Group use.

During September, 7 and 10 (Stores) Field Survey Depots crossed over to Italy leaving No. 26 as the only one remaining in North West Africa.

About this time the offensive operations of the allied armies under General Eisenhower in western Europe, and the Russians in the east, caused a general withdrawal of German forces on all fronts including the Balkans. This resulted in an increased demand for maps covering all approaches into Germany, and limited stocks to cover a possible advance into southern Germany were transferred to the armies in Italy. September was in consequence a busy month. Air shipments were extensive, over 100 tons being moved thus during September and October, including a large consignment to 3 Corps in Greece.

29 Field Survey Depot (Rear), under 15 Army Group control, moved forward from Rome to Fano in September, its task being to hold bulk stocks of maps

covering a zone ahead of the army operational area. Eighth Army was now having bitter fighting between Pesaro and Fiumicino, eight miles beyond Rimini, and 29 Field Survey Depot moved on from Iesi to Fano.

26 Field Survey Depot closed down in Algiers during October, as also did the Mediterranean Base Section map depot in Oran. All useful stocks held in North West Africa were shipped over to Italy, including a quantity to be used for printing on the back to alleviate the paper shortage.

The Survey Directorate, 15 Army Group was now stocking up with maps of southern Germany as an insurance against a possible sudden collapse of the enemy forces. These bulk stocks included road maps, and topographical maps on the 1/250,000 and 1/100,000 scales. Orders were also placed with Middle East for the printing of small quantities of all available large scale maps of the southern Balkans and the Aegean Islands.

Both armies advanced considerably during October. With Fifth Army an advanced mobile section, consisting of nine 2½-ton trailers racked for map storage, moved to the Futa Pass area so as to facilitate distribution to II (U.S.) and 13 (British) Corps.

The winter lull (January–March, 1945)

During January, all Palestinian personnel in 29 Field Survey Depot were replaced by British personnel from No. 26, which had been disbanded. The released Palestinians were utilized to form a new depot to operate under A.F.H.Q.

On its arrival in Italy, A.F.H.Q. Survey Directorate assumed the role of strategic map support to 15 Army Group, and this involved the building up in A.F.H.Q. forward map depots of insurance stocks covering northern Italy, north-western Yugoslavia and southern Germany. A stock-level policy was evolved which scheduled the map coverage and quantities of the strategic map reserve to be held by A.F.H.Q. This formed the stockholding policy for the map depots and, with more or less static operational conditions during March, it was possible to put this policy into effect by transferring stocks from 15 Army Group depots and sending up consignments from rear depots to those further forward.

Eighth Army moved their A.M.D. to Ravenna where stocks of all sheets up to the R. Po were assembled ready for issue. Their main and rear depots were at Cesena. The stage was now set for the April assault which proved to be the final chapter of the operations in Italy.

The last few weeks

A full scale assault by both armies was launched in April involving very extensive map distribution. Map depots were working right round the clock.

With Fifth Army the forward depot moved to Porretta, then to Modena for seven days followed by a quick move on to Verona. After the break-through in the Argenta Gap, demands in Eighth Army became heavy owing to the fluid situation and the employment of quick-moving armoured forces. Nearly all the operational deliveries subsequent to 9th April were made from the A.M.D. at Ravenna but, after the Army had crossed the R. Po, the depot moved forward to Ferrara.

The surrender of the German armies in Italy took place on 2nd May. Map issues continued to be brisk. Fighting in Germany was still going on and, at S.H.A.E.F. request, A.F.H.Q. arranged for two plane-loads of maps to be

ready for delivery to Sixth Army Group in the event of a move south into Austria. There was no difficulty in supply as all the maps required for entry into Austria had been assembled in the A.F.H.Q. forward depots.

H.Q. 15 Army Group transferred 14 Field Survey Depot to Bologna to which place all map stocks required for northern Italy, Yugoslavia and Austria had been moved from Rome.

Eighth Army now had two main tasks; firstly to take part in the occupation of Austria, and then to deal with the situation arising from the Yugoslav occupation of Trieste and Venezia Giulia. These final stages kept their map depot very busy. Six days after moving to Ferrara the main depot went on to Mestre near Venice and on 10th May to Udine. At first only those maps required for the occupation of Austria were stocked at Udine. Later it was necessary to include those needed for the Trieste area. This involved very heavy transport commitments, the depot having to collect from Mestre, Ferrara, Bologna, Cesena and as far back as Fano. The transport of the field survey depots could only meet about 10 per cent of requirements. Reliance was placed on using a pool of up to 30 lorries from field survey companies, mostly from 49 Company (S.A.E.C.).

Final comments

The number of maps produced for the theatre was over 134,000,000, made up as follows:—

From the U.K. and U.S.A.	55,950,000
From the Middle East	10,101,000
Printed by A.F.H.Q. units	36,163,000
Printed by 15 Army Group units and units of Fifth and Eighth Armies	31,887,000
Total	134,101,000

Not all of these were issued for use, but they had to be handled on receipt and stored in map depots where they were sorted, catalogued, and racked ready for immediate issue and delivery to other depots or direct to formations. All this involved a great deal of skilful organization, efficient co-operation, and hard work on the part of all concerned. The personnel of the various map depots, though working out of the limelight of publicity, deserved high credit for their contribution towards final victory.

SECTION 5. MAP SUPPLY TO THE AIR FORCES

Introduction

The evolution of an efficient system of map supply to the allied air forces in the Mediterranean Theatre was, perhaps, of special interest in that it was complicated by a variation in normal map supply procedure as between the British and U.S. forces.

The requirement was to furnish adequate quantities of maps of the following categories to all allied air forces and auxiliary units in the North African and Mediterranean theatres of operations:—

- (a) Standard and special navigational maps peculiar to air use.
- (b) Standard topographical maps on all scales. These were produced primarily for the ground forces, but were also essential to air operations.
- (c) Lithographic and photographic copies of photo-mosaics.

With an integrated (British-U.S.) Allied Force Headquarters for the theatre, the initial problem was to devise an organization which would produce the desired result without overlapping or duplication of effort.

Development of mapping support to the air forces in the Mediterranean Theatre

From the beginning of operation "Torch" (the invasion of North West Africa) it was agreed that the maps to be supplied to the allied air forces in the Mediterranean theatre for special air use would be the standard British air-maps, and that they would be supplied initially through the Directorate of Military Survey (War Office), and later by subordinate survey directorates. In December, 1942, the A.F.H.Q. Survey Directorate was established in Algiers and controlled the production and procurement of maps for both ground and air forces. Organized under the Chief Engineer, in accordance with U.S. practice, but with a British Director of Survey, it assembled stocks of the standard British air-maps for supply to the R.A.F. and the 12th U.S. Air Force, and assumed responsibility for all mapping in North Africa exclusive of Middle East areas. The special air-maps were supplied directly to the air forces in the quantities required by them, and this procedure was followed for the Sicilian operations and the opening stages of the Italian campaign. In October, 1943, D.D. Survey at H.Q. 15 Army Group assumed responsibility for supply to the tactical air forces which were in direct support of the ground forces. In addition to the special air-maps large quantities of standard topographical maps, as used by the ground forces, were supplied for close-support bombing and other purposes. The air forces so supplied included the Desert Air Force, the 12th U.S. Air Force, and the Tactical Bomber Force. Maps for air forces based in North Africa were supplied by A.F.H.Q. Survey Directorate in Algiers.

In November, 1943, it was agreed between D.D. Survey 15 Army Group and the Engineer Command 12th U.S. Air Force that map requirements for 12th Air Force would be determined by the latter and demands forwarded through the Engineer Command, the maps then to be supplied from map depots under the control of D.D. Survey. The other elements of the Tactical Air Force, in accordance with normal British practice, continued to deal direct with the survey directorates at H.Q. 15 Army Group and at H.Q. Eighth Army.

In January, 1944, the Engineer Command U.S.A.A.F. (Mediterranean) was formed. A forecast of map requirements for all U.S. air forces in the theatre was forwarded to A.F.H.Q. Survey Directorate who proceeded to stock up accordingly, and this arrangement continued till about October when it was agreed that as the Survey Directorate, through its subordinate survey representatives and map depots, had such a close contact with the air forces with regard to supply, the forecast of map requirements would follow the same channels as those through which the maps themselves were supplied, namely those of the theatre survey organization. The survey directorate then assumed complete responsibility, on an informal basis, for the supply of both air- and ground-maps to the air forces.

Although the accepted and normal channel for map supply to the R.A.F. was through the survey directorates according to British practice, the difference

between British and American practice left some doubt officially as to who was responsible for supply to the U.S. Air Forces. The system described above, which had developed through a progression of expedients, had by 1945 tended to conform to the standard British procedure, and the U.S. Air Forces seemed satisfied and desired its retention. To regularize the informal situation the C. in C. Allied Air Forces therefore issued a directive in April, 1945, assigning responsibility to A.F.H.Q. Survey Directorate for the supply of all maps, except target charts, to air forces in the theatre.

Thus the responsibility for the production, procurement, printing and distribution of maps for ground and air forces rested with one central authority, namely the theatre survey organization headed by the Director of Survey at A.F.H.Q.

Aeronautical charts

Late in 1944, the U.S. Air Forces enquired about the availability of the Army Air Force aeronautical charts which had been produced by the Aeronautical Chart Service in Washington. These had not previously been held in quantity by survey depots as they did not conform to the agreed standard series for use in the theatre. D. Survey, however, at once undertook to obtain sufficient stock to meet requirements.

Special map production for the air forces

Until about May, 1944, very little special map production was undertaken for the air forces other than the production of target charts by the engineer topographical companies (aviation).

Early in 1944, however, there were periodical requests for the production of special navigational maps, which were met on high priority by A.F.H.Q. Survey Directorate. During the winter of 1944-45 the production of special maps for air forces increased, and close contact was established between air force navigation officers, engineer topographical companies (Aviation), and the survey directorates in order to facilitate the production of special maps and navigational aids. These included the preparation of a special air navigation chart incorporating revised town shapes and flak overprints. The production of flak overprints on 1/500,000 air-maps, and the preparation of special overprints for long-range navigation using radar aids was also undertaken.

Survey data for "Shoran" controlled bombing methods

In October, 1944, A.F.H.Q. Survey Directorate was asked by the air forces to provide geodetic data for use in connection with "Shoran" controlled bombing methods, and a survey computing team was assembled to deal with this. The problem consisted of fixing two "Shoran" ground-stations by trig survey methods, accurately locating and fixing the position of selected targets from air photographs by photogrammetric methods, computing the geodetic distance from ground-station to target, and determining the air line distance, at the time of bomb-release, between the aircraft and the ground-station. It was estimated that the distances so determined were not likely to be in error by more than about 25 to 30 metres on average.

SECTION 6. AIR PHOTOGRAPHY FOR MAPPING AND REVISION

Early activities

In Chapter IX, which dealt with operations in North West Africa ("Torch"), it has been noted that there was practically no provision in that theatre for the production of survey photography except in the final stages when 60 Squadron of the South African Air Force, which was operating with Eighth Army, covered parts of Tunisia using two Mosquito aircraft which were at its disposal. The notes on the Sicilian operations (*see* Chapter XII, Section 4) show that D. Survey, Middle East had taken energetic action to obtain survey photography of Sicily well in advance of the projected operation so as to be able to compile new maps and revise existing ones. Much of this work was carried out from June, 1943, onwards by the Mosquitoes of 60 Squadron.

Other photography, taken primarily for Intelligence purposes, was undertaken by the North African Photographic Reconnaissance Wing (N.A.P.R.W.). They supplied 6-inch photos covering Sicily, Sardinia, parts of southern France and the toe of Italy. "Lightning" aircraft were used carrying a 6-inch vertical camera and two 24-inch obliques set at 6° or 9° from the vertical and flying at a height of from 25,000 to 30,000 feet. By mid-June, 1943, most of Sicily had been so covered, but the sorties were erratic and short.

Attachment of a survey officer to N.A.P.R. Wing

In July a survey officer was attached to the Wing for the following main purposes:—

- (a) To select photographs which would be of use for mapping.
- (b) To inform the survey organization of what photography was available, and to ensure that duplicate films were available for despatch to the Assistant Director Intelligence (Ph.) in London, G-2 (War Department, Washington) and the Middle East Intelligence Unit.
- (c) To obtain prints as required by A.F.H.Q. Survey Directorate.
- (d) To ask for photo-cover to be flown over areas required by Survey for mapping and revision.

Allocation and cancellation of a survey flight (Mosquitoes)

Representations having been made of the need for survey photography, one flight of three Mosquito IX aircraft was flown out to North Africa from 540 Squadron (Medmenham) specially for that purpose. However, owing to a sudden emergency elsewhere, the aircraft were required for other purposes and the flight returned to the United Kingdom almost immediately after its arrival. This left, as the next best available operational aircraft for photographic purposes, the "Lightnings" of a U.S. Photo Reconnaissance Squadron which was, in July, allocated for carrying out survey requirements on the Italian mainland.

Photo situation during the autumn of 1943

- (a) *Photography for Italian map revision.* By September, 1943, a considerable amount of photography was available covering southern and central Italy, and many sorties were being flown over parts of the Balkan peninsula. Sets of prints for use by the two armies in Italy were supplied from Cairo, and both armies now held all available 6-inch cover and a

large amount of 24-inch cover as far north as Spezia, though it was very incomplete. Air-photos were now in constant use for the revision of 1/50,000 and 1/25,000 maps of central and northern Italy and also of southern France. Weather conditions were bad during the winter months, and there were many gaps in the photography.

The supply of photographs from N.A.P.R.W. to Eighth Army was regularized by A.F.H.Q., and it was now possible for the army survey directorate to build up cover traces and organize its revision programme in a more satisfactory manner. The flimsy cover diagrams prepared by N.A.P.R.W. were very sketchy, however, and it was only by checking up with the Army Air-Photo Intelligence Unit (A.A.P.I.U.) that arrangements could be made for demanding further sorties to fill the gaps.

- (b) *Photo library.* In November, 1943, A.F.H.Q. Survey Directorate organized a photo library, making use of personnel belonging to 1601 Engineer Map Depot Detachment (U.S.), thus ensuring a better distribution of photos among the survey units.
- (c) *Cover diagrams.* A useful feature introduced about this time was the compilation of cover diagrams drawn up on 1/250,000 map sheets with the 1/100,000 sheet lines overprinted. This was found to be of great assistance in the organization of map revision as the 1/50,000 and 1/25,000 sheets formed subdivisions of the 1/100,000 sheet lines. During December A.F.H.Q. sent to both armies two sets of photos with the plots marked up on the overprinted 1/250,000 maps, and Eighth Army now held most of the available cover as far north as Bologna.
- (d) *Block-plots for target fixation.* A programme of target fixation for counter-battery purposes by the use of block-plots was taken up during the winter, the work being done on 9 × 9-inch prints at about 1/50,000 scale, using large scale photos for identification. To cover the gaps in these block-plots, 15 Army Group asked for further 6-inch photography. The construction and operation of the block-plots was done by 7 General Field Survey Section R.E. and continued with success during the remainder of the war.

The early part of 1944

- (a) *Formation of the Mediterranean Allied Photo Reconnaissance Wing (M.A.P.R.W.).* In January, 1944, the N.A.P.R.W. became M.A.P.R.W. All orders for photographs were then canalized through the Mediterranean Photo Intelligence Centre. A.F.H.Q. arranged for sorties over northern Italy, southern France, Greece and the Balkans. Demands were now heavy as new large scale mapping was being undertaken by Multiplex methods for southern France, the Balkans and parts of Italy.
- (b) *Demands for new large scale maps.* Both artillery and infantry in Eighth Army were now demanding fully detailed large scale maps in areas where none hitherto existed. When producing a special 1/25,000 map in the Orsogna area it was realized that gaps in photography, which seemed small on the 1/250,000 sortie diagrams, appeared enormous when it came to actual large scale compilation. However, complete cover for this job was obtained by D.D. Survey through G (Air) at Army H.Q.

- (c) *Film library.* A.F.H.Q. Survey Directorate established a film library for original 6-inch negatives. This was organized and controlled by 30 Engineer Topographical Battalion (U.S.) which was doing new map compilation by Multiplex methods, and required the original negatives from which to make the diapositives. These films covered the Balkans, southern France, and central Italy, and films of the more northerly parts of Italy were ordered. During March 6-inch sorties were flown along the Rhone Valley, and gaps in Italy to the north-west of Turin and in the Spezia district were covered under A.F.H.Q. control.
- (d) *Redistribution of photo coverage.* By March, 1944, the hand-over of air-cover from A.F.H.Q. to H.Q. Allied Armies in Italy was complete except for areas in north-east Italy, and an air-photo library was set up with 19 Field Survey Company R.E. which was operating under the direct control of D.D. Survey 15 Army Group. With changes in army areas and responsibilities, March was a busy month with regard to air-photos. It was necessary to redistribute the photo-coverage between the armies and units. All photos taken over by Eighth Army were sorted and indexed on a 1/100,000 map-sheet basis.

The spring and summer of 1944

- (a) *Improvement in weather conditions.* Conditions for air photography had been bad during the winter, but with better weather from April onwards great impetus was given to the photographic programme. Eighth Army was now receiving a steady flow of large scale photos, but the presence of many gaps made it difficult to plan a long-term revision for the 1/50,000 and 1/25,000 series. A further flying programme was asked for through G (Air) at Army H.Q. to fill these gaps.
- (b) *Preparations for the invasion of southern France.* By the end of July, 1944, photo-cover had been obtained for that part of France lying to the south of Lat. 46° and east of the meridian of Paris, as this appeared to be the most likely operational area for the projected invasion. Experience in large scale map compilation by Multiplex methods showed that the 6-inch photos alone were unsatisfactory and should be augmented by larger scale photos for the identification of control and detail. It was hoped to combine split 12-inch cameras with all 6-inch sorties over France, but the mounting of the cameras caused delays.
- (c) *North-east Italy, Yugoslavia and Austria.* During August, 1944, Eighth Army took over a record number of photos which covered the whole of north-east Italy lying to the north of Ravenna and east of Verona. These were at once sorted, listed and plotted on the cover diagrams so that the revision planners could organize their work.

Photography in northern Yugoslavia and in southern Austria made a lot of progress during these summer months, and in September the 6-inch mapping photography covering the approaches to Vienna had been completed in accordance with an A.F.H.Q. specification. The rapid advance of the allied forces northwards through southern and central France made it possible to cancel many of the flying demands which had been placed there and switch the photographic resources elsewhere.

- (d) *Gridded photos.* During the summer there was a growing demand for gridded large scale photos. Nearly 700 of these were produced and issued during July and August. The gridding was done by comparison with the 1/25,000 maps, each grid intersection being plotted by revision methods. They gave a wealth of detail at a scale of about 1/15,000.

The final stage (October, 1944–May, 1945)

- (a) *Transfer of film library to Italy.* In November the 6-inch film library which had been maintained by 30 Engineer Topographical Battalion in North Africa was transferred to Italy, with a section to do the contact printing, enlarging and rectifying.
- (b) *Austria.* With the prospect of the German armies being eventually forced back into Austria, an extensive mapping project for that country was organized under A.F.H.Q. control. Photo-coverage was an urgent essential and, as the mapping was to be done by Multiplex methods, 6-inch (K-17) original negatives were required. By January, 1945, much of the basic cover had been received, and the original negatives together with the master positives of long focal length photos covering the main communications, were sent to A.M.S., Washington, and also to S.H.A.E.F. (for E.T.O.U.S.A.), both of whom were to assist in the productive work.

During January and February, bad weather conditions hindered the flying programmes over Austria, but in March a considerable increase in output was possible owing to a good spell of fine weather, and progress thereafter continued to be satisfactory. The maps of Austria were not actually required for operations but were completed for occupational use.

CHAPTER XI

FRANCE, BELGIUM, HOLLAND, AND GERMANY 1944-5 (OPERATION "OVERLORD")

The following diagrams, maps and plates are relative to this chapter:—

	<i>Page</i>
<i>Diagrams</i>	<div style="display: flex; justify-content: space-between;"> <div style="flex: 1;"> <div style="display: flex; align-items: center;"> <div style="font-size: 3em; margin-right: 5px;">{</div> <div> <p>7. Survey organization in N.W. Europe 1944-45</p> <p>8. Grid Zones in Central Europe</p> <p>9. Belgium-England-France Triangulation Connection</p> <p>10. Geodetic Connection between the Triangulation Systems of Belgium-Holland-France-Luxembourg-Germany</p> <p>11. Trig connection between Denmark and Norway</p> <p>12. Airfield Sites in N. France</p> <p>13. Map Supply Organization in U.S. Army</p> </div> </div> </div> <div style="flex: 1; text-align: right; vertical-align: bottom;"> <p>facing 368</p> <p>414</p> <p>418</p> <p>431</p> <p>433</p> <p>450</p> <p>465</p> </div> </div>
<i>Sketch Maps</i>	<div style="display: flex; justify-content: space-between;"> <div style="flex: 1;"> <div style="display: flex; align-items: center;"> <div style="font-size: 3em; margin-right: 5px;">{</div> <div> <p>11. N. France and the Low Countries</p> <p>12. North West Europe</p> </div> </div> </div> <div style="flex: 1; text-align: right; vertical-align: bottom;"> <p>345</p> <p>facing 400</p> </div> </div>
<i>Plates at end of book</i>	<div style="display: flex; justify-content: space-between;"> <div style="flex: 1;"> <div style="display: flex; align-items: center;"> <div style="font-size: 3em; margin-right: 5px;">{</div> <div> <p>36. N.E. France and Belgium 1:50,000</p> <p>37. N. France 1:50,000</p> <p>38. E. France 1:50,000</p> <p>39. N.E. France and Belgium 1:100,000</p> <p>40. France 1:100,000</p> <p>41. N.W. Europe 1:250,000</p> <p>42. France 1:250,000</p> <p>43. N.E. France and Belgium 1:25,000</p> <p>44. Dieppe 1:12,500</p> <p>45. N. France 1:25,000</p> <p>46. N. France (Photo-map) 1:25,000</p> <p>47. Holland 1:25,000</p> <p>48. Holland 1:25,000</p> <p>49. France 1:12,500</p> <p>50. Germany 1:250,000</p> <p>51. Germany 1:100,000</p> <p>52. Germany 1:25,000</p> <p>53. Germany 1:50,000</p> <p>54. R. Rhine 1:12,500</p> <p>55. Airfield Reconnaissance Diagram</p> <p>56. Lattice Map (Mercator Projection)</p> <p>57. Dropping Zone Map (Airborne Forces in Normandy)</p> </div> </div> </div> <div style="flex: 1; text-align: right; vertical-align: bottom;"> </div> </div>

SECTION 1. SURVEY ORGANIZATION AND NARRATIVE (see Sketch Maps Nos. 11 and 12)

General picture of the Survey organization

The build-up of the British survey organization for service with the Allied Expeditionary Force in Western Europe has been described in Chapter III.

When operation "Overlord" was launched in June, 1944, the allied survey organization was as under:—

(a) SUPREME HEADQUARTERS (S.H.A.E.F.)

Survey Directorate. (Map and Survey section. G-3 Division.)

Director of Survey—Brigadier A. B. Clough (British).

Deputy Director—Colonel H. J. McCrimmon (U.S.).

Chief Clerk (U.S.).

Composed of integrated British and American personnel numbering 10 officers and 21 British other ranks and U.S. enlisted men it was originally formed in December, 1943, for duty with the "Overlord" planning staff under the Chief of Staff to the Supreme Allied Commander (C.O.S.S.A.C.). It was organized as follows:—

Survey sub-section. (Geodetic policy and research. Triangulation and field survey control. Radar survey control. Air survey photography and air survey mapping.)

Lieut.-Colonel (British).

Major (U.S.).

Map sub-section. (Mapping and map supply policy. Co-ordination of revision programmes. Special map production.)

Lieut.-Colonel (U.S.).

Lieut.-Colonel (British).

Captain (U.S.).

Administration and Stores sub-section. (Administration of the section. Accommodation. S.H.A.E.F. Map Library and Map Store. Map distribution policy. Kodak negative library. Stores, etc.)

Major (British).

Captain (U.S.).

Clerks, draughtsmen, computers, map storekeepers.

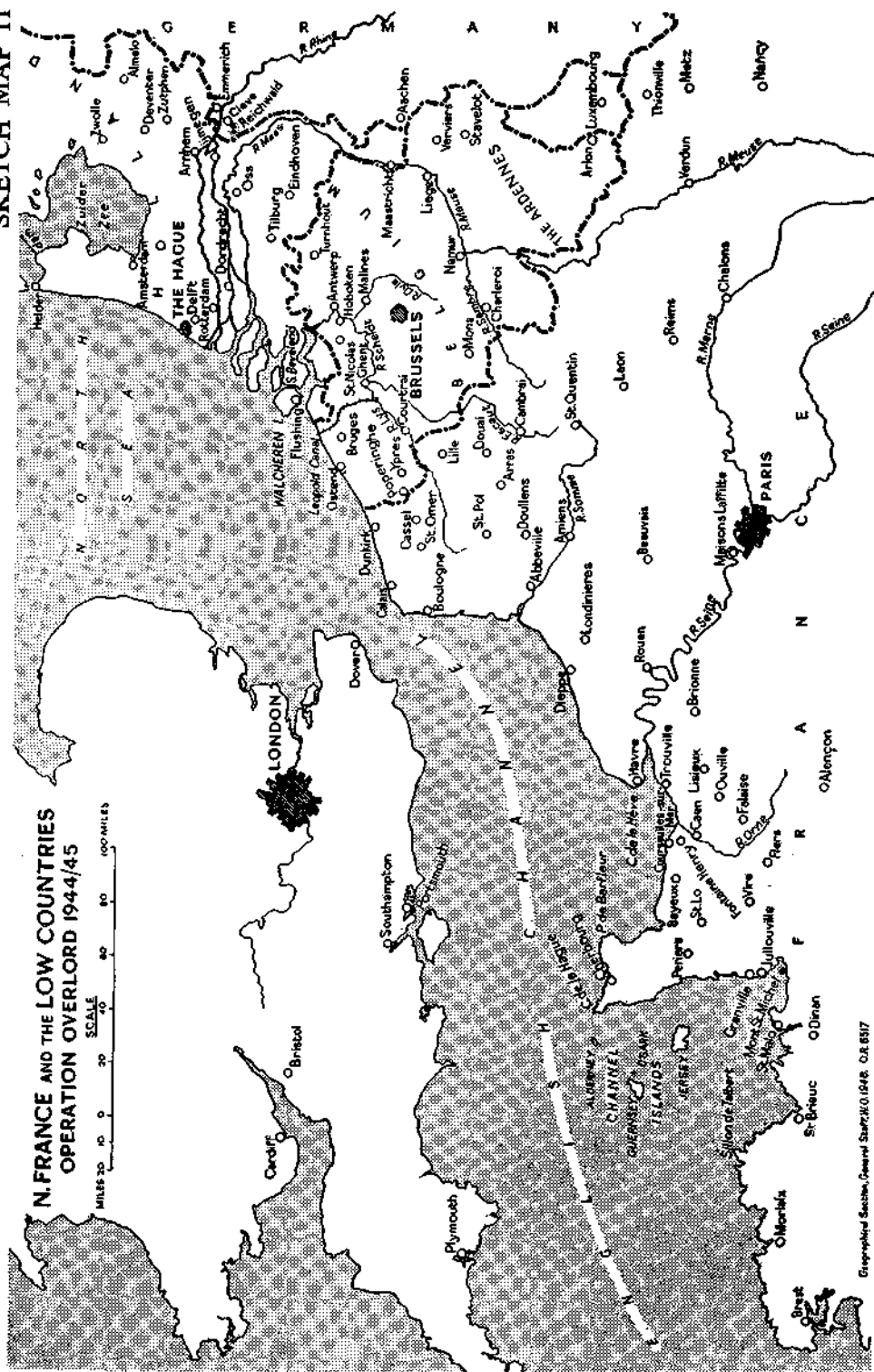
(21 British other ranks and U.S. Enlisted Men.)

Most of the British personnel had been working together for some months on survey planning; firstly at G.H.Q. Home Forces, and subsequently at H.Q. 21 Army Group. Colonel McCrimmon had been employed on the staff of the Chief of the Intelligence Division under the Chief Engineer, E.T.O.U.S.A., in London, and had thus been in close touch with the British survey planners. From its formation under C.O.S.S.A.C. in December, 1943, the Survey Directorate continued its planning and mapping control activities at high pressure during the six months leading up to "D"-day on 6th June.

Under the direct control of the Survey Directorate a map store was opened at S.H.A.E.F., whose main purpose was to supply the needs of all S.H.A.E.F. divisions and branches. A map library was also organized, in which it was aimed to hold a specimen copy of every map that was likely to be needed for reference purposes. The Survey sub-

SKETCH MAP II

**N. FRANCE AND THE LOW COUNTRIES
OPERATION OVERLORD 1944/45**



Geographical Section, General Staff, J.C. 15448. O.R. 6517

section built up a trig library holding triangulation and other survey data and records of all areas in the theatre which were likely to be of operational interest.

To provide facilities for local map drawing and reproduction at S.H.A.E.F. level, authority was obtained for No. 13 Map Reproduction Section R.E. and No. 9 General Field Survey Section R.E. to operate under the technical control of D. Survey (S.H.A.E.F.). Later on these units were transferred from 21 Army Group to S.H.A.E.F. for all purposes. They were very fully employed on the preparation of high-security maps of all sorts for the use of S.H.A.E.F. staffs in connection with planning and operations, and on the preparation and production of much basic work of a special nature for use by field formations.

(b) 21 ARMY GROUP

Headquarters. The Survey Directorate was organized as under:—

Director of Survey (Brigadier A. Prain).

Deputy Director (D.D. Survey) (Colonel H. A. L. Shewell).

(Primarily responsible for map supply and distribution.)

Asst. Director (A.D. Survey).

(Triangulation, field surveys including radar surveys, air survey, survey intelligence, and captured maps.)

Deputy Asst. Director (D.A.D. Survey).

(Mapping and map production.)

Assistant (Captain).

Army Group Units.

515 Field Survey Company R.E.

4 and 5 Field Survey Depots R.E.

4, 5 and 9 General Field Survey Sections R.E.

(No. 9 under S.H.A.E.F. technical control.)

13, 14, 15 and 16 Map Reproduction Section R.E.

(No. 13 under S.H.A.E.F. technical control.)

1 Air Survey Liaison Section R.E.

(c) BRITISH SECOND ARMY

Headquarters. The Survey Directorate was organized as under:—

D.D. Survey (Colonel A. W. Heap).

A.D. Survey. (Triangulation and field surveys.)

D.A.D. Survey. (Mapping, map supply and distribution.)

Survey Liaison Officers (Captains). (One to each corps under command. For survey contacts with corps and divisions on map supply and distribution matters.)

Army Troops Units.

14, 519 and 521 Field Survey Companies R.E.

3 (Army) Field Survey Depot R.E.

1, 2 and 3 General Field Survey Sections R.E.

(d) FIRST CANADIAN ARMY

Headquarters. The Survey Directorate was organized as under:—

D.D. Survey (Colonel H. Meuser, R.C.E.).

A.D. Survey. (Triangulation and field surveys.)

D.A.D. Survey. (Mapping and air surveys.)

Captain. (Map supply and distribution.)

Survey Liaison Officers (Captains). (One to each corps for contacts with corps and divisions on map supply and distribution matters.)

Army Troops Units.

2 Canadian Field Survey Company R.C.E. (Field surveys.)

3 Canadian Field Survey Company R.C.E. (Reproduction.)

4 Canadian Field Survey Company R.C.E. (Mapping and air survey.)

1 Canadian (Army) Field Survey Depot R.C.E.

(Note.—It will be observed that the Canadian Field Survey Company organization was on a different basis from the British. In the latter, the units were self-contained, each having its quota or personnel and equipment for field surveys (topographical), drawing (including air surveys), and map reproduction. In the Canadian Army, the units were organized on a functional basis, one being wholly for field-survey work, one for mapping and air surveys and the third for map reproduction and printing.)

(e) HEADQUARTERS ALLIED EXPEDITIONARY AIR FORCE (A.E.A.F.)

Under British policy, the Military Survey Service was responsible, as a common user service, for supplying the mapping needs of both the Army and the Royal Air Force. During the early war years, therefore, it was arranged that a survey officer should be held on the establishment of the principal Air Commands in Great Britain, with a small staff to operate map stores and to carry out special map drawing and other miscellaneous jobs. When, therefore, an integrated A.E.A.F. Headquarters was assembled, a Map Section was allotted to it, organized as under:—

D.A.D. Survey (Chief of Section—Major E. G. Godfrey) (British).

Deputy Chief of Section—Major (U.S.).

Clerical office 3 clerks (Corporals W.A.A.F.).

Drawing office 1 Serjeant, 1 Corporal, 2 Draughtsmen.

Map Store 1 Corporal, 3 other ranks.

The section was at first placed under the navigation officer, but this was not satisfactory. As in all cases of map and survey activities, the principal contact should be with the "Operations" and "Planning" branches of the staff. It was therefore agreed that it should be transferred so as to come directly under the Deputy Chief of Operations and Plans, and this proved to be a very satisfactory arrangement.

The problem of map supply is dealt with in Section 7 of this chapter and will not be elaborated here. For clarity, however, it should be understood that the Military Survey Directorate at the War Office was responsible for the production and supply of adequate stocks of whatever types of maps were considered necessary for the R.A.F. In cases where the R.A.F. was operating under or in conjunction with an army formation, for example the 2nd Tactical Air Force (T.A.F.) with 21 Army Group, it was the responsibility of the survey directorate with the military formation concerned to supply its map requirements.

In the case of the A.E.A.F. there were, however, many formations and other map users who did not come in the same supply category as 2nd T.A.F., and it was necessary that their mapping needs should be properly safeguarded. It was also essential that there should be a responsible agency for co-ordinating the supply of maps to all the air commands, sub-formations and units of the A.E.A.F., whether or not the actual physical supply would be arranged for by an army formation. Being in close touch with the "Plans" and "Operations" branches, the Map Section was in a position to obtain early and first-hand information about future air operational policy and, in so far as this affected design, supply, or distribution, was able to take whatever action was necessary to ensure that the requirements were met. With the development of radar aids to navigation, the section chief was responsible for much of the work concerning the initiation of field surveys for fixing the positions of the radar stations, and the preparation of the special lattice maps which were used in connection therewith.

The Map Section was, in effect, a direct descendant of a similar section which had been operating under Major Godfrey at H.Q. Air Defence of Great Britain (A.D.G.B.) during the years 1940-44. This officer with part of his staff was transferred from A.D.G.B. to A.E.A.F. and, until the latter went overseas, the two sections worked more or less as one. On the departure of H.Q. A.E.A.F., the map supply duties for A.D.G.B. were left in the capable hands of the W.A.A.F. officer who had for some time been assistant to the section chief.

During the planning stage the section was kept extremely busy. Map supply for training, and for the air operations that were constantly being carried out all over the coastal areas of Western Europe, was a major item, and large map stores were controlled by the section for this purpose. Operation boards for the various air operations control rooms were constructed. Special maps for a large variety of purposes were drawn and reproduced to meet the needs of the air staffs. Special map tables were also constructed for use in the headquarters ships of the Royal Navy which operated off the Normandy coast for controlling air operations during and after the assault on "D"-day.

On 21st September, 1944, part of the Map Section moved overseas with main H.Q. A.E.A.F., which was located alongside S.H.A.E.F. at Versailles. The Section Chief was at all times under the technical control of D. Survey S.H.A.E.F., who was responsible for all survey and mapping matters for both ground and air forces. In October there was an organizational change. H.Q. A.E.A.F. was disbanded as a separate headquarters and was absorbed into S.H.A.E.F. as S.H.A.E.F. (Air). The Map Section then became S.H.A.E.F.(Air)/Maps. The rapid advance of the allied forces during September from the Normandy bridgehead across the Seine and through north-eastern France and Belgium was a source of anxiety and hard work to the section as it was to all others who were concerned with map supply. The lull in October came as a welcome respite.

On the map reproduction side, much assistance was given to S.H.A.E.F.(Air)/Maps by 942 Topographical Aviation Battalion, an American engineer topographical unit serving with IX U.S. (Tactical) Air Force. This unit undertook the reproduction of many special

maps for use by the allied air forces and staffs from material supplied by S.H.A.E.F.(Air)/Maps.

The provision of maps for the allied airborne forces was a subject of much interest and activity on the part of the Map Section, especially in the early stages, before the formation of H.Q. First Allied Airborne Army with its own survey representation.

During February, 1945, when S.H.A.E.F. opened an advanced headquarters in Rheims, S.H.A.E.F.(Air)/Maps moved forward from Versailles, and as the S.H.A.E.F. Survey Directorate temporarily remained back at Versailles with S.H.A.E.F.(Main), an advanced S.H.A.E.F. map store was opened up at Rheims which was looked after by S.H.A.E.F.(Air)/Maps. By this means the needs of the staff divisions at both main and advanced headquarters were adequately met.

After the autumn lull, the *tempo* of operations quickened up again with the enemy offensive in the Ardennes, the approach to and crossing of the Rhine, and the rapid advance into Germany. A final move of the Map Section took place when S.H.A.E.F. moved forward to Frankfurt, and this was its final destination until disbanded in June, 1945.

U.S. ARMY TOPOGRAPHICAL ORGANIZATION

This subject will only be dealt with briefly, in so far as it affected the general survey set-up for operations in western Europe. Under basic U.S. Army policy, all map and survey matters were handled by the engineer staffs at formation headquarters. This fundamentally differed from British practice, where there was a separate survey service functioning with direct responsibility to the General Staff. Experience in the Mediterranean Theatre had indicated that this American organization had some weaknesses and, during the planning period for "Overlord," when co-operation for mapping and survey matters between British and U.S. representatives was of the most cordial and helpful nature, it was suggested, and strongly supported by the senior U.S. survey liaison officer, that some sort of compromise between the British and U.S. survey organizations should be adopted. This was to take the form of a specially selected topographical branch, to be allocated to the engineer sections at army group and army headquarters, which would concern itself solely with mapping and survey matters. This would then leave the Engineer staff as a whole to carry on with its normal engineer duties, and make sure that survey matters would not be side-tracked and neglected. This was agreed to by the War Department, and topographical branches, composed of officers and enlisted men with suitable survey qualifications, were appointed to the First (later Twelfth) U.S. Army Group, and to the First and Third U.S. Armies. They carried out their duties with conspicuous success.

The American unit organization was also different from the British. With each corps there was one engineer topographical company operating directly under the corps engineer, which was capable of carrying out field survey work on the corps front in conjunction with the corps observation battalion which corresponded to the British survey regiment R.A. It frequently happened that the survey platoons of the engineer topographical units were placed under command of the observation battalion for work within corps areas. These American units, like the British field survey companies, had a mapping or drawing platoon, and also reproduction platoons with mobile, lorry-borne

printing machines to enable them to undertake map production and printing in the field.

Each army had one engineer topographical battalion, which was organized as under:—

Battalion H.Q. and headquarter company.

Company A for field survey.

Company B for mapping, including air survey, map production, and printing. They were equipped with mobile lorry-borne reproduction plant.

There were no survey units directly at the disposal of U.S. Army Group Headquarters, as there were in the British Army, but the topographical branch at those headquarters exercised a general control over the mapping and production resources of the topographical units with armies under command.

Base map production and supply in the field was effected by having one or more engineer topographical battalions and map depot teams at the disposal of the Chief Engineer of the Communications Zone (Com. Z.). For mapping and survey matters, the Chief Engineer delegated technical control to the head of his Engineer Intelligence Division (Colonel H. Milwit) who was, in effect, the representative of the War Department in the European Theatre of operations for all mapping and survey activities, and acted as chief liaison officer with the British survey service. It is not too much to say that, by virtue of his high technical skill, administrative ability and ready co-operation, the working and social relations between the British and U.S. mapping and survey organizations were at all times close, effective and cordial.

Moves of units overseas

SECOND ARMY

The first survey troops to proceed to Normandy were the directorate and survey units of the British Second Army, who went over by detachments on light scales soon after "D"-day. All their vehicles had been waterproofed so as to enable them to get ashore from "landing craft" across the beaches. The residues of the units, consisting of those personnel not essential for the earliest tasks, and the bulk of the heavy vehicles crossed over later in June. The survey directorate accompanied Army H.Q. on "D" + 3.

The light scales organization for 519 and 521 Field Survey Companies, and the detachments in which they landed, were as follows:—

1st Detachment ("D" + 3). Reconnaissance detachment of 1 officer (O.C.) and 1 other rank with one 15-cwt. truck.

2nd Detachment ("D" + 4). Company H.Q. and drawing section consisting of 1 officer and 22 other ranks, with one 3-ton lorry, one water truck, one motor-cycle, and one cycle.

Topographical H.Q. 7 other ranks with one 3-ton lorry.

Two topographical sections each of 1 officer and 14 other ranks, with three 15-cwt. trucks and three motor-cycles.

3rd Detachment. Reproduction section. 1 officer and 22 other ranks, with two 3-ton lorries, one printing lorry, one photo-mechanical lorry, one trailer generator and one motor-cycle.

Photo section. 11 other ranks, with one 3-ton lorry, one camera lorry, one process lorry and two trailer generators.

The "residue" of each company consisted of 1 officer and 53 other ranks, with the following vehicles:—

Company H.Q. vehicles—Two 3-ton lorries, two 8-cwt. trucks, one trailer generator and one motor-cycle.

Topographical vehicles—Three 15-cwt. trucks and two 8-cwt. trucks.

Reproduction vehicles—Two 3-ton lorries, one printing lorry, one photo-mechanical lorry, one trailer generator and one motor-cycle.

14 Field Survey Company with 3 General Field Survey Section under command crossed over on light scales on "D" + 14.

1 and 2 General Field Survey Sections crossed over on light scales on "D" + 3 and "D" + 4 respectively each in one detachment only consisting of one officer and 21 other ranks, with one 3-ton lorry, two 15-cwt. trucks and three motor-cycles. The residue for each was four other ranks, one 3-tonner and one 15-cwt. truck.

3 (Army) Field Survey Depot went over on light scales in eight detachments (excluding the corps and divisional sub-sections which accompanied the headquarters of their respective formations). Two small detachments of the depot landed on "D"-day, second tide, under command of 1 and 30 Corps respectively, the main depot following in small detachments between "D" + 3 and "D" + 7. The rear depot crossed over about "D" + 14.

Some of the Army Group headquarters survey units reached Normandy during June, and were temporarily under command of Second Army. The units concerned were:—

4 Field Survey Depot R.E. (Maps). Completely overseas during June.

4 General Field Survey Section R.E. Over on light scales.

515 Field Survey Company R.E. Reconnaissance party only over during June.

5 Field Survey Depot R.E. (Stores). Two other ranks only over in June.

During July there was no change in the organization of Second Army survey units, which continued to be occupied on field survey work within the bridge-head, the printing of large scale (1/25,000) maps for all arms, the supply and distribution of maps on all scales from their own map depot, the revision of existing maps, and other miscellaneous tasks. The general field survey sections were placed, one each under command of the three field survey companies, two of which were employed on survey work in forward areas, with one in reserve. During the month the 21 Army Group units which had been temporarily under Second Army command, passed to L. of C. command, though still remaining under the technical control of Second Army.

21 ARMY GROUP

By the end of July the following Army Group H.Q. units were over in France, less their residues which were *en route*:—

4 and 5 Field Survey Depots R.E.

4 and 5 General Field Survey Sections R.E.

515 Field Survey Company R.E.

14 and 15 Map Reproduction Sections R.E.

A third field survey depot (No. 25) was allocated to 21 Army Group during July for employment as an L. of C. depot handling both maps and stores, which would be passed forward from Nos. 4 and 5 (Base) Depots.

In late April or early May, 1944, soon after Army Group H.Q. (Main) had moved to the south coast of England, the survey directorate had been split into two echelons, D. Survey and A.D. Survey going forward with main H.Q., while D.D. Survey, D.A.D. Survey and most of the directorate personnel remained at rear H.Q.

Survey (main H.Q.) crossed over to France on 4th August, D. Survey himself having preceded them by a few days, and rear Survey H.Q. followed on 12th-13th August. The directorate was then reunited at main H.Q. where it remained till the end of hostilities. A.T.S. clerks crossed over with rear H.Q., other A.T.S. personnel (draughtswomen and storewomen) having been replaced by men before "D"-day.

The three months during which the directorate was divided demonstrated clearly the disadvantages of splitting it in two echelons. Survey (main) was understaffed and overworked, and Survey (rear) was out of touch with the day-to-day needs and requirements of Second Army and 21 Army Group troops.

FIRST CANADIAN ARMY

The Canadian Army survey directorate was in Normandy by 25th July and, during the latter part of the month and early August, the following Canadian survey units took their place within the bridgehead:—

- 2 Canadian Field Survey Company R.C.E. (topographical).
- 3 Canadian Field Survey Company R.C.E. (reproduction).
- 4 Canadian Field Survey Company R.C.E. (mapping).
- 1 Canadian (Army) Field Survey Depot R.C.E.

U.S. ARMIES

For the assault operation the First U.S. Army was placed under command of 21 Army Group. The headquarters of the U.S. First Army Group did not exercise command overseas until the latter stages of the bridgehead operations, when the U.S. Third Army began to exploit the break-out. It became operational on 1st August, being renamed the Twelfth Army Group, and commanded both the First and Third U.S. Armies.

S.H.A.E.F. Survey Directorate

It might be well, at this stage, to consider the role of S.H.A.E.F. Survey Directorate in relation to the survey activities of the allied forces in the West European Theatre. Being a completely integrated Supreme Allied Headquarters, S.H.A.E.F. exercised command and control over all the allied forces at its disposal, of whatever nationality. With regard to survey this implied a centralized direction of allied survey and mapping policy. It was obvious that differences between allied technical methods and survey training made it impracticable to aim at complete standardization either for field survey work, map production and printing, or for map supply and distribution. There were no grounds, anyway, for suggesting that one method was right and the other wrong. The possibility, however, that formations of one nationality might find themselves temporarily under command of another allied formation, and the certainty of their having to co-ordinate their surveys

at points of junction, made it essential to bring about a certain degree of standardization concerning co-operation between engineer and artillery surveys and the recording and maintenance of survey data. It was also an agreed policy that all allied ground and air forces under S.H.A.E.F. command should use the same basic standard maps, grids, and map co-ordinate system. The Royal Navy and U.S. Naval Forces were also much concerned with the map co-ordinate and grid systems in connection with gunnery control during the assault, and the radio control of aircraft from headquarter ships. This made it desirable to draw up and publish Operational Policy Memoranda laying down certain basic rules regarding the above. D. Survey (S.H.A.E.F.) drafted two such memoranda for publication by the Chief of Staff. They were:—

- | | | |
|----|--------------------------------|------------------------------------|
| 28 | Artillery and Engineer Survey. | } See Appendices
Nos. I and II. |
| 9 | Map Co-ordinates. | |

S.H.A.E.F. also published a summary of existing War Office and War Department policies concerning map supply, together with a statement showing their application to "Overlord."

S.H.A.E.F. Survey Directorate had, during the planning period, made investigations into the triangulation systems of western Europe, and had prepared a series of trig lists covering all likely operational areas. These were issued to all concerned, together with fully descriptive notes about the various national trig systems and their characteristics. Throughout the whole campaign S.H.A.E.F. continued to issue technical information of all sorts to the allied survey organization in the form of Survey Technical Instructions.

At a conference between survey representatives of the War Office and the War Department in Washington soon after the entry of the United States into the war (*see* Chapter IV), it had been agreed that the War Office should be responsible for mapping policy and the initial production of basic map series for the whole of the European Theatre. As the responsible officer for all survey and mapping matters overseas within the area of S.H.A.E.F. control the Director of Survey (S.H.A.E.F.) maintained a very close liaison with the Director of Military Survey at the War Office on all matters concerning the production of these map series. As a result of his personal contacts with planning staffs at G.H.Q. Home Forces, at 21 Army Group, C.O.S.S.A.C. and at S.H.A.E.F. successively, he was able to ensure that the mapping programmes were being co-ordinated and kept up to schedule to conform with military plans.

It had been agreed also that, during the period of concentration and training in the United Kingdom, the assault itself, and the early period of subsequent operations, the British survey service would be responsible for providing stocks of all basic standard maps to the American forces. Thereafter, as soon as direct channels of communication had been opened up between the United States and France, the War Department would take over responsibility for bulk supply to U.S. forces within the Theatre. All this necessitated very close liaison between the D. Survey (War Office), D. Survey (S.H.A.E.F.), and Colonel Milwit (E.T.O.U.S.A.).

In view of the geographical proximity of the United Kingdom to the operational area, the prospective size of the allied forces, and the fact that most of the bulk stocks, anyway for the British, would be printed under War Office arrangements in the United Kingdom, it was decided that bulk map supply would normally be effected direct between the War Office and the consumer. This meant that D. Survey 21 Army Group dealt direct with the War Office

for the physical supply of map stocks, and this applied equally to E.T.O.U.S.A. (later Com. Z.), for bulk stocks which the Americans would be drawing from War Office sources. The same principle of direct dealing, cutting out S.H.A.E.F. except when policy questions arose, applied to the supply of technical survey stores for use by British units. This system avoided much duplication of effort and office work and saved a lot of time.

Although the production of most of the basic small and medium scale maps was a War Office responsibility, there were many items of map production which came directly under the control of D. Survey S.H.A.E.F. in both the planning and operational stages. Notable amongst these was the 1/25,000 mapping from air photographs of large areas of northern France which were not already covered with maps on that scale. The co-ordination and control of revision programmes for large scale maps of the whole Theatre was also a S.H.A.E.F. responsibility. Before "D"-day, two of the more important items controlled by S.H.A.E.F. were the surveys of enemy beaches from air-photos for the determination of beach gradients (*see* Chapter XIV, Section 10), and the air surveys of potential airfield sites in Normandy (*see* Section 5).

For S.H.A.E.F. Survey Directorate it was always a case of looking well ahead, keeping well briefed about probable future plans, forecasting future mapping, revision and survey requirements, and taking all necessary steps, in conjunction with the War Office, the chief topographical officer (E.T.O.U.S.A.) (and through him the War Department), and the allied Army Groups, to ensure that all possible requirements could and would be met.

It was always considered likely that, under emergency conditions, an interchange of map stocks between allied formations might be necessary and that, under such conditions, D. Survey (S.H.A.E.F.) would be responsible for issuing the necessary orders for such transfers. It so happened that this contingency frequently arose, but the close and friendly relations that existed between British and U.S. survey staffs in the field usually enabled local transfers of map stocks to be effected without any need for S.H.A.E.F. interference.

Another item which from December, 1944, was centrally controlled by S.H.A.E.F. was the survey of radar stations in connection with the establishment of "Gee" Chains for navigational control. Up to that date 21 Army Group had controlled and executed all radar surveys irrespective of their location. S.H.A.E.F. now dealt direct with the R.A.F. Group concerned to ascertain requirements, and delegated the actual survey work to the appropriate Army Group, dependent on the location of the station.

In order to keep all concerned informed of the ever-changing situation regarding the state of publication of standard map series, revision programmes, and kindred matters of general survey interest, progress reports were issued at frequent intervals by S.H.A.E.F. Survey Directorate, indicating the week-to-week mapping and revision situation and future prospects.

By these means S.H.A.E.F. was able to effect a proper co-ordination and control of the allied survey effort. In many respects it will be noted that the S.H.A.E.F. Survey Directorate was organized and functioned on somewhat different lines from the corresponding directorates at G.H.Q. Middle East, and at A.F.H.Q. in the Mediterranean Theatre. As these latter were separated by long distances from the United Kingdom, and as sea communications, especially in the mid-war years, were long and uncertain, they were necessarily more independent and self-contained with regard to bulk map production and supply.

Survey staff for H.Q. Allied Airborne Army

During August survey officers were assigned for duty with the newly formed headquarters of the First Allied Airborne Army (F.A.A.A.). By the nature of things, their map demands were extensive, varied, and always urgent. It was obvious that expert technical control of map supply at Army H.Q. was vital but, when it was suggested that survey officers should be appointed for this purpose, it was stated that no more officers could be added to the establishment of Army H.Q. as it was already large enough. There was, however, no question about their needing survey assistance. Two extra British officers were therefore posted to the S.H.A.E.F. Survey Directorate, from where they were detached for duty with H.Q. F.A.A.A. In one respect there was a great advantage in this procedure; security for airborne operations was essential, and the fact that these officers wore the S.H.A.E.F. flash on their shoulders, instead of the betraying Airborne Army flash, introduced a disguise of some merit when they were visiting map supply organizations or depots in their quest for map stocks. Similar arrangements had to be made for the American officers who completed the integrated survey team at Army Headquarters.

Further build-up of survey units

August witnessed the break-out from the Normandy bridgehead, the overrunning of the Brittany peninsula, and the spectacular pursuit of the German forces through northern France and Belgium. During the first half of August the main and rear portions of 21 Army Group Survey Directorate had crossed over and were reunited at Main H.Q. No. 25 Field Survey Depot had arrived overseas, and Nos. 14 and 15 Map Reproduction Sections were fully working within the bridgehead by late August. No. 25 Field Survey Depot joined 21 Army Group as an advanced L. of C. depot for maps and stores, and an advanced party of No. 16 Map Reproduction Section had also crossed over. No. 13 Map Reproduction Section and No. 9 General Field Survey Section who had for some months been under S.H.A.E.F. control, were finally transferred to S.H.A.E.F. for all purposes during August. The only 21 Army Group H.Q. survey unit still in the United Kingdom was No. 1 Air Survey Liaison Section R.E.

As a result of a somewhat unexpected and abnormal demand for 1/25,000 maps by all arms, especially in the close "bocage" district of Normandy, further mobile printing resources were demanded by Second Army, and agreed to by War Office. This entailed the addition to each field survey company of two printing lorries and one extra graining machine, together with the necessary technical and supervisory personnel. These were obtained mainly from Nos. 520 and 523 Field Survey Companies which were still in the United Kingdom.

The speed of the pursuit threw a great strain on the map supply and distribution organization. This will be referred to in more detail in Section 6, but it proved that an ordinary standard field survey depot, as then constituted, was inadequate to deal with the situation at Army Group level. Local civilians and extra military labour amounting to about 100 assorted personnel were employed during most of August. These included French typists, Spanish pioneers, French civilians, British pioneers and, on occasions, a general field survey section, two topographical sections from a field survey company and all the available survey reinforcements in the country. Their work was

mainly concerned with the handling and sorting of bulk stocks arriving from the United Kingdom, and sending them forward to the rapidly advancing armies. It was also clear that the depot's unit transport was inadequate even for its purely domestic affairs, and it was necessary to attach permanently one 15-cwt. truck for rations and water, one jeep to enable the O.C. to go to and fro between the depot and the docks, and one motor-cycle for the collection and delivery of mail and messages. The depot was also given first call on the 10-ton lorries belonging to the map reproduction sections for forward delivery of maps in bulk.

With Second Army, where the augmented No. 3 (Army type) Field Survey Depot was operating, all went well till the last week in August when it was found necessary to allot to the depot the personnel and transport of two topographical sections from a field survey company, and two general survey sections, to speed up the moves of the depot. Twenty 3-ton R.A.S.C. lorries and a platoon of pioneers had also to be borrowed. The Canadians experienced similar troubles during the advance owing to shortage of personnel and transport with their depot.

Departure of U.S. Base topographical organization overseas

The U.S. Base and L. of C. organization, known as the Communications Zone (Com. Z.), started moving over to France during August. It formed a separate American Command quite distinct from the U.S. Army Groups and its Commanding General was responsible directly to General Eisenhower, the Supreme Commander. The staff of S.H.A.E.F., though working in close co-operation, did not however exercise any command function over Com. Z. The base survey organization for U.S. forces in the Theatre, to deal with bulk map production, printing, and supply, was included within the Com. Z. command, under the control of the Chief Engineer, who, as stated previously, delegated the work to the Chief of his Intelligence Division, Colonel H. Milwit. This officer had been working in close touch with D. Survey (S.H.A.E.F.) and the War Office since 1942, and the happy, close co-operation between them continued through to the conclusion of hostilities. During the planning period he regularly attended the fortnightly map production conferences at the War Office, and was, with his staff, in almost daily personal touch with D. Survey (S.H.A.E.F.) to the mutual advantage of all concerned.

Field surveys

The triangulation work and check surveys which were carried out by both British and U.S. units during the bridgehead operations, mainly in connection with the provision of a control framework for the artillery, are dealt with in Section 3. When the break-out occurred and the pursuit was on, the need for this work temporarily lapsed. All survey units were, however, provided with trig data for the whole area and could, if the need arose, start work anywhere and provide the artillery with their necessary control points at short notice.

Map supply anxieties

The rapid pursuit following the break-out from Normandy was a source of considerable anxiety to the U.S. topographical branches at the headquarters of U.S. formations, especially in connection with General Patton's Third Army,

which raced along the Loire valley, across the Seine, and on towards Verdun and Metz at a great pace. There had been some difficulties regarding the transport of bulk stocks across the Channel and over the beaches, and during the first few critical weeks supplies were short. Ships containing map stocks printed in the United States, had crossed the Atlantic and were lying around the British coast. Cherbourg had been captured but was in a state of devastation and was not yet able to handle much shipping. Urgent representations at a high level resulted in the cargoes of the map ships being discharged. Road transport, which was at a premium, was obtained for rushing the maps forward, further stocks were flown over from the United Kingdom by air and, in one way or another, the advancing troops were just kept supplied, though not without causing much anxiety to the survey staffs concerned.

French Service Géographique (Institut Géographique National)

In late August Paris was occupied and, as this was in the U.S. Zone of operations, D. Survey (S.H.A.E.F.) allocated to the Chief Topographical Officer (Com. Z) the responsibility of investigating and controlling the map production resources of the French Service Géographique, which had its headquarters in Paris. First contact with this was made by the topographical branch of 12th U.S. Army Group, and it was satisfactory to find that General Hurault, who had worked so closely with the War Office immediately before the war, and with the Director of Survey, British Expeditionary Force, during 1939-40, was still in command. He proved most co-operative and placed all his resources at allied disposal. Com. Z. immediately sent a liaison officer to install an office at the headquarters of the Service Géographique and, with General Hurault's assistance, lithographic printing firms were requisitioned, and urgent programmes of map production were begun to meet the existing critical map situation. An officer from S.H.A.E.F. Survey Directorate also visited General Hurault to establish contact and obtain urgently required French triangulation data and other information.

Departure of S.H.A.E.F. Survey Directorate overseas

Early in September a forward echelon of S.H.A.E.F. Survey Directorate joined S.H.A.E.F. (Main) at Jullouville in the Cherbourg peninsula. The remainder crossed over soon after when S.H.A.E.F. (Main) had moved to Versailles. There it remained during the whole winter of 1944-45. The S.H.A.E.F. map store and library were opened up at Versailles and good accommodation was found nearby for 13 Map Reproduction Section and 9 General Survey Section who spent a busy winter providing the planning and other staffs with their many and varied special map requirements.

Staff increases

One result of the intensive map supply activities during late August and September, 1944, was the need for an increase in the establishment of Survey Directorates at the H.Q.s of both 21 Army Group and Second Army. The existing staffs were working at great pressure and were unable, without the risk of breakdown, to cope with the enormous volume of work that required urgent treatment. An extra D.A.D. Survey (Major) was therefore added to both, to assist with map supply and distribution work. The rank of the officer

commanding No. 4 Field Survey Depot, which was handling great quantities of maps under very trying conditions, was upgraded to captain, and two additional subalterns and extra personnel were added to the unit.

Survey Directorate 21 Army Group moves to Brussels

During September, H.Q. 21 Army Group, having moved forward from the bridgehead to Amiens, moved on again to Brussels where it remained for the winter months. Although 14 Map Reproduction Section and Nos. 4 (Maps), and 5 (Stores) Field Survey Depots still remained back in the Bayeux-Caen area, all the other 21 Army Group H.Q. survey units, including No. 1 (Air) Survey Liaison Section which had crossed over from the United Kingdom rather later than the others, were now in the Brussels area.

Military Geographical Institute, Brussels

D. Survey 21 Army Group made early contact with the Director of the Belgian Military Geographical Institute in Brussels, from whom he received most valuable co-operation. Unlike the French Service Géographique, which had managed to continue its work on a more or less civilian basis during the German occupation, the Belgian Institute had practically ceased to function. Its records had been stolen, and most of its plant and equipment had been removed. Fortunately a number of civilian printing presses, which had been requisitioned by the German mapping service, were found in good condition, also large quantities of paper and printing stores. Personnel of 15 and 16 Map Reproduction Sections were flown up from Normandy to operate these machines, their own equipment following later by road. As Brussels was in the British Zone of operations its local map printing resources were controlled by D. Survey 21 Army Group.

Survey stores

No. 25 Field Survey Depot, which had arrived from the United Kingdom, was installed at Brussels for handling both maps and stores. Owing to the continuation of the rapid advance, it was found necessary for No. 5 (Stores) Depot, which was still back in Normandy, to continue for the present to supply paper and survey stores direct to the army depots. The rapidly increasing distance between consumer and supplier made it difficult for the armies to send back to No. 5 Depot for their requirements and, as much of the L. of C. transport pool had been allotted to the two armies to keep them moving, there was a shortage of transport in the back areas. It was, therefore, an anxious and difficult matter to get the map stocks and survey stores forward but it was accomplished as a result of intensive efforts on the part of those concerned.

Map supply and distribution

Map supply and distribution will be described in more detail in Section 6, but a few remarks concerning the organization involved will not be out of place here. The map supply situation with armies became very critical during September. Stocks undoubtedly ran short, and issues had to be cut, but the formation commanders never had cause to complain that operations had been prejudiced by a lack of maps, and it is probable that the situation appeared to be more serious to the survey staffs themselves, who knew the real picture, than

to the actual map users. The fact is that no one type of map supply organization will successfully meet every operational contingency. The basic system, which should be framed to meet the most probable normal requirements, must be sufficiently flexible and capable of adjustment to ensure that the maps which become available from the various sources of supply will be put into the users' hands in plenty of time to be of use. This means that the survey staffs must be ready, in emergency, to throw in personnel and transport from other survey units when normal pool transport is unobtainable. The use of daily air-lifts for map delivery on a long-term basis, to bridge a crisis caused by temporary shortage of stocks and rapidly lengthening communications, should also be considered as a flexible and sure means of meeting a rapidly changing map situation. This may sometimes, as occurred during the September operations, entail air-lifts direct from the main source of supply (e.g., the War Office). The need for conducting officers cannot be over-emphasized. Without them map consignments will often be lost or mislaid.

Captured enemy map stocks

There was another item which demanded flexibility of treatment—the investigation and sorting of stocks of captured enemy maps. This formed a big and important task for both British and American survey services. The job was urgent, as the acquisition of new or recently revised enemy map material was needed for our own new map production and revision. The personnel of field survey units was at first used for this purpose, at the expense, of course, of other productive work, and in Paris, where enormous stocks of German maps were found, the French provided personnel to assist.

At a later date it was found necessary to organize special "Captured Map" sections for dealing with this work.

"Kodamine" sections

During operation "Overlord," as in other major war theatres, the reproduction of maps in the field by large numbers of widely scattered survey units assumed vast proportions. A difficult problem arose concerning the distribution, recording, and revision of the reproduction material and the control and use of revised material so as to ensure that the kodamines held by units were up to date and consistent. Survey Directorates at all levels found it necessary to have "Kodamine" sections to look after this matter and, as it seems more than likely that similar conditions will apply in any other war, provision for this should be made in war establishments.

The effect of rapid movement on the survey organization

The ability of survey directorates and units to pack up and move quickly was of great importance. Second Army H.Q. moved six times during September, the longest move being 160 miles. This entailed six moves for 3 (Army) Field Survey Depot with its map stocks and stores, a considerable transportation problem. On two occasions the rear section with the survey stores was left behind to ease the strain. The field survey companies moved five times in that period. On one occasion, when very urgent printing programmes were in hand, they were deliberately left 50 miles behind Army H.Q. so as to avoid a disturbance of the programme. Normally, however, it is undesirable to have these units widely separated from Army H.Q. and the Survey Directorate.

Some aspects regarding the organization of survey units

There were many obvious merits in the British organization of field survey companies whereby they were self-contained, each with its own sections for field survey, drawing and map production. There were, however, many occasions in the western European Theatre when it was advantageous to concentrate individual resources together so as to facilitate a mass-production output of work. The Canadians organized their survey units on this principle of functional output. On balance it is considered that the British system was the better. It is probably easier to concentrate the drawing, printing or field sections together from the various units than to throw together a mixed team when occasion demands.

In mid-September there was a change in the Canadian survey organization. Hitherto they had worked with three separate companies, one for field survey, one for reproduction, and one for mapping. The programme of new mapping and revision from air photographs was daily increasing in importance. New personnel was being trained in the technique of air survey mapping, and an efficient and well-equipped organization, including multiplex plotting apparatus, was now available. It was decided, therefore, to form an Air Survey Company, consisting of H.Q., one air survey liaison section, eight air survey sections (for map compilation and fair-drawing), one proving section, and one photographic section. The inclusion of these two latter sections was considered desirable as, in the course of producing a map from air-photos, there were many occasions when photography and the preparation of printing plates for pulling impressions and proving the work were necessary. This new company was therefore self-contained, and was not dependent, for some of its essential processes, on other units which might be some distance away.

Sixth U.S. Army Group comes under S.H.A.E.F. command

An important organizational change within the Theatre during September was the arrival of the U.S. Sixth Army Group, which included the U.S. Seventh Army and the First French Army. These two armies, coming from the Mediterranean area, had effected a successful assault-landing on the southern French coast, advanced rapidly up the Rhone valley and contacted the right wing of the U.S. Twelfth Army Group, where they encountered strong resistance in the Vosges mountains and the Belfort gap. They had been originally mapped up by A.F.H.Q. in the Mediterranean but, at an agreed stage, they came under general survey control from S.H.A.E.F. and subject to map supply from Com. Z. A topographical branch of the Engineer Section had been provided for H.Q. Sixth Army Group and, in the case of the First French Army, although there was a shortage of survey equipment and trained survey personnel, they organized the equivalent of a small survey directorate at their Army H.Q. and co-operated well with the topographical staff at H.Q. Sixth Army Group, under whose technical control they were placed.

Mapping programmes for western Germany

The approach of the allied armies towards the German frontier made it necessary to hasten the programme of mapping work on all scales covering western Germany. The War Office had in hand the preparation of series on 1/250,000, 1/100,000, 1/50,000 and 1/25,000 scales. Part of the 1/50,000

programme, covering the probable U.S. operational zone in the south, was allocated to the U.S. base mapping organization in order to hasten completion. The 1/25,000 sheets were being produced by direct facsimile copying from German maps. Many of them were out of date, and S.H.A.E.F. took over responsibility for the control of a revision programme from air photographs. For some months the R.A.F. and U.S. Army Air Force had been photographing western Germany in accordance with the priority programme instituted by S.H.A.E.F. East of the Rhine the map series was divided up into blocks for revision by the Army Groups and Com. Z. The area lying to the west of the Rhine was retained for revision by the War Office. As events turned out, this was an unwise decision. In the case of large scale map revision, which will normally be the responsibility of the survey organization in the field, it is better that the areas which are likely to be most urgently required should be revised in the field by the formations which will be using the maps. If the War Office or some other distant organization is to take over a share of the work, it should be allotted an area further ahead, which can be worked on a longer-term basis. The Twelfth and Sixth U.S. Army Groups sub-allocated sheets of their areas to armies under command, the work being undertaken by the engineer topographical battalions. 21 Army Group sub-allocated part of their area to the British Second and First Canadian Armies, retaining a large block themselves. To deal with this latter, D. Survey formed an Air Survey Group by assembling together, in Brussels, several general field survey sections, including two from Second Army. This was a similar arrangement to that which had been adopted in the United Kingdom for the preparation of 1/25,000 maps of northern France before "D"-day.

In addition to the above revision programme, survey units were continually engaged in the preparation of special maps covering important areas, mostly from large scale air photographs.

Increase in the war establishment of No. 4 Field Survey Depot R.E.

Previous mention has been made of the growing task of investigating and classifying captured enemy map material and other survey records. This, combined with the ever-increasing labour in connection with the recording, storing and issuing of kodak negatives of map series in the Theatre, made it necessary for D. Survey 21 Army Group to ask for an increase of establishment so as to form two new sections at his headquarters, one for enemy maps and records, and one for dealing with the kodak negatives. As no further additions were permissible to the war establishment of H.Q. 21 Army Group, the establishment of No. 4 Field Survey Depot was adjusted. The responsibilities and work of this unit, which was the principal map depot with 21 Army Group, had grown so much that a special establishment was approved. As a result it now consisted of three officers (captain and two subalterns), one warrant officer Class I, and 83 other ranks with the following transport:—

Motor cycles	2
Car, 2-seater	1
Trucks, 15-cwt.	3
Lorries, 3-ton	3
Lorries, 10-ton	5

A comparison between this and the original establishment of the unit will indicate the changed conditions. The depot was holding at that time between 15 and 20 million maps, a figure which rose still higher later on.

The German counter-offensive in the Ardennes

The comparative lull during October, November and early December enabled all concerned to go ahead with their mapping and revision programmes, to build up map stocks, and to carry out essential field surveys for artillery requirements along the front. Map planning for future operations was a major item, including preparations for the advance to, and the crossing of, the R. Rhine. The lull was broken during the latter half of December, when German forces counter-attacked strongly in the Ardennes, making a deep bulge in the allied line extending westwards nearly as far as the R. Meuse. The resulting quick moves of supporting formations, both British and American, caused many unexpected complications regarding map issues. It was a good test for the allied map supply organization, and afforded proof of the excellent liaison and co-operation that existed between British and American survey staffs and units. As a temporary measure, the survey activities of the First and Ninth U.S. Armies were transferred to the control of D. Survey 21 Army Group, though Com. Z. continued to be responsible for the supply of bulk map stocks to the advanced map depots serving both these armies.

As a precautionary measure, in case the enemy break-through should be extended across the Meuse into central Belgium, the topographical sections of two of the Second Army survey units were brigaded, and worked as one team under the command of O.C. 521 Field Survey Company. They carried out survey work for possible artillery requirements along the R. Dyle, just east of Brussels. Happily the contingency did not arise and the work was stopped after two weeks of activity.

A.T.S. Drawing Sections

The first of two A.T.S. Drawing Sections arrived for work under D. Survey 21 Army Group in November. They had been trained at the R.A.F. Photographic Station at Medmenham for the preparation of sortie diagrams and other work in connection with survey photographic programmes, and they were located with the R.A.F. squadron which was undertaking survey photography for 21 Army Group. They more than justified their inclusion as part of the survey team.

Preparations for the Allied offensive into Germany

By the end of January, 1945, vigorous action had practically eliminated the whole of the Ardennes bulge. Sixth U.S. Army Group in the south was in process of squeezing the German forces out of the Colmar pocket. In the north the British Second Army had successfully cleared the enemy out of the area between the Rivers Maas and Roer. Only in the Saar was the enemy aggressive. Everywhere else the Allies had regained the initiative. In the east, the Russians had opened a big offensive on a broad front from East Prussia to the Carpathians.

Normal field surveys were carried on along the front for checking triangulation and establishing new control. A special survey project was undertaken by the Canadians in the Antwerp area, in connection with the installation of detection equipment against V-weapons. The survey sub-section of S.H.A.E.F.

Survey Directorate concentrated its efforts on the preparation of trig lists of western Germany. In view of the large amount of computing work which field formations were undertaking in connection with the conversion of trig values from one system to another, consideration was given to the advisability of forming a centralized computing centre at S.H.A.E.F. After discussions with Army Groups, it was decided not to proceed with the project, which would have entailed the detachment to S.H.A.E.F. of many of their best computers.

During February, the Belgian Cartographic Institute, under the general guidance of D. Survey 21 Army Group, formed a special topographical section for air survey consisting of Belgian personnel. This section was attached for training to the Canadians and made excellent progress.

With past experience as a guide, and the probability of quick movement over long distances, preliminary steps were taken in 21 Army Group towards the formation of a mobile advanced map depot which could move forward at short notice without disturbing the elaborate set-up of the two existing Army Group map depots. Personnel from these latter were used for formation of this map depot on wheels.

A new U.S. Army (Fifteenth) became operational during March, involving the usual allocation by Com. Z. of an advanced map depot just to the rear of the army area. The stage was now set for the assault crossing of the Rhine. Survey staffs and units were working under high pressure, and a large and varied assortment of maps, defence overprints, flood diagrams, photo-mosaics, relief models, etc., were in demand. Artillery control points were fixed on both banks of the river. Surveys were carried out to assist the engineer troops who were charged with the erection of permanent bridges as soon as the river had been crossed. The additional strength in mobile reproduction sections with Second Army was found invaluable to deal with the heavy printing programmes. An airborne operation to assist the river crossing in the Wesel area had been planned which involved much careful map supply preparation not only for the initial airborne part of the operation, but also for the subsequent period when the airborne troops would come under the command of a ground formation. For further details about the mapping up of airborne forces see Chapter XIV, Section 11.

The crossing of the Rhine and subsequent operations

Enemy opposition to the allied assault across the Rhine was, generally speaking, not so stubborn as had been anticipated. The crossing was successful along almost the entire allied front, and the deep, rapid advance into Germany involved a period of intense activity for the whole survey service.

The speed of the advance made it necessary to review the programmes of new mapping and revision so as to meet the fresh situations that arose almost daily. It was necessary at this stage to arrange with the War Office for the quick production of 1/25,000 maps of Denmark. With the prospect also of the German High Command withdrawing their best formations southwards to the so-called "National Redoubt" in the mountainous area of southern Germany and Austria, and the possibility that forces under S.H.A.E.F. control might reach northern Austria before those coming up from Italy, it became necessary to assemble stocks of maps covering this "Redoubt" area and extending further south into northern Italy. By arrangement with A.F.H.Q. (Italy), the necessary reproduction material was obtained by air from Italy, and production was hastily put in hand by Com. Z. in Paris.

Planning for possible airborne operations during March continued with unabated activity. The mapping up of units, the cancellation of one operation and preparations for another, followed each other in quick succession day after day.

Consideration of survey organization under occupational conditions

It became necessary, at this stage, to make preparations for the survey organization which would be required in Germany under occupational conditions in the event of a German collapse. Establishments were drawn up and preparations included the setting up of a small survey directorate at the London headquarters of the British Control Commission. The printing of German administrative boundary maps, and maps showing the agreed inter-zone boundaries between the allied forces of occupation, was being carried out under S.H.A.E.F. arrangements. Plans were also prepared for the taking over and control of the German National Survey organization, or whatever portions of it might still be in existence.

Investigation of German survey organizations

With the entry of allied forces into Germany itself, arrangements were made for locating, investigating and reporting on the various German survey installations which would be uncovered during the advance. This included survey representation with the appropriate Intelligence staffs at S.H.A.E.F. and allied Army Groups who were organizing "T" (Target) Force parties for exploiting every form of German activity. There was also a special survey investigation party, known as the "Hough" team, which was sent over from the War Department, whose activities were co-ordinated by D. Survey (S.H.A.E.F.) with those of the Army Groups so as to prevent duplication and overlap. Major Hough and his team of experts obtained material of great value.

Mobile map depots with Second Army

For the second time, as the result of a quick break-through, Second Army found it necessary to adopt abnormal map distribution arrangements, the essential point being that the map supply organization must be mobile. This probability had been foreseen, and detailed plans had been made well in advance. Three mobile sub-depots were organized, one being allocated to each Corps H.Q. Each of these consisted of a general field survey section (less draughtsmen), with one storeman, one driver and one 3-ton lorry from No. 3 (Army) Field Survey Depot. Each sub-depot therefore had a total of three 3-ton lorries filled with maps and four 15-cwt. trucks for the transportation of maps and for moving personnel. With their help the quick-moving corps and divisions were supplied successfully with their map requirements.

Preparations for a possible campaign in Norway

With a German collapse in Germany itself a foregone conclusion, there was a possibility that the German High Command might decide to make a last stand in Norway, so as to continue their U-boat campaign as long as possible. Planning for a possible large scale operation was put in hand on the assumption that it would be mounted from the Continent through Denmark and southern Sweden. The whole of Norway might have been involved, and as map provision for that country had hitherto been limited to small areas in the vicinity of

certain ports and large towns, this new possibility entailed an extensive mapping programme with very limited time in which to carry it out. The task for D. Survey (S.H.A.E.F.) was not made any easier by the fact that the planning staff, in their otherwise praiseworthy desire for extreme secrecy, or possibly forgetful of the mapping side of the picture, did not notify him of this new plan as early as they might have done. Every hour was of vital importance, and this omission made the mapping task much more difficult than it need have been. However, as events turned out, the complete German surrender enabled the mapping project to be abandoned, to the relief of all concerned.

The final stages

21 Army Group Survey Directorate moved into Germany during April, accompanied by 515 Field Survey Company, 19 Map Reproduction Section and a detachment of 4 Field Survey Depot. The remaining survey units under direct Army Group control stayed back at Antwerp and Brussels, except for No. 1 (Air) Survey Liaison Section which was with 34 Wing R.A.F. at Eindhoven.

With the clearance of a large portion of north-western Germany, 1 Corps was allotted for an occupational role in Westphalia. A detachment of No. 5 Field Survey Depot was placed under command of Second Army to serve the map needs of this corps.

The speed of movement more or less eliminated the need for field survey for artillery purposes. Even for the Elbe crossing the gunners did not call for any R.E. survey, the existing trig lists having been found adequate. Levelling work was carried out in connection with the establishment of tide gauges on the rivers Weser and Elbe. Demands for defence overprints were considerably less during April but were produced for the Elbe crossing, the investment of Hamburg, and the final clearance of the Cuxhaven peninsula. Towards the end of April, the speed of the advance tended to slacken, and demands for 1/25,000 maps increased.

The first week of May witnessed the final surrender. Increasing pressure had been maintained from all quarters. The final allied offensive in Italy led to the surrender of all German and Italian forces in that Theatre. Berlin was occupied by the Russians on 3rd May, and on 5th May all German forces in north-western Germany surrendered, including those in Holland, Denmark, Heligoland and the North German islands. In the south Sixth U.S. Army Group linked up with the Fifth Army from Italy at the Brenner Pass, and the German forces opposite them surrendered. In north-eastern Austria U.S. Third Army, having taken Berchtesgaden, were approaching Linz and Salzburg, the Russians coming in from the east. The collapse was now complete, and on 7th May German representatives signed surrender terms at S.H.A.E.F. Headquarters in Rheims.

The surrender of German forces in Norway brought into action operations "Doomsday" and "Apostle," whereby an Allied occupational force moved over from Scottish Command to take over the surrender and temporary control of the country. Arrangements had been made for a long time whereby this force would be mapped up by the A.D. Survey, Scottish Command (Lieutenant-Colonel R. H. Denniss, R.E.). The latter, with a small survey directorate, accompanied Force Headquarters to Oslo, and remained there to look after their map requirements and to investigate German survey resources and records.

S.H.A.E.F. opened up a forward H.Q. at Frankfurt towards the end of May,

and an advanced map depot was installed there, the Survey Directorate following in about mid-June. It was now a question of tidying up and preparing for occupational tasks. Provisional instructions were issued by S.H.A.E.F. regarding post-hostilities mapping programmes, control action regarding the German Survey Service, and other matters.

A final conference was held by D. Survey at S.H.A.E.F. early in July, attended by the Director of Military Survey (War Office), D. Survey 21 Army Group, and senior representatives of the American and French survey organizations. Preliminary details were arranged regarding subsequent mapping and revision programmes, and other survey matters under occupational and control conditions.

The Survey Directorate at S.H.A.E.F. was officially disbanded on 30th June, 1945. H.Q. British Second Army dissolved at the same time, and early steps were being taken to tranship American forces for further action in the Far East.

The allied survey organization in Western Europe at the close of hostilities is shown in skeleton form in Diagram 7. The total resources in allied survey personnel under the general control of the Survey Directorate, S.H.A.E.F. amounted to approximately 550 officers and 10,000 other ranks.

SECTION 2. MAPS AND MAP PRODUCTION

(A) MAPPING IN THE UNITED KINGDOM

Historical background

The threat of a German invasion of Great Britain following the evacuation of the B.E.F. from Dunkirk made it necessary, for a time, to concentrate practically all available mapping resources on the urgent task of producing maps for home defence. As soon, however, as that requirement had been fulfilled G.S.G.S. took action to provide for actual and potential mapping requirements for overseas operations. Whatever might happen elsewhere it was an axiom of British policy, ever since Dunkirk, that, at some future date, a return would be made to the Continent for the ultimate defeat of Germany. The entry of the United States into the war at the end of 1941 strengthened this policy and hastened the likelihood of its achievement and, though there was some difference of opinion about when the opening of a "Second Front" would be feasible, it was agreed that the defeat of Germany in Europe should have priority over the concentration of resources to defeat Japan.

This policy of an ultimate return to the Continent made it necessary from an early date to consider what mapping programmes would be required for operations in western Europe and to take early action to begin work on this project.

Mapping organization and control

The responsibility for the initiation and control of mapping programmes for operations in Western Europe was, by agreement with the War Department, Washington (see Chapter IV) in the hands of G.S.G.S. (War Office). Since the outbreak of war G.S.G.S. had under its technical control the full productive resources of the Ordnance Survey. It also had its own map production and

printing installation which, during 1940 and 1941 and part of 1942, was located at Cheltenham. When G.S.G.S. moved from there to Eastcote in the summer of 1942 this installation was greatly enlarged and became the War Office Survey Production Centre (S.P.C.), located at Hanwell. Some organizational features regarding the work of the Ordnance Survey and the S.P.C. during the war are discussed elsewhere under "Map Production in the United Kingdom." (See Chapter XIV, Section 1.)

Further mapping resources during the preparatory planning period were provided by the military survey organization with Home Forces including a survey directorate at G.H.Q., a small directorate at the headquarters of each Command, and a small number of field survey companies R.E. The Canadians also had their own survey directorate and field survey company R.C.E., which later was expanded to three companies. This survey organization with the Home Forces was expanded between 1941 and 1943 until, about the middle of 1943, 21 Army Group was formed consisting of the British Second and Canadian First Armies. The majority of the survey units which had served with Home Forces were transferred to 21 Army Group, and further units of various sorts were added, such as Map Reproduction Sections, General Field Survey Sections, Air Survey Liaison Sections, etc. This provided a considerable source of strength to map production facilities in the United Kingdom before "D"-day, and subsequently overseas.

Meanwhile American forces had been building up in the United Kingdom including topographical units, and in early 1944 S.H.A.E.F. was formed with its own integrated Survey Directorate. This latter exercised a general control over all allied mapping and survey activities in western Europe and maintained close and constant touch with the War Office with regard to mapping policy and requirements.

During the planning and preparatory period for "Overlord," apart from the time necessary for essential military and technical training, the whole of the resources of military survey units in the United Kingdom were made available to assist in map production for the forthcoming operations. Certain mapping tasks, forming part of the general map production programme, were allotted to these units, with target dates for completion, and without their help there would have been little in the way of 1/25,000 maps available for the initial operations in Normandy and other parts of northern France.

Map production conferences

In order to co-ordinate and control the mapping programmes and available resources, regular map production conferences were held by Brigadier Hotine, the Director of Military Survey at the War Office. These were normally held at fortnightly intervals, and were attended by representatives from G.H.Q. Home Forces (and later from S.H.A.E.F. and 21 Army Group when they were formed), from the U.S. forces and from the Ordnance Survey which was doing much of the productive work under War Office technical control. The conferences were invaluable. They enabled all concerned to be kept informed of the progress of the various map series under production, the build-up of the survey organization and its equipment, and afforded an opportunity for those attending to exchange views, offer suggestions, and discuss technical methods and other problems. Full minutes were kept which were circulated to all those concerned in the United Kingdom and to Directors of Survey in overseas theatres.

Mention should be made of the value gained by the regular attendance of Colonel H. Milwit, the chief survey representative of the U.S. forces in Europe. His ready co-operation and skilled technical knowledge were at all times an invaluable aid to the British military survey service, and he not only undertook a considerable amount of mapping work with his own units, but also acted as intermediary on many matters between the War Office and S.H.A.E.F. and the U.S. mapping organization in Washington.

Map series available in 1940

The only British military maps of France and Belgium available at the time of the Dunkirk evacuation were (*see* Chapter II, Section 2 and Plates 1-5):—

- 1/250,000. GSGS 4042. A 9-sheet series covering Belgium and part of north-eastern France.
GSGS 2738. A 16-sheet series covering northern France to the west and south of GSGS 4042.
- 1/50,000. GSGS 4040, covering Belgium and part of north-eastern France.
GSGS 4040 A, overlapping the above and extending westwards to about Le Havre.
- 1/25,000. GSGS 4041, covering approximately the same area as GSGS 4040 (above).

A small amount of patchy revision data for the above had been accumulated by the B.E.F. and sent home to the War Office. It will be realized, however, that, with the German occupation of the whole of the coastline in north-western Europe, the above limited map coverage was quite inadequate for any future operations that might take place on the Continent.

Strategical considerations

Until such time as precise plans could be drawn up for an invasion of the "enemy-held" coast, it was necessary for the Geographical Section to use its own judgment and intelligent anticipation about what mapping work should be undertaken. As soon as the imminent threat of enemy invasion had passed, G.H.Q. Home Forces started to plan for raids on the enemy coastline, and this entailed the preparation, under high security conditions, of special large scale maps of selected areas. These were produced mainly from air photographs by the Home Forces Survey Directorate and its units.

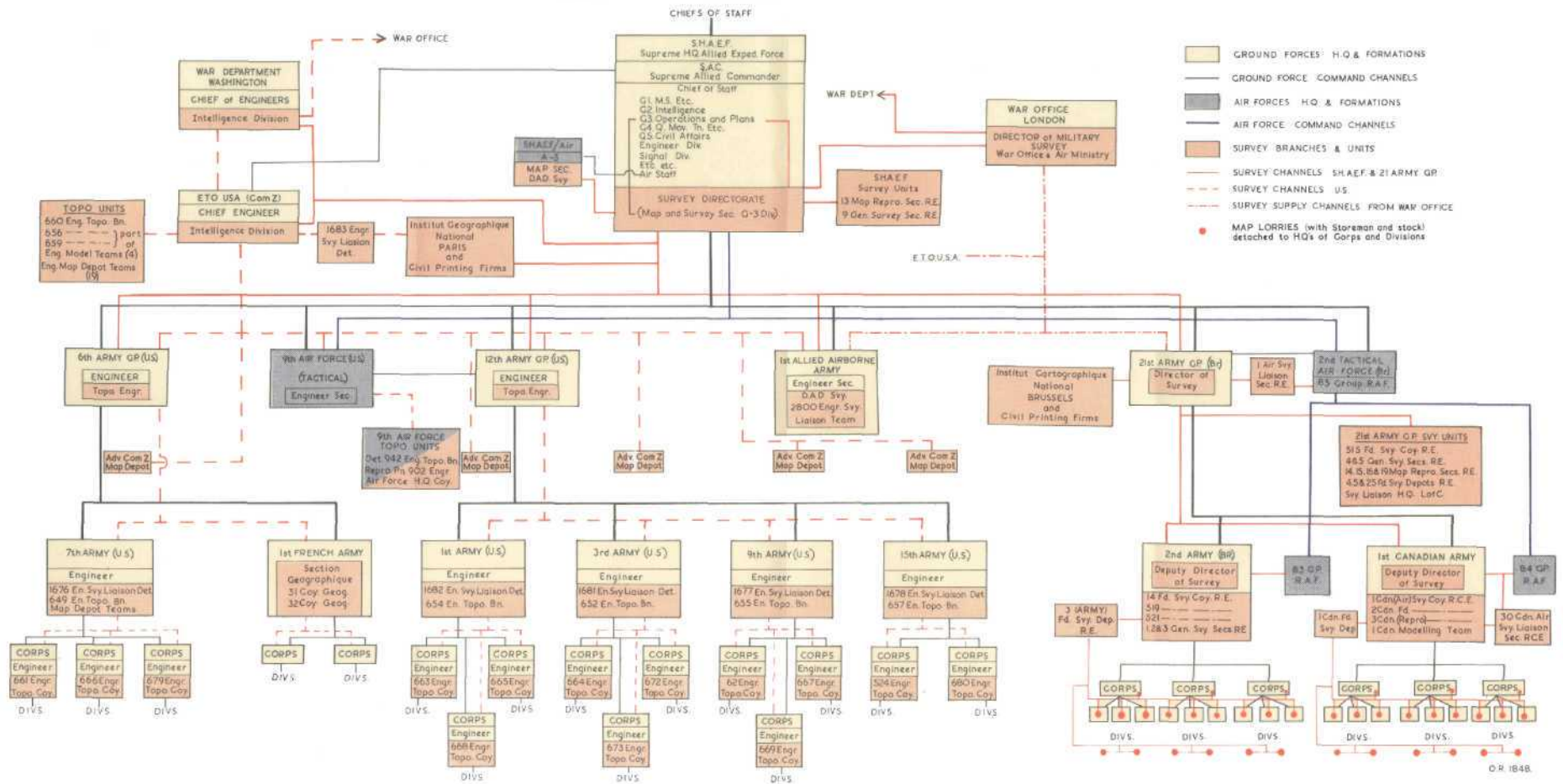
During the summer of 1942 the C.-in-C. Home Forces was directed to consider plans for an assault operation on the enemy-held coast as an opening bid for the final defeat of Germany in Europe. A small planning staff was set up, and it was early appreciated that the probable locality for the actual assault was limited, for various reasons, to that part of the Normandy coast lying between the Cherbourg peninsula and the mouth of the R. Seine.

As an early measure G.S.G.S. had put in hand the overhaul and revision of the existing B.E.F. map series referred to above but, when a clearer picture was available from the planning forecasts, it became possible for G.S.G.S. and the Director of Survey, Home Forces (and later S.H.A.E.F. and 21 Army Group) to plan new mapping programmes on a priority basis to cover all probable operational areas. As planning became firmer and more detailed it was possible to obtain a forecast of how the initial operations might develop subsequent to the invasion assault, and what would be the most probable axes

ALLIED EXPEDITIONARY FORCE N.W. EUROPE (1944-45)

DIAGRAM 7

MAP AND SURVEY ORGANIZATION



of movement. This enabled the mapping programmes for the inland areas to be planned in proper sequence.

In brief, the task confronting the survey service was to provide map coverage on all essential scales for the allied forces likely to take part in operation "Overlord" more or less in the following order of priority:—

The Normandy coastal area and inland as far south as the R. Loire (inclusive).

Brittany.

North-eastern France and Belgium on a central axis running approximately from Paris towards Brussels and Antwerp.

Holland.

The Atlantic seaboard of western France.

Germany, as far east as approximately Berlin, where it was anticipated that the Western Allies and Russia would make contact.

Denmark and parts of Norway.

This left the whole of central, eastern, and southern France more or less unmapped for the time being though there arose later on a priority requirement for south-eastern France in connection with a planned assault operation mounted from the Mediterranean, whereby an allied force would land in south-eastern France and move northwards to join up with the "Overlord" forces under General Eisenhower. The mapping arrangements for this were co-ordinated between G.S.G.S. and the Survey Directorate at A.F.H.Q.

Although, by agreement with the United States, the European theatre fell within the War Office sphere of mapping responsibility, it is pleasant to record the great amount of help and assistance which was rendered by the A.M.S. in Washington during all stages of the preparations for and the execution of operation "Overlord." There was the fullest and happiest co-operation between the British and American mapping authorities and, not only did the Americans print very large stocks of maps, but they also undertook the compilation and drawing of several large blocks of sheets which were allocated to them as part of the general programme.

Some of the principal mapping tasks which were undertaken under G.S.G.S. control, and by survey units in the United Kingdom in preparation for "Overlord," are discussed hereunder.

France and Belgium

(a) 1/50,000.

- (i) *GSGS 4040 (North-eastern France and Belgium)* (Plate 36). During 1941, G.S.G.S. directed the Ordnance Survey to take up the systematic overhaul and revision of this existing series, using whatever air-photos and other revision material could be obtained. During the course of this work the overlaps between sheets were eliminated, thus reducing the size of the sheets so that they could be printed, if necessary, on the demy-size mobile machines in the field, or printed two up on the larger machines. The sheet-lines remained on a grid-line basis. This work, which was much hampered by the lack of photos of suitable standard, continued until 1944, many sheets being revised three or four times as more photography became available. Road and track classification was

carefully examined, and action was taken as a result of previous adverse comments on the series, which criticized the omission of detail of tactical importance. This series was extensively used by allied forces during the pursuit of the German armies through north-eastern France and Belgium in 1944 and subsequent operations in, and occupation of, that area.

- (ii) *GSGS 4040 A and B.* GSGS 4040 A, which was one of the 1939-40 B.E.F. series (Plate 4), did not extend further west than the mouth of the R. Seine. When it became clear that the whole of Normandy and Brittany were likely to be operational areas, sheets were produced for these extended zones in the same style as 4040 A by direct enlargement from the French 1/80,000 map, and they were gridded with the appropriate Lambert grid. As there was also the possibility of operations being undertaken down the Atlantic coastline, a narrow strip along that coast was covered by similar-style sheets.

These 4040 A and B sheets served as a "stop-gap" until they were superseded by a newly drawn 1/50,000 series (GSGS 4250), which is referred to below. They served also as a stage in the production of this new series. Like the original 4040 A sheets they were printed in black only, with coloured grid figures, and were difficult to read in hilly country where the hachures tended to swamp the rest of the detail.

- (iii) *GSGS 4250 (North-western and western France).* Production of this new series was started late in 1941 by the Ordnance Survey and continued right through to 1944 (Plate 37). By "D"-day the sheets of the Normandy area had just been completed in time. The series covered north-western and western France, replacing the series 4040 A and B.

The French 1/80,000 map in its enlarged form (*see above*) formed the basic material, and the sheet lines followed those of the French national series. In the new drawings, revision was incorporated from air-photos wherever they could be obtained. At the start of the series only very haphazard and rather inferior photographic cover was available from reconnaissance sorties and the revision was therefore patchy and incomplete. Later, when a more systematic programme of survey photography was undertaken for the large scale mapping they, and the new 1/25,000 maps, were used to improve further these 1/50,000 sheets. The uncertain and long-delayed supply of the right type of air-photos, however, added very considerably to the difficulties and delays of completing the sheets which were so urgently required, not only for the actual operation, but also for the preparatory planning.

Some of the sheets contained inaccurate detail, and the contouring, being dependent on a somewhat free interpretation of the French hachures, left a good deal to be desired. The map was designed with an eye to rapid production by a somewhat inexperienced drawing staff, many of whom had recently been recruited and had undergone only a superficial training. To save time it was also decided that the same drawings should serve for both the 1/50,000 and 1/100,000 series. For that reason the drawing

was on an intermediate scale, the manuscripts being enlarged up for the former scale and reduced for the latter. Roads were shown by single red lines of varying weight, and contours were at first broken down through a screen so that they could be printed in half-tone from the black plate. This was unsatisfactory, and they were then printed as continuous lines in grey. The green and black circle symbols for woods and orchards were heavy and clumsy, and the lettering for the place-names was a weak feature, the positioning in many cases being ambiguous. There were also many spelling mistakes.

Priority was given to sheets covering Normandy, then Brittany and the western coast. Those required for the actual invasion area reached the winning post of completion just a short head in front of the operation itself.

In the north-east the sheets of GSGS 4250 overlapped those of GSGS 4040 covering north-eastern France and Belgium, and the index layout provided a straight-line junction with another 1/50,000 series (GSGS 4471) covering eastern France.

Generally speaking, GSGS 4250 was not a very good or satisfactory map either in design, appearance or accuracy.

- (iv) *GSGS 4471 (Eastern France)*. When the French started the production of their modern (post-1914-18) map series on 1/20,000 and 1/50,000 scale, they gave priority to their eastern frontier zones. By 1939-40 there were a number of sheets on both scales available in eastern France adjacent to the Italian, Swiss and German frontiers, and extending also along the south coast as far west as Marseilles.

When, therefore, there arose the possibility of allied operations in southern France, it was necessary to take up the production of a new 1/50,000 series for allied use, and this was to be based, wherever possible, on modern French mapping material. Where they existed the French 1/50,000 maps were reproduced by facsimile copying using colour-separation methods (Plate 38). In some cases new compilation was possible from 1/20,000 sheets, where maps on 1/50,000 scale had not yet reached production.

Revision was incorporated from air-photos, and the old French 1/80,000 map was not used as basic material in this area except where it could be supplemented by good air-photo cover. It is interesting to note that the work of producing new sheets was carried out simultaneously in the United Kingdom, at Washington, and at A.F.H.Q. Immediately a sheet had been completed reproduction material was circulated by air so that printing could be undertaken wherever required.

- (b) 1/100,000. No maps on this scale were provided for use by the B.E.F. After Dunkirk, when the British Army was being reconstituted and trained in the United Kingdom, it was decided that, to cater for the rapid movement of armoured forces, a map on the 1/100,000 scale was desirable. For training purposes in England a special edition of the Ordnance Survey $\frac{1}{2}$ -inch map was issued, and consideration was given to the preparation of 1/100,000 maps for future operations in Europe.

As a result, the following were put into production to cover France and Belgium:—

- (i) *GSGS 4336 (North-eastern France and Belgium)*. A series of 21 sheets had been published by the War Office during the 1914–18 war. It had been compiled from French 1/80,000 and Belgian 1/40,000 maps, and the printing plates and other reproduction material were still available. As revision from air-photos and modern French and Belgian maps was being undertaken for maps on larger scales, the same material was used for revising the 1/100,000 sheets. Railways and roads received special attention, the roads being classified according to the standard French and Belgian width categories.

On the whole this was a clear and legible map and was found satisfactory in use. It was published in Army/Air style with purple layers (Plate 39).

- (ii) *GSGS 4249 (Plate 40)*. This series eventually covered the whole of France except for the small part in the north-east which was already covered by GSGS 4336 (above). The details and design for this map were settled in November, 1941, simultaneously with the beginning of the new 1/50,000 series (GSGS 4250). Each sheet embraced an area covered by six of the 1/50,000 sheets and, where those of the latter scale were in production, the same drawings were used for both series. For the smaller scale, however, the footpaths and some of the names of minor villages and hamlets were omitted so as to avoid overcrowding.

The method of preparation varied. The majority of the sheets were based on the French 1/80,000 map, but where good modern French 1/50,000 maps were available in the eastern frontier zones they were used as basic material and, in the north and south-east, where new 1/25,000 maps were being compiled from air-photos, they also were made use of.

A large block of sheets in central and southern France was allocated for production to the A.M.S. in Washington. Though working to the same specification, there was naturally some difference in the appearance of the finished products owing to slight variations in cartography, lettering, etc. The British-compiled sheets were drawn and reproduced at the Ordnance Survey.

The series was published in Army/Air style. Speaking generally it was not a satisfactory map. The topographical detail was indistinct and difficult to read, it had the appearance of being fussy and overcrowded, and was not nearly bold or crisp enough for use, as it had been intended, by crews inside a tank doing their map-reading under difficult conditions.

- (c) 1/250,000. The same two series covering parts of France and Belgium which had been used by the B.E.F. in 1939–40 were again published for use by allied forces during operation "Overlord." Extra sheets were added to cover the probable extended area of operations and all sheets were subjected to revision and other alterations. Work on them was started in April, 1942.

- (i) *GSGS 4042 (North-eastern France and Belgium) (Plate 41).* This series, consisting originally of nine sheets, was extended to the north so as to cover Holland, and all 11 sheets were revised from air-photos and from other material which was being used for the revision of the larger scales. Communications were brought into line with the latest available information. For France the road classification followed that shown on the Michelin road maps, but for Belgium and Holland the road systems were classified into width categories from modern road maps and from Intelligence reports, many of which were of doubtful accuracy.

The series was published in Army/Air style.

- (ii) *GSGS 2738 (Plate 42)* covered the remainder of France lying to the west and south of GSGS 4042. Sheets covering northern France had been originally published during the 1914-18 war, and were used by the B.E.F. during 1939-40. These were revised, and the series was extended by the production of new sheets covering the whole of central and southern France. These new sheets were gridded with the appropriate Lambert grid and, in the case of the old sheets, which used to carry a system of reference squares only, the lines were deleted and the Lambert grid substituted. The original design and drawing of the series were not conducive to the production of a pleasing or satisfactory map. The new sheets were an improvement on the old with regard to clarity and appearance.

(d) *1/25,000 and larger scales.*

- (i) *General considerations.* Continued progress and development in artillery technique, radar and other modern devices made it essential to ensure that all probable operational areas in western Europe should be covered by good, accurate maps on 1/25,000 scale. The certainty also that the final battles on the Continent would be preceded by an assault on the enemy-occupied coastline made it all the more necessary that at any rate the mapping of the actual coastal area of the invasion zone on this scale should be completed in good time. This would provide suitable mapping material for detailed planning and other purposes.

In June, 1940, the only 1/25,000 map series available for France and Belgium was GSGS 4041. This 1939-40 series (Plate 5) covered all Belgium but only a small part of north-eastern France, not even reaching the coastline in the Pas de Calais. Over the rest of France there was no large scale mapping material other than a relatively small number of modern 1/20,000 sheets which the French had published along their eastern frontier zone, and a few odd sheets covering Paris and some of the principal naval bases such as Cherbourg, Brest, etc.

The problem was therefore a big one. It entailed not only the revision of all the existing sheets of GSGS 4041, but the production of a large number of new ones to cover the initial operational areas in north and north-western France, and extending southwards as far as the invasion operations were considered likely to develop during the early stages.

It was clear that such a task would involve the accumulation of

a mass of compilation material including air-photos, considerable resources in skilled man-power and a great deal of time. It was necessary, also, that an early indication of priority areas should be given so that the most vital areas could be completed first. This implied a close and harmonious link between the Director of Survey concerned and the planning staff.

In May, 1942, the Ordnance Survey was directed to revise the existing sheets of GSGS 4041 (Plate 43). Responsibility for the production of the new 1/25,000 mapping was allocated to the Director of Survey, Home Forces, who was best able to keep in close touch with the planning, and who had at his disposal a number of field survey units.

It was obvious that, as there was no suitable French mapping material on large scale covering the proposed invasion zone, air photography would be required, and for this class of accurate work the photos would have to be specially flown to the high specification necessary for survey purposes. With regard to the compilation of the maps, though a certain number of the survey unit personnel had received some training in air-photo mapping, they were not all experts, and there were sure to be a large number of "teething" troubles. Apart from any other considerations, there was no doubt, however, that the proposed programme would provide excellent training in air-photo mapping work for the survey units in preparation for the demands which it was certain would be made on them when they went overseas.

- (ii) *Some early large scale mapping tasks.* Before we consider details of the systematic 1/25,000 mapping programme of the invasion area, reference should be made to various large scale maps of a special nature which were undertaken for G.H.Q. Home Forces between 1940 and the time when intensive planning started for "Overlord." The following are typical examples:—

Calais-Gris Nez area.

When enemy heavy guns were installed on the French coast opposite Dover and the British heavy guns were mounted on the Kentish coast, there was a demand for a large scale gridded map of the Calais-Gris Nez area so that, by fixing the positions of our own and the enemy gun positions on the same grid, effective counter-battery fire could be carried out. In this connection a modern geodetic survey connection between the British and French coasts was observed (see Section 3).

The mapping work was undertaken by the 1 Canadian Field Survey Company R.C.E., and was the first air-photo mapping task carried out by this unit after its arrival in the United Kingdom. The only survey material available consisted of medium and small scale maps and charts, the co-ordinates of some French trig points, and some air photographs which had been taken for reconnaissance purposes only and were not nearly up to the high standard necessary for accurate mapping. At that date no proper survey photography had been carried out.

Planimetric control was based on the positions of plotted trig points, but the only height control was that provided by contour heights taken from smaller scale maps where the contours crossed main roads, railways and canals. On this shaky control the contours were then sketched in by stereoscopic examination of the air photographs.

The equipment available to the Canadian Survey Company at that time was somewhat rudimentary but the experience gained enabled them to plan many improvements in technique and apparatus. When the sheets reached the compilation stage they were sent to the Ordnance Survey where the fair-drawing and reproduction were completed.

It is interesting to note that this small drawing section forming part of 1 Canadian Field Survey Company was the nucleus of what was later to become the large and highly efficient Canadian Air Survey Company, equipped with Multiplex plotting apparatus and other photogrammetric equipment, which carried out such a large amount of air-photo mapping both before "D"-day and also with the Canadian Army overseas from the Normandy bridgehead right through to Holland and Germany.

Pas de Calais coastal series (1/12,500).

The next air-photo mapping task undertaken by the Canadians was a series of maps at 1/12,500 scale extending down a narrow coastal strip of the Pas de Calais from Boulogne southwards. These were produced during 1941-42 at a time when there was a likelihood of coastal raids being undertaken along that part of the French coast. The conditions of supply and the quality of the air-photos and other material for this job were similar to those for the Calais-Gris Nez maps. A revised edition was later issued when better-quality photos were obtained.

French coastal series (1/25,000).

During the early part of 1942, at a time when a return to the Continent was in its earliest stages of planning, D. Survey Home Forces considered it was desirable to produce a series of 1/25,000 maps covering a coastal belt extending from Calais along to the western side of the Cherbourg peninsula. This had a dual purpose. Firstly it would make sure that there was at least some form of large scale map coverage of the coastline in case of raids or minor operations. Secondly it would provide a practical training exercise in air-photo mapping for those units which would later be engaged in the systematic mapping of the area. The sheet lines, which were on a grid basis, did not conform to any regular arrangement. They were selected so as to cover the whole coastline with the minimum number of sheets and to give the maximum coverage on each sheet inland from the coast.

The sheets were allocated to all the survey units then serving with Home Forces, and the air-photos and necessary control

data were issued to them with a design specification so as to ensure uniformity. The resulting sheets were carried to reproduction stage so that printing could be undertaken in case of emergency, but they were superseded by the later regular series covering northern France. The lessons learnt during this project were of great value.

Channel Islands.

Quite apart from the possibility of allied raids on these islands there was a map requirement for allied occupation in the event of a German evacuation or surrender. Jersey, Guernsey and Alderney were already covered by Ordnance Survey maps on various scales, and these were revised. There was no existing map covering Sark, Herm and Jethou. To meet a possible Combined Operations requirement the Survey Directorate at G.H.Q. Home Forces produced in 1942 a new map on 1/12,500 scale covering these three small islands. Detail was compiled from air-photos and Admiralty charts.

Ushant.

For a planned commando raid on this island a special map was prepared from air-photos by Survey Directorate Home Forces on 1/12,500 scale. The raid did not take place.

Dieppe.

For the large scale raid on Dieppe, Survey Directorate, Home Forces produced a series of maps on 1/25,000 and 1/12,500 scale with enemy defences overprinted covering the town and harbour and the adjoining coastal areas. These were prepared under high security to meet the date originally proposed for the operation. The raid was postponed, and when it eventually took place the enemy defence overprint was brought up to date from the most recent reconnaissance photos (Plate 44).

Other special maps.

For the raid on a German radar station at Bruneval, and for other raids of a similar nature, large scale maps of specified coastal areas were produced.

The printing of these special maps, which were compiled and drawn at G.H.Q. Home Forces, was undertaken under conditions of high security by 523 Field Survey Company R.E. located near Byfleet, Surrey. Its work was of the highest class and, both from the security aspect, speed of output, and reliability, this unit gave splendid service. At a later date this sort of work was carried out under 21 Army Group control by the newly formed 13 Map Reproduction Section R.E. which had working alongside it 9 General Field Survey Section. These two units were later transferred to S.H.A.E.F. for similar duty.

- (iii) 1/25,000 *Series of northern France* ("Benson" series) (Plate 45). This series, which was given the code name "Benson," was planned to cover those probable operational areas in northern France which were not already included within the existing GSGS 4041 series. This latter, as stated previously, covered Belgium and a small portion only of north-eastern France. It did not even extend as far as the coast of the Pas de Calais.

An appreciation of the strategical situation indicated that the priority areas for this new mapping to meet probable invasion requirements were as follows:—

The coastal zone of Normandy, covering the proposed invasion bridgehead area.

Brittany.

An extension of the Normandy coastal zone southwards to the R. Loire.

An extension of the existing GSGS 4041 series to the west and south-west to cover the Pas de Calais and to join up with the new mapping of Normandy.

The Director of Survey Home Forces, who assumed responsibility for the control and supervision of this project, prepared a layout and specification, and allocated blocks of sheets to field survey units for execution.

The "Benson" programme included an extension of GSGS 4041, and two new areas to which were given series numbers GSGS 4347 and GSGS 4365.

GSGS 4347 covered most of Normandy and Brittany, extending south as far as the junction between Lambert Grid Zones I and II.

GSGS 4365 extended the above map coverage southwards within the limits of Lambert Zone II, but only over the western half of France.

All sheets of the above series were made up on grid sheet lines and measured 15 kms. by 10 kms.

(The remainder of France to the south and east was to be covered by another new series, GSGS 4411, which was not part of the "Benson" project. The sheets of this were to conform to the sheet lines of the new French 1/20,000 mapping, some sheets of which already existed in the eastern frontier zones. Where the latter sheets existed the new sheets of GSGS 4411 were made up by facsimile copying from the French material. For the production of new sheets of GSGS 4411 priority was given to the area in south-eastern France where it was planned to carry out an allied assault operation mounted from the Mediterranean (operation "Anvil"). This work was done by arrangement between the War Office, A.F.H.Q. and the A.M.S. in Washington.)

For the planimetric control of the "Benson" area French trig lists were available. These were based, so far as north-western France was concerned, on records of an old French triangulation and, as many of the listed points were church spires and other prominent features, it was hoped that they would be identifiable on the air-photos. Generally speaking this turned out to be the

case, but there was always some doubt about the accuracy and validity of the co-ordinate values, and a certain number of churches had obviously been rebuilt in different positions since the date of the original triangulation.

For height control there were a limited number of spot heights available from the 1/80,000 map at cross-roads and other identifiable places. The lack of an adequate height control was a source of much trouble.

The arrangements for obtaining survey photographs are described in Section 4. Those provided by the R.A.F. (140 Squadron) were mostly flown by Spitfires equipped with a 12-inch Fairchild camera. Flying at an average height of between 25,000 and 30,000 feet this produced photos at a convenient scale for compilation.

To provide a central control organization, an air survey group was formed in April, 1942, consisting of six newly raised General Field Survey Sections R.E. Its task was to assemble all the photographs and trig data necessary for the work, and to carry out the plotting and adjustment of the control before the compilation of detail could be undertaken by the survey units.

The area to be mapped was divided up into blocks of 25 sheets. For each of these blocks the air survey group prepared a large paper-mounted board of plywood on which the grid was carefully drawn. The trig points were plotted on this grid and the minor control plots for each photographic sortie were transferred to the board and the necessary adjustments carried out. Lists were prepared giving the measured co-ordinates of all the control points so established.

To each of the survey units then serving with Home Forces, including the Canadian Field Survey Company, was allotted one or more of the 25-sheet blocks, and the air survey group passed to them the photographs, control data, and other information which they required for the compilation of detail and contouring. The units undertook the fair-drawing, and carried the sheets through to the reproduction stage including the preparation of kodak negatives for outline, water and contours. Soon after the start of this project the mapping company of 660 Engineer Topographical Battalion (U.S. Army) reached the United Kingdom and was installed at Kew, Surrey, very convenient of access from G.H.Q. Home Forces, then at St. Paul's School, Hammersmith. This unit took over a share of the new "Benson" programme and, as their resources increased, further blocks of mapping were assigned to them.

In the early stages the air survey group carried out the minor control plotting by the "Arundel" radial line graphical method but, as soon as it was possible to obtain sets of the "slotted template" equipment, such as was used by the American units, this latter method was adopted thus improving both the speed and accuracy of the work.

The inadequate height control made it very difficult to provide the survey units with accurate data for contouring. The air survey group tried various methods of overcoming the problem including

the use of stereo-comparators, but the situation always remained unsatisfactory.

Lack of camera equipment with units at that time influenced the decision that fair-drawing should be done on translucent kodatrace on the final scale of reproduction, so that printing plates could be made by direct-contact exposure from the original. Difficulties were encountered owing to the flaking of the drawing ink from the kodatrace. Various expedients were tried, including the use of photopake as a drawing medium, but this was not satisfactory. The American unit, which was extremely well equipped for all types and stages of mapping work, made the fair-drawings on white board which were then photographed in the normal way.

660 Engineer Topographical Battalion was equipped with Multiplex stereographic plotting apparatus but, as the use of this required photographs specially taken with a particular type of 6-inch camera, and as the only photos available at that time were those provided by the R.A.F. taken with a 12-inch camera, plotting with the Multiplex equipment in those early days was not feasible for the "Benson" mapping.

A simple design was specified for the fair-drawing so as to produce clarity, speed of production, and economy of printing. The original specification provided for 3-colour printing in the field, all detail and names being in black, water in blue, and contours in brown. For each sheet, therefore, three separate kodakline negatives were necessary and, as these had to be true to size so as to give good registration between colours, it was essential to use topo-base film which was reputed to hold its shape and size.

Roads were shown by single lines of varying widths depending on their classification. Tracks and footpaths were included; so also were hedges, walls and other field divisions. Although these fully detailed 1/25,000 maps were produced primarily for artillery use, the infantry and their supporting tanks found them to be invaluable in the close "bocage" country of Normandy. There had been some divergence of opinion regarding the showing of hedges and field divisions but the British viewpoint, which was fully confirmed during actual operations, was that the inclusion of this close detail was essential in spite of the extra time required for its compilation.

The existence of more than one grid system in France added certain complications, and it was peculiarly unfortunate that there should have been a change of grid just at the eastern end of the invasion bridgehead area where it might be expected that heavy fighting would take place. The Nord de Guerre and the Lambert Zone I Grid systems had their junction approximately on the meridian of the Seine estuary. This was unavoidable, so on those sheets which included the grid junction, each grid system was extended over the adjoining one by means of grid ticks marked along the marginal edges of the maps. It was thus possible for the artillery, who might have their gun positions in one grid area and their targets in the other, to work in terms of either one grid or the other. It was necessary to lay down very clear instructions as to the use of

grid co-ordinates so that there should not be any confusion between the two different systems. One sheet contained the tri-junction between the Nord de Guerre, Lambert I and Lambert II Grid Zones, so on that particular sheet there were portions of three separate grid systems.

The production programme for the first priority area covering the projected Normandy bridgehead went rather slower than anticipated and, as no further British units were available to start work on the Brest peninsula area, which had high priority, the task was allocated to Company B (U.S. 660 Engineer Topographical Battalion). To start with they used the R.A.F. 12-inch photos but, with a view to accelerating the work and improving the contouring by the use of their Multiplex equipment, arrangements were made for photography of the area by the U.S. Air Force using the special K-17 6-inch cameras. The area to be covered was a large one and time was very limited, but their speed of production progressively increased, and completion was attained by the target date.

When it was known that further mapping resources were available in the United States for this class of work arrangements were made for an extension area lying to the south of the Normandy project to be undertaken by the A.M.S. in Washington. Photographs, control data and full specifications were flown over and the work was started. Tracings of marginal detail along the edges of adjacent sheets which were being produced in the United Kingdom were also flown over as they became available so as to ensure continuity of topographical detail between sheets.

- (iv) *Photo-maps* (Plate 46). The photo-map was essentially an American product. U.S. topographical units were trained and equipped for their rapid production. For the "Torch" operations in north-western Africa large numbers were made and printed but they were seldom used as their quality was poor and adequate map-coverage was available. The British Army did not like them, and never asked for them or used them.

During preparations for "Overlord," however, the U.S. mapping authorities were of the opinion that, in view of uncertainty of the timely completion of the 1/25,000 mapping programme, it was desirable to cover the vital priority areas with photo-maps which could be produced relatively quickly and would serve as a map substitute pending the completion of the 1/25,000 maps. It was also contended that, as they purported to show all ground detail, they would provide a valuable adjunct to the maps themselves.

An extensive project of over 1,000 sheets, on 1/25,000 scale, was begun in June, 1943, covering the Brest peninsula, and an area lying to the south of the first priority "Benson" area in Normandy, where the topographical maps were not likely to be available for some months. This project was later extended to cover the entire area of immediate operational interest. The goal was to provide 1/25,000 coverage in one form or another to a depth of 100 miles from the coast by the spring of 1944.

Most of the work was undertaken by the mapping company of 660 Engineer Topographical Battalion, but the corps topographical

companies which were arriving from the United States each took their share in the project.

The original photo-maps of the Brittany area were prepared from mosaics laid down on a map control. The French 1/80,000 sheets were enlarged to 1/25,000 and the air photographs, scaled to the map, were stuck down in position. The only photos available at that time were those taken by the R.A.F. using 12-inch Fairchild cameras. Many difficulties were encountered owing to random flight lines, tip and tilt, and gaps between flights. In the summer of 1943 a rectifying enlarger was obtained, and the quality and quantity of the mosaics showed considerable improvement. Photographs were ratioed to slotted template control and the tilt in the original negative was rectified.

The photo-map sheets measured 10 kms. by 10 kms. and were gridded similarly to the regular map series. Important detail such as roads and rivers was intensified on the mosaics before the latter were photographed through a half-tone screen.

The photo-map project in northern France eventually comprised nearly 1,600 sheets covering an area of 63,300 square miles, and involved the use of 32,600 rectified prints.

- (v) *Duplicate negatives and block-plots.* The "block-plot" originated at the battle of El Alamein. A description of its origin and use will be found in Chapter V (p. 64) dealing with the Middle East operations.

When the "Benson" 1/25,000 project for northern France was started, there was some doubt about whether the maps would be completed in time. It was decided, therefore, to guard against such a contingency by preparing a skeleton block-plot for each sheet in the Normandy area, on which the positions of the principal points of each photo used in the compilation would be carefully plotted. At the same time the principal points were marked on each original negative by a small fine cross, and duplicate sets of these marked and numbered negatives were made and issued to each of the field armies together with copies of the skeleton block-plots.

By this means, in the absence of the maps themselves, detail plotting could be done overseas of small areas if the emergency should arise, and counter-battery plots could be built up on the El Alamein pattern.

The principal point positions of the photos were marked and numbered also on the 1/25,000 maps in case it might be found necessary later on to intersect targets located on reconnaissance photographs.

The labour of marking up the negatives, making duplicate sets, and preparing the skeleton plots was considerable. As events turned out the 1/25,000 maps were available in time for the operations and, so far as is known, the duplicate negatives and skeleton plots were never used.

- (vi) *Special mapping for the assault.* This included the following items:—
1/12,500 *Coastal areas.* Some 40 sheets covering specially selected coastal areas were prepared from air-photos by survey units under S.H.A.E.F. control.

1/5,000 Beach maps. These were produced by a combined U.S.-British section under the direct control of A.D. Survey 21 Army Group. The section, composed of one U.S. topographical platoon and one British general field survey section, was located at Kew alongside the U.S. Engineer Topographical Battalion. The maps were compiled from enlargements of the 1/12,500 maps and were revised from the latest large scale air photographs and other material available. They showed beach obstacles, including those under water, cliff heights, nature of sand, etc.,

Operational overprints. Over a period of some months leading up to "D"-day, S.H.A.E.F. Survey Directorate controlled the production of operational and intelligence overprints and other special maps for G-2 (Intelligence) and G-3 (Operations) Divisions of S.H.A.E.F. to illustrate planning and intelligence reports. These overprints showed all known enemy defences and dispositions, beach obstacles, and other information relevant to the planning of the assault (Plate 49).

For the operation itself S.H.A.E.F. Survey Directorate, in conjunction with the Theatre Intelligence Section, produced operational stocks (including a stop-press edition) of overprints showing enemy defences and engineer intelligence information comprising 50 sheets at 1/25,000 and over 20 at 1/12,500 scale.

Special mapping for radar use. Detailed plans at a scale of 1/8,000, with contours at 1-metre interval, were prepared of a narrow coastal belt in the assault area by 660 Engineer Topographical Battalion. These were for use in connection with radar determination of position by craft approaching the coast in fog or darkness.

"Security" edition of 1/25,000 maps for briefing. Second Army survey units prepared a special "security" edition of the 1/25,000 sheets covering the assault areas, with fictitious names and other devices to prevent the actual location from being recognized. These maps were used for briefing purposes immediately before the assault.

Holland

- (a) 1/250,000 (GSGS 4042). To cover Holland at this scale two extra sheets were added to the 1939-40 B.E.F. series. These were slightly different in style from the remainder, but were published, like the others, in an Army/Air edition. Special layers in a greeny-brown tint were used to denote areas below sea level.
- (b) 1/100,000 (GSGS 2541). This series was first prepared during the 1914-18 war from Dutch 1/50,000 sheets, but it only covered the south-west and centre of Holland. For "Overlord" it was revised from modern large scale maps and from air-photos, and it was extended by adding two sheets to cover north-west Holland. Eastern Holland was eventually covered by a new 1/100,000 series of Germany which is described later.

- (c) 1/50,000 (GSGS 4083). This series was copied by photo-lithographic methods from Dutch 1/50,000 maps which were very detailed and highly coloured. The resulting map was fussy and obscure and, in view of limited time and the fact that the 1/100,000 and 1/25,000 series appeared to meet tactical requirements, it was decided to concentrate resources on the revision of the two latter series.

Limited stocks of the 1/50,000 sheets were printed for use by intelligence and planning staffs but the series was not issued for operational use. In July, 1944, the A.M.S. in Washington accepted responsibility for the production of a new 1/50,000 series. This was compiled from a new 1/25,000 series which they also produced at the request of the War Office from recent air photography.

Some captured German 1/50,000 maps of Holland were used by planning staffs in September and October. Some of the sheets were reproduced by 21 Army Group and used during operations.

- (d) 1/25,000 (GSGS 4096). To provide initial coverage at this scale the highly-coloured Dutch 1/25,000 maps were reproduced in black only (Plate 47). The originals being very fully detailed and in colour, the result was difficult to read and was unsatisfactory. These sheets were replaced by a newly drawn series (GSGS 4427) described below.

GSGS 4427, covering the western half of Holland, was produced by the A.M.S., Washington (Plate 48.) It was an entirely new drawing, the detail being taken from the most modern Dutch sheets and brought up to date from air-photos. The resulting map was clear to read and pleasing in style. The eastern half of the country was covered by sheets belonging to the German 1/25,000 series. Though made up on sheet lines of the German series they were drawn in the same style as GSGS 4427 referred to above.

Germany, Austria, Poland and Czechoslovakia

- (a) 1/250,000 (GSGS 4346). (Plate 50.) Apart from the standard map series at 1/M scale and the special air maps at 1/500,000 and 1/250,000 this was the first mapping of Germany to be taken up so as to provide coverage for initial planning. It was followed in due course by maps on larger scales. The production priority naturally flowed from west to east and conformed to the most probable trend of operations after entry into Germany. It was based largely on the German national 1/300,000 map and was produced by photo-lithography from black copies of that map. Various methods were adopted to clean up and clarify the resulting map, and colours were added to roads, woods, water and contours so as to publish the series in Army/Air style. In the extreme east and south-east the series was based on Austrian, Czechoslovak, Hungarian and Polish material. Sheets were on a graticule basis and the British military grid was added. Suitable junctions were effected with neighbouring map series covering Holland, Belgium, France, Italy, Denmark and the Balkans so as to ensure continuity and the avoidance of overlaps. During preparation, revision was incorporated from all available material including air photographs.
- (b) 1/100,000 (GSGS 4416). (Plate 51.) This was a newly drawn map based primarily on the German black 1/100,000 national series which, with

its rather dense detail and hill features shown by hachures, was not an easy map to read, and was considered unsuitable for reproduction as it stood. GSGS 4416 covered eventually a large part of Central Europe, and its production was shared between G.S.G.S. and the A.M.S., Washington, who worked to a common specification drawn up by the former. The new sheets carried less detail than the German originals and were published in colour both in Army/Air style and also without layers to meet a demand for this type. On the whole it was a good clear map, and it was revised from all available sources including revised 1/25,000 sheets, to which reference will be made later.

- (c) 1/25,000 (GSGS 4414). (Plate 52.) Germany had been well surveyed on large scale, and 1/25,000 maps of good quality existed for practically the whole country, the only gap being in the south-east where the Bavarian 1/25,000 series was incomplete. The maps were published in black with a German grid, and record copies were held in the War Office map library. The first task was to photograph the record copies of all sheets up to approximately the meridian of Berlin, where it was assumed junction would be made with the Russian armies, and to prepare kodak negatives for issue to field formations.

In November, 1943, which was the earliest date by which resources could be spared for the work owing to more urgent commitments, the Ordnance Survey was instructed to undertake the reproduction of the German sheets, numbering approximately 3,000. During the course of this initial work the German grid was eliminated and the British military grid substituted. Marginal notes and data in English were added in place of the German version. Production was limited at this stage to the supply of kodak negatives for monochrome printing, and the printing of a small stock of 6,000 copies for early planning and other purposes. The production of overprint colour plates (e.g., for roads, woods, water, etc.) for adding clarity to the map was scheduled as a field responsibility. Priority was from west to east with special priority given to those sheets which covered the most likely axes of allied advance into Germany. By October, 1944, first-edition kodak negatives of practically all sheets had been distributed.

Many problems and difficulties arose during the revision of this first edition. They were principally due to certain characteristics of the original German series and led to much subsequent confusion, uncertainty and extra work.

The large scale mapping of Germany had been undertaken separately by each of the individual states—Prussia, Württemberg, Baden, Saxony, Hesse and Bavaria. The Prussian survey was the most extensive of these. Each state produced its own 1/25,000 maps and these were based on the individual state surveys, each on its own geographical origin. Unfortunately, these separate origins were not in sympathy with each other, thus causing discordant junctions between the various systems.

A programme of survey and mapping unification throughout Germany had been put in hand, but this project was not complete by 1939 when war broke out. By that date some of the state series had been wholly converted to the Prussian system which, being the biggest and most important, was accepted as the basic series. In the case of

Baden and Wurttemberg, which were both on the same origin, only a limited number of sheets had been converted to the Prussian system, the remainder still being "State" sheets.

The material available for the initial production of GSGS 4414 was therefore a mixed lot, and sheets belonging to discordant systems fell in a somewhat haphazard pattern over southern Germany, the north being entirely covered by sheets of the Prussian system.

There was no doubt or difficulty about the sheets which belonged to or had been converted to the Prussian system. They were consistent with regard to graticule and detail junction at the sheet edges. But in the case of the Baden and Wurttemberg sheets which had not been converted, the discordance in graticule resulted in either gaps or overlaps at their junction with the Prussian sheets.

During the process of initial production at the Ordnance Survey, these gaps and overlaps were mostly attended to so as to ensure a proper junction of detail, and clear notes were in most cases added to indicate the system to which each individual sheet belonged. There were, however, some failures to do this, involving a good deal of trouble and confusion in the field later on.

The 1/25,000 series of Bavaria, which was incomplete, was on sheet lines quite different from those for the rest of Germany and the sheets were smaller. There was, however, a 1/50,000 series of Bavaria which covered the whole state.

Many of the German sheets were out of date and required revision. As soon, therefore, as the first-edition kodelines had been distributed, revision of the series became an urgent task. The systematic air photography of western Germany had been asked for some months previously and when, after many delays, blocks of photography were beginning to come in, a revision programme was drawn up between G.S.G.S. and the Director of Survey (S.H.A.E.F.). The intention was that the work should be shared between home-based resources (the Ordnance Survey) and the survey organization under S.H.A.E.F. control. One block of sheets in western Germany having been allocated to the Ordnance Survey, S.H.A.E.F. allotted blocks of sheets to British and American survey organizations on an operational area basis, and with due regard to probable operational priority. The British share was controlled by D. Survey 21 Army Group, who sub-allocated blocks to the Second British and the First Canadian Armies. The American commitment was handled by Colonel Milwit, who sub-allocated the work to his base topographical organization and to the topographical units with the U.S. 6th and 12th Army Groups. Some sheets were also allotted to the French. Further details of this revision programme in the field will be found later under "Mapping in the Field."

- (d) 1/50,000 (GSGS 4507). (Plate 53.) It had originally been thought that with maps of Germany on scales of 1/25,000, 1/100,000 and 1/250,000 there would be no need for a 1/50,000 map. Later, it was decided at S.H.A.E.F. that, as the allied forces would fight over France and Belgium on a 1/50,000 tactical map to which they would become accustomed, a similar scale map should be provided for Germany. By this time there was little time available for production.

G.S.G.S. drew up details of design and the O.S. was instructed during the summer of 1944 to start work on the project. The map was to be newly drawn, each sheet covering the area of six of the 1/25,000 series, the revised detail of the latter forming the basic material for compilation. The size of the sheets was selected so that they would fit the U.S. Webendorfer press.

As time was pressing, and as the U.S. base topographical organization in Paris was quickly built up to strength, a block of sheets in south-western Germany was transferred in October, 1944, from the O.S. to S.H.A.E.F. Another block of sheets in southern Holland was allocated for production to A.M.S., Washington.

Priorities were based on S.H.A.E.F. forecasts of the probable developments of operations in Germany, and the programme had to be amended as the strategic situation developed.

The map was in five colours, and was designed in simple style to facilitate quick drawing and easy printing. The western sheets were ready just in time for the operations leading up to the Rhine crossings, but after that the armies moved so rapidly that production could not keep pace.

On the whole it was a clear satisfactory map without any pretensions to cartographic beauty. In the original specification too many minor tracks of little if any tactical importance were included. This tended to clutter up the map and confused the more important detail. They were deleted.

(e) *Miscellaneous maps of Germany, Austria, etc., produced in the United Kingdom.*

- (i) *Reproductions of existing maps.* Reference has already been made to the newly drawn 1/100,000 series (GSGS 4416) of Germany which was published for operation "Overlord" and which covered most of central Europe. Before that publication G.S.G.S. reproduced several existing national map series so as to ensure the existence of a medium scale tactical map over Germany, Poland, Czechoslovakia and Austria. Some of these, which were eventually replaced by GSGS 4416, are briefly touched on below:—

Germany 1/100,000 (GSGS 4081). This was a direct reproduction, with no revision, from German 1/100,000 originals which were dated about 1935. They were in black, were very detailed, and hill features were shown by black hachures which, in hilly country, overpowered the rest of the detail. They carried a German grid.

Poland 1/100,000 (GSGS 4177). Reproduced direct, with no revision, from Polish 1/100,000 originals which were good clear maps, some in black and some in colour. Most sheets carried the Polish military grid.

Austria 1/75,000 (GSGS 5005). A direct all-black reproduction from Austrian 1/75,000 originals which were fully detailed, with relief shown by contours and hachures.

Czechoslovakia 1/75,000 (GSGS 4060). A direct reproduction, without revision, from Czechoslovakian 1/75,000 maps which were fully detailed, and relief was indicated by hachures

and contours. The reproduced sheets mostly had colour-tints added to clarify the roads, woods, etc.

The Ruhr 1/50,000 (GSGS 4156). The French had published a nine-sheet series covering the Ruhr, based on German 1/25,000 maps. As the Ruhr was topographically a somewhat complicated industrial area, this 1/50,000 series provided a useful supplement to the GSGS 1/100,000 maps of Germany for this vital district, and served as such until the production of the new 1/50,000 map (GSGS 4507) and special larger scale maps of the Ruhr area which will be described later. It was published in colour, but no revision was incorporated and no grid added.

Bavaria 1/50,000 (GSGS 4492). The Bavarian State survey had published a 1/50,000 series covering the whole of Bavaria. As the Bavarian 1/25,000 series was incomplete, G.S.G.S. reproduced the whole of the 1/50,000 sheets so as to ensure complete map coverage at medium/large scale over that area. The Nord de Guerre grid was added, and most of the sheets, which dated from 1930-38, were reproduced for printing in four colours, a few of the older sheets being in monochrome only. Kodak negatives were produced and distributed to field formations.

- (ii) *New compilations.* To provide large scale maps of the industrial Ruhr area and the River Rhine the following series were published:—

The Ruhr 1/12,500 (GSGS 4525). As it was clear that the Ruhr would form one of the principal strategic objectives in western Germany, and that large scale town plans would be wanted for many of the contiguous towns within that area, G.S.G.S. decided to prepare and publish a special large scale series on 1/12,500 scale in 18 sheets. This would avoid a multiplicity of separate, overlapping town plans. Sheets of the 1/25,000 map were enlarged to the required scale and revised from air-photos. Other information was added from town-plans and other documents, and important factories and installations were annotated. The base map was printed in brown with blue water, black names and certain important buildings picked out in black.

The Rivers Rhine and Main 1/12,500 (GSGS 4517 and 4518). (Plate 54.) The R. Rhine, being the major obstacle to the allied advance into the heart of Germany, offered a multitude of planning problems affecting the assault crossing. To provide as much topographical information as possible in handy form, a series of over 60 sheets on 1/12,500 scale was produced, covering the Rhine from Switzerland as far as Nijmegen in Holland. These, like the Ruhr series, were produced from revised enlargements of the 1/25,000 maps, and in somewhat similar style to the Ruhr sheets. After a first edition they were subjected to further revision and issued in improved form. They were, however, found unsatisfactory by the British and Canadians, partly owing to their being enlargements, and

partly also because the revision material was not of the best quality. A new series, on grid-sheet lines, was prepared early in 1945 by First Canadian Army, covering its own front and that of Second Army.

Denmark

- (a) 1/250,000 (GSGS 4479). This series of three sheets was produced by enlargement and colour-separation from original Danish sheets at 1/320,000 scale dated 1938, after making corrections to certain features such as roads and railways. Roads were reclassified on a width basis and red road-filling overprints were prepared. Green tints for woods and blue for water were added, and railways were emphasized. The sheets were on national sheet lines except that the southern sheets were cut so as to join up with the German series GSGS 4346.
- (b) 1/100,000 (GSGS 4210). This was an unrevised colour-separated reproduction of the Danish 1/100,000 map dated 1927-38, and the southern sheets were cut so as to join up with the German 1/100,000 series GSGS 4416.
- (c) 1/25,000 (GSGS 4554). The production of this series was taken up by G.S.G.S. in March, 1945. Each sheet consisted of two of the original Danish 1/20,000 sheets combined and reduced to the required scale. The work was carried out at the O.S., and kodaline negatives for monochrome printing were distributed to field formations in the normal manner.

Miscellaneous

- (a) *Town Plans.* These may be required for tactical purposes. More often they are needed for administrative use, especially in the case of ports and towns where important headquarters may be established and where extensive billeting, office, and storage projects are involved.

In the case of "Overlord" the requirement was a large one, and it was difficult to draw up a priority list for an extensive programme covering France, Belgium, Holland and Germany. The greater part of the work was completed before "D"-day and first attention was naturally paid to the principal towns in Normandy and the main ports in northern France. The War Office (G.S.G.S.) controlled the programme and carried out much of the work at its own Production Centre and at the O.S. British and U.S. survey units took their share, and the Central Interpretation Unit R.A.F. (C.I.U.) and the I.S.T.D. gave much valuable co-operation and help.

The basis of production varied considerably. In some cases, especially for the larger towns, there already existed plans of varying quality and style. Where copies were obtainable, reproduction was effected by direct photo-lithographic methods and the result was printed in black or in colour.

Some were copied from crude originals, and had no pretensions at being anything other than street diagrams. Many were newly compiled from air-photos alone. Wherever possible, no matter what was the basic material available, the plans were brought up to date from air-

photos and from any other modern intelligence material that could be obtained.

By December, 1943, upwards of 150 town plans had been produced covering parts of France, Belgium and Holland. For Germany there were about 50 plans ready by March, 1944, together with a small number in Denmark, Austria, Czechoslovakia and Poland. Further plans were taken up later as demands became firmer.

From the tactical point of view, perhaps the most interesting were the plans of specified villages and small towns which were produced by G.S.G.S. for airborne operations subsequent to "D"-day. For some time the First Allied Airborne Army, or at least part of it, was based operationally in the United Kingdom where airfield resources were naturally more favourable during the early stages of the campaign. Subsequent to the break-out from the Normandy bridgehead, a large number of airborne operations were planned in order to assist the advance of the allied forces across the Seine and through north-eastern France into Belgium and Holland. For all these operations, which required much meticulous and urgent planning, there were demands for standard tactical maps, including those on the 1/25,000 scale, and also for plans of hamlets, villages and small towns which formed specific objectives of the operation. In most cases there were no existing town or village plans, so they were compiled and printed within a matter of a few hours from air photographs. This work would normally have been the responsibility of S.H.A.E.F. Survey Directorate overseas, but as the operations were being mounted from the United Kingdom and time was vital, the War Office took over the task of production and supply. Large numbers of these urgent plans were produced very rapidly by a special section of the Central Interpretation Unit R.A.F. at Medmenham.

As events turned out, the majority of these planned airborne operations never took place, but their cancellation could usually be notified only at the last moment when it was found that the ground forces had advanced more rapidly than had been anticipated, and the mapping preparations had by then been completed.

- (b) *Through-way plans.* In addition to the normal and more detailed type of town plan there was likely to be a requirement for less detailed plans to enable drivers of vehicles to find their way quickly and directly through towns. They required to be simple in style and of small and handy size. Through-way plans were therefore produced for a large number of towns in the probable area of operations in France, Belgium, Holland, Denmark and Germany. They followed the style adopted by the Automobile Association and were published in small-size pamphlet form.

For France and Belgium the Michelin guide provided just the type of plan required, and for other countries corresponding types of guides were used, the plans being reproduced in facsimile. Much help was received during preparation from the I.S.T.D. and the production was carried out by the survey directorates at G.H.Q. Home Forces and at 21 Army Group.

The approximate number of towns for which through-way plans were produced was as under:—

France (in 6 volumes)	950
Belgium	60
Holland	60
Germany (in 2 volumes)	370
Denmark	140
Austria	20

- (c) *Communications of Europe* (1/800,000). This special series, showing the main road, railway and water communications in western Europe, was prepared by G.S.G.S. from Bartholemew's 1/M map of Europe. Roads were plotted according to their various national systems of road classification. Railways were taken from the official railway maps of the countries concerned, and were amended and brought up to date by the War Office Transportation Section. Waterways were taken from official waterways maps, and classified in terms of the capacity of the vessels that could use them.

In addition to a fully coloured edition showing all the communications separate editions were printed showing the basic topographical detail together with either roads, railways or water communications separately, or in any desired combination.

- (d) *Road maps*. In accordance with British mapping policy British forces had been trained, and were accustomed, to use the standard small scale (1/250,000) map for road transport purposes. American troops, no doubt influenced by common civil practice in the United States, favoured the use of special road maps which, while omitting unimportant topographical detail, concentrated on the representation of all important road features. It was decided, therefore, to provide suitable road maps for use by the allied forces in Europe.

For France, Belgium and Holland a direct reproduction in colour was made by G.S.G.S. of the Michelin 1/200,000 road-map series which already existed. There was thus a close association between these maps and the through-way town plans referred to previously which were based mainly on the Michelin guide.

For Germany there was no Michelin road map in existence before "D"-day. During the planning stage the preparation of a nine-sheet road-map series covering all Germany at the scale of 1/500,000 was undertaken by colour-separation from the German Conti atlas of 1938. This provided a satisfactory "stop-gap," but was not much liked by the Americans who, at a later stage, produced some further road maps which will be referred to subsequently.

- (e) *Gazetteers*. These were published to cover all countries in western Europe which were likely to be operational areas. In most cases they were based on the 1/250,000 maps, and contained the names of all towns and villages appearing on those maps together with their map co-ordinates. Production was shared between the War Office and the Central Interpretation Unit.
- (f) *Guide books*. The Theatre Intelligence Section at S.H.A.E.F. undertook the preparation of a series of pamphlets for northern France which would give, in a condensed form, such information about the character and resources of the towns and countryside as might be required by

the allied forces after landing in Normandy. This included data of an administrative, economic, industrial and topographical nature.

The information was collected from a variety of sources, and the assistance of the Survey Directorate at H.Q. 21 Army Group (later C.O.S.S.A.C. and S.H.A.E.F.) was sought with regard to printing and publication.

There were five volumes, each of which contained a number of pamphlets, each pamphlet dealing with one of the French "Départements" such as the Pas de Calais, Nord, Oise, etc. Each pamphlet contained the following information:—

- (i) A general description of the "département" as a whole with particulars about industry, agriculture, waterways, bridges, ports, water-supply, communications, power-supply, airfields, dumps, etc., illustrated by maps.
- (ii) A write-up of each "arrondissement," describing briefly all towns with a built-up area of over 1,000 inhabitants, and smaller towns of special interest.
- (iii) A detailed note of each town of major importance together with a town plan.

Detailed references, with map indices, of all the standard map series covering the area of each pamphlet were included and, as there were so many town-plans, etc., to be printed, the Survey Directorate agreed to print the whole publication provided the text was typewritten in a form suitable for photo-lithographic reproduction. This was done and the volumes were finally bound and made ready for issue by H.M. Stationery Office.

(g) *Relief models.* By December, 1943, when detailed planning for "Overlord" had been started by H.Q. 21 Army Group, several relief models were available of the invasion beaches and hinterland. These had been constructed by an integrated British-U.S. team of model-makers working at the R.A.F. station at Medmenham.

In view of expanding demands for these models and the limitations of manufacturing resources D. Survey (S.H.A.E.F.) decided to co-ordinate all demands from British-U.S. staffs, who were becoming increasingly appreciative of the value of such aids to planning and briefing.

As time passed, practically all army staffs engaged on planning were demanding some form of relief model, and it became necessary to organize a method of manufacture which would satisfy the requirement. H.Q. 21 Army Group therefore held a conference at which all available aids to planning were on view to potential users. These aids included lantern-slide anaglyphs, the standard "Medmenham" type terrain model at various scales, U.S. Naval rubber-cast models, and a quickly made portable model known as the "egg-box" type which could be made up under field conditions by quickly trained personnel. This latter type was so called because the basic framework of the model consisted of sets of parallel strips of stiff material which fitted into each other at right angles, similar to the cardboard divisions for holding eggs in a travelling egg-box. The top edge of each strip was trimmed to shape so as to

correspond, on an agreed exaggerated vertical scale, with the shape of the ground along that particular section which the strip represented in plan. When all the strips had been fitted together the surfacing material, incorporating a map of the area, was stretched over the top thus giving a representation of the ground in relief.

The egg-box model had been introduced from Italy where it had met with considerable success. As a result of the conference an organization was set up under the general control of the Survey Directorate 21 Army Group to undertake the training of model-making teams. The chief instructor was the U.S. Army officer who had introduced the model from Italy, and the school was accommodated at Chelsea Barracks under conditions of high security. Teams of six workers each, largely from Corps Intelligence Sections (British and Canadian) were trained there and were afterwards engaged on the preparation of models of the beach areas over which their own formations would be fighting. On completion these models were sent to corps, where they were further distributed to lower formations before embarkation. They were also used to assist in detailed technical planning.

For further details regarding relief models *see* Chapter XIV, Section 2.

(B) MAPPING OVERSEAS

Organization and equipment

A summary of the principal mapping work which was undertaken in the United Kingdom for operation "Overlord" has been given in Section A. Much of this was in preparation for the assault, and had therefore to be ready before "D"-day. The completion of further projects to meet allied requirements as they moved eastwards across France and Belgium into Holland and Germany, and further demands from S.H.A.E.F. for new mapping, revision and bulk-printing, kept the mapping resources in the U.K. working at high pressure from "D"-day till the end of hostilities. Resources in the United States were also heavily committed, not only in taking a share of new mapping production, but also in bulk-printing for American forces on the Continent subsequent to the initial stages of the operation.

The general policy was that the War Office and War Department, Washington were responsible for the provision of bulk-printed stocks of small and medium scale maps for their respective forces, and that the allied survey organization overseas was responsible for the revision and printing of all large scale maps, and for the production and printing of any special maps or map-series which were found necessary and had not been provided by the home-based authorities.

Some of the projects for new mapping, revision and printing which were undertaken overseas will now be considered. It was realized that there would be occasions when stocks of medium and smaller scale maps would run short as a result of unexpected high consumption, losses in transit and other causes, and in such circumstances it would be necessary to print extra stocks locally. The printing of large scale (1/25,000) maps, especially in the Normandy bridge-head, was a very heavy commitment. Also the requirements of planning and intelligence staffs and other staff branches were always considerable and

varied. There were many special mapping tasks which had to be undertaken, a number of which were of a day-to-day urgent operational nature, while others were of a more long-term character. Examples of the latter were the administrative boundary maps of Germany which were produced by S.H.A.E.F. Survey Directorate in anticipation of occupational requirements, and which required a great deal of careful research.

Before describing the actual mapping work undertaken it may be well to summarize the principal mapping resources which were available with the Allied Expeditionary Force for new mapping, revision, map production and printing. The number of units given represents approximately the situation towards the end of the war in the spring of 1945. There were, of course, transfers of survey units from one formation to another as demanded by changing situations. See Diagram 7.

(a) *Supreme Headquarters and U.S. Base Installations.*

- (i) *Supreme Headquarters.* The integrated British-U.S. Survey Directorate had under its direct control two small British units for meeting the special mapping requirements of S.H.A.E.F. and for the preparation of certain special maps for general use. This work was controlled by the Mapping sub-section of the Directorate, which maintained close touch with all staff branches of S.H.A.E.F. and the survey branches of lower formations. The planning, intelligence, operations and engineer branches were the most active customers. The units concerned were:—

No. 13 Map Reproduction Section R.E.

No. 9 General Field Survey Section R.E.

- (ii) *U.S. Base survey organization.* This was part of the U.S. Communications Zone organization and was controlled by the Chief Engineer through Colonel H. Milwit (Chief, Intelligence Division). He had at his disposal 660 Engineer Base Topographical Battalion with its survey, photo-mapping and reproduction companies, lavishly equipped for all sorts of mapping work, including Multiplex apparatus for plotting from air photographs. This unit was augmented by 659 Base Topographical Battalion and was installed in Paris where it formed the Engineer Base Mapping Plant.
- (iii) *French "Institut Géographique National" (I.G.N.).* (Service Géographique de l'Armée.) The French National Survey organization, with its headquarters in Paris, somewhat resembled a combination of the British Military Survey Directorate (War Office) and the Ordnance Survey. It functioned also as the "Service Géographique Militaire de l'Armée" and was commanded by General Hurault, already well known to several of the British survey officers. As Paris was in the American zone of operations Colonel Milwit exercised co-ordinating control over the I.G.N. mapping activities, and one of his officers was installed at General Hurault's headquarters for this purpose. General Hurault was in a specially favourable position to requisition aid from several of the civilian printing firms in Paris, and during the course of the war after the liberation of Paris, the I.G.N. provided most helpful co-operation and practical aid.

(b) *British and Canadian Forces.*

21 Army Group.

The Director of Survey, 21 Army Group (Brigadier A. Prain) exercised control over all mapping activities within 21 Army Group for which the following resources were available:—

(i) *H.Q. 21 Army Group.*

- 515 Field Survey Company R.E.
- 14, 15, 16, and 19 Map Reproduction Sections R.E.
- 4 and 5 General Field Survey Sections R.E.
- 1 Air Survey Liaison Section R.E.

(ii) *British Second Army.*

The D.D. Survey (Colonel A. W. Heap) had under his control the following survey units for mapping and reproduction work:—

- 14, 519, and 521 Field Survey Companies R.E.
- 1, 2, and 3 General Field Survey Sections R.E.

(iii) *First Canadian Army.*

The D.D. Survey (Colonel H. Meuser) had at his disposal:—

- 1 Canadian Field (Air) Survey Company R.C.E., a highly trained specialized unit for mapping and revision, especially from air-photos.
- 3 Canadian (Reproduction) Survey Company R.C.E., with mobile (demy) reproduction plant.
- 2 Canadian Field Survey Company R.C.E., principally for field survey but capable of being employed also on mapping work.
- 30 Canadian Air Survey Liaison Section R.C.E.

(iv) *Belgian "Institut Cartographique Militaire."*

The Belgian national survey organization had been almost completely disrupted during German occupation. Most of their records had gone and only one or two printing presses were still available. Colonel Mary, the Director, was, however, still in Brussels and he gave most valuable co-operation and assistance in enabling D. Survey 21 Army Group to take over the plant of a high-class printing firm in the city. A Map Reproduction Section R.E. was installed at the H.Q. of the "Institut."

(c) *U.S. Forces.* General over-all control of mapping work carried out by American topographical units serving in western Europe was exercised by Colonel Milwit referred to above. Apart from the base units serving directly under his control were the following, which formed part of the various field formations:—

(i) *12th Army Group.* General control of mapping and reproduction work was in the hands of the engineer at Army Group H.Q. who had on his staff a topographical branch headed by Colonel W. D. Milne.

Unlike the British, he had no survey units under his direct control at Army Group H.Q., but he exercised policy-control over the work of the topographical units serving with the following formations (as they existed during the latter stages of the war):—

First U.S. Army.

654 Engineer Topographical Battalion (Army).

663, 665, and 668 Engineer Topographical Companies (Corps).

Third U.S. Army.

652 Engineer Topographical Battalion (Army).

664, 672 and 673 Engineer Topographical Companies (Corps).

Ninth U.S. Army.

655 Engineer Topographical Battalion (Army).

62, 667, and 669 Engineer Topographical Companies (Corps).

Fifteenth U.S. Army.

657 Engineer Topographical Battalion (Army).

524 and 680 Engineer Topographical Companies (Corps).

- (ii) *6th Army Group.* The Engineer, 6th Army Group controlled the mapping and reproduction work of units within the Army Group through his topographical branch (Colonel L. Wirak). The units were as under:—

Seventh U.S. Army.

649 Engineer Topographical Battalion (Army).

661, 666, and 679 Engineer Topographical Companies (Corps).

First French Army. Colonel Recordon, of the Geographical Staff Section at Army H.Q., had under his control the 31st and 32nd Geographical Companies. These units did not receive their mobile printing equipment (U.S. Webendorfer presses transferred from Algiers) until towards the end of the war.

- (d) *Equipment.* The Allied units were equipped for map reproduction as under:—

(i) **BRITISH.**

Field Survey Companies R.E. Each company had as standard two Crabtree full-auto-feed presses (demy-size) mounted in lorries. Photo-mechanical equipment and cameras were also lorry-mounted, and grainer, generating plant and other ancillary equipment were available. Owing to the great amount of 1/25,000 printing that became necessary the allocation of printing presses to these units was practically doubled soon after their arrival overseas.

Map Reproduction Sections R.E. These were equipped with semi-mobile double-demy Crabtree presses (full-auto-feed) on a scale of one single-colour and one two-colour machine to each section. They also had one Baby Mann press for dealing with small jobs.

A static double-demy camera and full ancillary equipment made this small unit capable of turning out rapidly a great deal of useful reproduction work, especially where two such units could be located together.

(ii) CANADIAN.

Though their survey units were organized on a different basis from the British, the equipment available to the Canadian Army was, so far as the mobile units were concerned, similar to that provided for the British field survey companies. They did not have any map reproduction sections.

(iii) U.S.

Base mapping plant. When finally installed in Paris the printing equipment of two engineer topographical battalions was available, together with several other machines of various types belonging to the French commercial printing installation where they were located. The standard equipment of each battalion included four 22" × 29" Webendorfer presses and one 40" × 40" copy camera. 660 Battalion had added six of the British Crabtree presses of the semi-mobile type, four being two-colour double-demy, one single-colour double-demy, and one single-colour quad-crown. Extra camera equipment was also added.

Engineer topographical battalions (Army) and topographical companies (Corps). These units, which formed part of the army and corps organizations respectively, were well equipped with mobile reproduction trains consisting of specially designed lorries in which the equipment was mounted. Originally the printing presses were "Harris" machines which had a maximum sheet size of 20" × 22½" only and cameras of similar small size. As the standard 1/25,000 maps of France were 24½" × 19½" the Harris presses could not print them. On representations being made to Washington, Webendorfer presses (22" × 29") and larger-size cameras were substituted.

(iv) FRENCH.

Details of the map-printing equipment at the disposal of the Institut Géographique in Paris are not known but, with the civilian printing firms which were called on to help, the resources were considerable. The two small field units which served with the First French Army were eventually equipped with Webendorfer machines.

It will thus be seen that the map reproduction and printing resources available on the Continent were extensive.

For map compilation and drawing the American units were more lavishly equipped than the British. Their base and army units had a considerable amount of Multiplex air-photo plotting apparatus and other devices such as rectifying enlargers, etc. The Canadians also had a limited amount of Multiplex equipment and large numbers of air-photo rectifiers for table use. The British units had no Multiplex apparatus and, except for a few "Thompson" stereo-comparators, depended largely on simple table-model stereoscopes for their air-photo work.

Operational mapping during the first phase. (In the Normandy bridgehead, June-August, 1944)

ARRIVAL OF SURVEY UNITS

In accordance with the light scales assault organization one reproduction section and one photo section accompanied each of the Second Army field survey companies which crossed over in successive detachments soon after "D"-day. They were a few days behind schedule, and some of the intelligence overprints and artillery fire-plan maps which were asked for during the early fighting could not be supplied. The balance of the equipment followed as convoy space could be made available. In the American sector of the bridgehead, printing equipment accompanied the First Army topographical units.

Canadian Survey units with their mapping plant followed during July.

1/25,000 STANDARD PRINTING

All survey units had been supplied with kodak negatives of the 1/25,000 "Benson" series of northern France. There was a heavy demand for this large scale map from all arms, and not only from the artillery for whom it had been primarily produced. One main reason for this was that the 1/50,000 maps were insufficiently detailed and too generalized, and they could not, of course, show the hedges and other field-divisions which formed such a vital tactical feature during the close fighting in Normandy.

The accuracy of detail on the 1/25,000 maps was, in general, very satisfactory, though the contouring was found to be inaccurate. This latter defect was owing to the lack of reliable height-control when the series was being compiled.

The printing sections were soon working to full capacity, and both the British Second and First Canadian Armies found it necessary to ask for further printing lorries. This was approved, and their mobile equipment was practically doubled as soon as the extra plant could be supplied. The rapid increase in 1/25,000 printing is shown by the following figures applying to British and Canadian survey units:—

June (part of)	20,000 copies (3 colours)
July	535,000 copies (3 colours)
August	2,575,000 copies (3 colours)

The increasing rate was due to a variety of causes. In June, formations had been well mapped up before the assault, and the printing machines did not begin to arrive in the beach-head till late in the month. In July units were not up to full strength in printing lorries till well on into the month. By August units were printing well ahead of demands (until the break-through and the rush across France overran the maps), and building up stocks.

During July and August the topographical units of First U.S. Army printed 370 sheets of the 1/25,000 map totalling 3,000,000 copies, and Third U.S. Army was likewise fully extended from the moment it reached France.

After the break-out the allied advance became so rapid and fluid that, for a time, the printing of 1/25,000 maps to keep pace with movement was very largely suspended pending some indication that the advance was likely to be held up. In the case of the First U.S. Army, after crossing the Seine the maps were printed in one colour only to save time, the contours being printed in a half-tone from the black plate.

"GOING" MAPS, DEFENCE OVERPRINTS, AND OTHER SPECIAL MAPS

There was an early demand in Second Army for special maps and overprints. "Going" maps in colour were produced, not only to facilitate the planning of armoured movement, but for actual use by tanks in action. By using a blue-grey base, with orange and red overprints in solid and stipples, the various types of "going" were shown, *i.e.*, areas which were impassable, or suitable for armoured movement.

There were also defence overprints, fire-plan traces, traffic lay-out diagrams, and many others. For the defence overprints and fire-plan traces, it was generally found convenient to send a printing lorry on detachment to the headquarters of the corps artillery.

By late August, 21 Army Group Survey Directorate had installed two map reproduction sections in the Caen area, and these were soon working to full capacity on all forms of map printing including standard series to maintain vital stocks, airfield maps, railway, road and soil intelligence maps, and assault traces for the projected crossings over the Rivers Seine and Somme.

The Canadians completed a number of new 1/12,500 sheets from air-photos covering the planned Canadian crossing sites over these rivers, but the rapidity of the advance was such that there was no need for their publication.

U.S. Army units had always been accustomed to the use of clearly annotated road maps and, in July, First U.S. Army produced the first sheet of a 1/100,000 road map of northern France. During August, further sheets were published and nearly half a million copies were printed, but the series was discontinued as soon as the rapid move eastward began. Later on, with a return to more static conditions, there was a renewed demand for road maps for operations in Germany.

Photo-maps had been prepared by American topographical units for large areas of northern France and kodelines of these were carried. A small number were printed during the early operations but, with an adequate 1/25,000 map available, there did not seem to be much demand for the photo-maps even by the Americans, and none were required by the British.

REVISION

One of the first tasks undertaken by Second Army survey units was the road-classification of those 1/25,000 sheets which fell within the occupied bridgehead area. Revision of detail and contours was undertaken with the aid of ground reconnaissance, air-photos, and captured German maps. Progress was slow, and the results, especially those of contouring, were unsatisfactory. It seemed evident that the training of the personnel for topographical work in the field was not up to the desired standard, but this was undoubtedly largely owing to the fact that, since their training courses at the Survey Training Centre, the junior officers and men of the survey units had been almost exclusively occupied on the air survey plotting and drawing of the 1/25,000 maps of Normandy. This work had to be carried out at such high pressure that little if any time was left over for consolidating, much less increasing, their practical knowledge and skill in field topography. The same weakness was noticeable in other theatres, and draws attention once more to the need for intensive practice in plane-table work in the field, combined with the concurrent stereoscopic study of air-photos of the same area. This is surely

the most certain method of producing that "topographical mentality" which is so valuable an asset for a surveyor.

The break-out from the bridgehead put a stop to this revision programme.

The second phase (the advance to the Rhine)

OPERATIONAL BACKGROUND

This second phase included the period of rapid advance through north-eastern France and Belgium, the entry into Holland, the forcing of the Siegfried Line, the cleaning-up operations west of the Rhine, and the preparations for the Rhine crossing.

21 Army Group consisted of the Second British and First Canadian Armies. 12th U.S. Army Group eventually comprised the U.S. First, Third, Ninth and Fifteenth Armies, and, after a successful assault operation in southern France, the U.S. Seventh Army with the First French Army formed the 6th U.S. Army Group. During this period strong base U.S. map reproduction resources were built up in Paris. 21 Army Group installed a powerful group of map reproduction units at Brussels and Antwerp.

In anticipation of a possible early thrust into Germany, attention was naturally focussed on the need for hastening the completion of the standard maps of Germany which were being undertaken in the United Kingdom and in the United States, and the revision of the large scale maps by field formations. There was also the need for the preparation of special maps of all sorts to assist airborne operations, to facilitate the crossing of the Rhine and the cleaning up of the Ruhr, and to indicate all the various zonal and administrative boundaries which would be adopted by the Allies during the occupation of Germany.

The rapid pursuit of the German forces was slowed up in southern Holland, along the German frontier in Belgium and Luxembourg, and in the Saar and Alsace regions of eastern France. This afforded a welcome respite for building up map stocks and the revision and preparation of maps for subsequent operations.

BASE MAPPING ORGANIZATIONS

S.H.A.E.F. and U.S. Communications Zone. By the end of September, S.H.A.E.F. Survey Directorate had joined S.H.A.E.F. (Main) at Versailles, and an advanced party of 13 Map Reproduction Section, with a Baby Mann printing press, was installed in a factory building at Suresnes (Paris) for the hasty production of maps for G-3 (Ops.) and G-2 (Intelligence). The main body of 13 Map Reproduction Section and 9 General Field Survey Section closed down in the United Kingdom on 7th October and was in operation at Suresnes by early November, the transport of the heavy machinery taking some considerable time. These two units served the special mapping needs of S.H.A.E.F. until the close of hostilities, and proved to be a most efficient and happy organization.

Meanwhile E.T.O.U.S.A., which had started to move over to France in August and was redesignated Communications Zone (Com. Z.) for operational purposes, moved into Paris early in September and Colonel Milwit (Office of the Chief Engineer) set up his H.Q. there and installed his base map reproduction plant in the commercial printing works of a high-class French magazine, which were located at Bobigny on the outskirts of Paris. From then onwards D. Survey (S.H.A.E.F.) was able to maintain almost daily contact with Colonel

Milwit for the co-ordination of mapping policy to meet allied requirements within the theatre.

Institut Géographique National (I.G.N.) Immediately after the liberation of Paris D. Survey S.H.A.E.F. and the Topographical Engineer 12th Army Group (Colonel Milne) made contact with General Hurault, the Director of the I.G.N., and arranged for his co-operation and the utilization of his cartographic and printing facilities. Colonel Milne also took over available printed stocks of French maps of the immediate operational area for issue to the American Armies at a time when the supply and distribution of allied map stocks was proving a difficult problem.

Copies of all French map production since 1940 were obtained and sent to the War Office, and arrangements made for a French officer to visit S.H.A.E.F. and take with him all available information on many survey and mapping subjects, including material for Indo-China and other parts of the Far East which might be of value to the War Office.

SIEGFRIED LINE DEFENCES

Copies of French defence overprints of the Siegfried Line were obtained and were delivered to G-2 S.H.A.E.F. for incorporation in S.H.A.E.F. traces of the German defences. Co-ordinated arrangements were then made between S.H.A.E.F. and the War Office for the production of base maps (Germany 1/25,000) and defence overprints covering the Siegfried Line defences, and for the direct delivery of reproduction material to army groups for their immediate use in planning. Just over 100 sheets were required to cover the area of the known defences.

ADMINISTRATIVE MAPS OF GERMANY

In accordance with allied plans for the occupation of Germany S.H.A.E.F. Survey Directorate began the preparation, during September, 1944, of various maps of Germany and Austria to show, in the form of overprints, the various administrative and zone boundaries which would be used in connection with military government and the administration of the country. These included the following:—

- 1/1,600,000 showing German states, provinces, etc., and the agreed boundaries between allied zones.
- 1/1,000,000 showing German administrative boundaries.
- 1/250,000 showing German administrative boundaries.
- 1/200,000 (Berlin) showing districts, and boundaries between the allied sectors.
- 1/16,000 (Berlin) showing district boundaries.
- 1/25,000 (Germany) selected sheets showing in detail the agreed boundary between British, American, and Russian zones of occupation.
- 1/1,000,000 (Austria) showing administrative and zone boundaries.
- 1/75,000 (Vienna) showing administrative and zone boundaries.

The preparation of the above maps involved much detailed research in order to ensure that the most recent and authoritative version of the various boundaries was shown. The work of preparation was undertaken by 9 General Field Survey Section and 13 Map Reproduction Section under the general direction of Lieut.-Colonel J. S. Sheppard at S.H.A.E.F. Survey Directorate.



During September, 1944, preliminary plans and co-ordinated arrangements were made by S.H.A.E.F. with the War Office, Com. Z., and army groups for the revision of the 1/25,000 series of Germany which had been initially produced by the War Office. The War Office took over responsibility for the revision of a block of sheets covering the critical area between the Belgian frontier and the Rhine. Further to the north a block was allocated for execution by survey units at H.Q. 21 Army Group and by Second British Army and First Canadian Army units. Another block in south-western Germany was given to Com. Z. for revision by base mapping units, and by topographical units of the U.S. 6th and 12th Army Groups. The basis for this revision was air photography, and every possible attempt was made to ensure a speedy completion of the photographic programme. All available sources were tapped to obtain suitable photos, but the lack of a firm survey photographic policy at that time, combined with bad-weather periods, caused dangerous and annoying delays.

Towards the end of October, when it seemed evident that the flow of revised sheets from the United Kingdom would not meet the required completion date, S.H.A.E.F. Survey Directorate authorized army groups to undertake their own independent revision, in areas of critical operational urgency, as an insurance against the possible non-availability of revised editions which were being produced at the O.S. It was foreseen that an undesirable situation might arise as a result of having two separate, and possibly different, revised editions produced concurrently, and appropriate steps were taken to meet this situation. All concerned were warned about this, and instructions were issued regarding the adoption of a single operational edition only. As events turned out the sheets actually accepted for use during operations in the extreme west of Germany and in Holland were those revised by survey units overseas. On completion of these early blocks the War Office assumed responsibility for the revision of blocks of sheets further to the east up to and including Berlin. Experience indicated that it is safer and better that the revision of areas of probable early urgency should be carried out by units with field formations overseas rather than by a home-based organization, and for the latter to concentrate on areas further ahead.

The Director of Survey (S.H.A.E.F.) realized the essential need for maintaining a proper and effective control over the preparation and issue of revised editions, and of supplying to all concerned up-to-date information regarding the latest edition of any map. This was perhaps of particular importance during "Overlord" on account of:—

- (a) The large number of potential originators of a revised edition. These included the Survey Directorate (War Office), S.H.A.E.F., 21 Army Group (with, under command, Second British and First Canadian Armies, and sometimes one or two U.S. Armies), 6 and 12 U.S. Army Groups (with U.S. Armies under command each having their engineer topographical battalions and corps topographical companies), and also the U.S. base mapping organization in the Communications Zone.
- (b) The fairly frequent changes of boundary between army groups and armies whereby formations frequently found themselves fighting on maps which had been revised by survey units of other formations.
- (c) The wide-ranging interest of the air forces who, for close support and intelligence photographic purposes, required to use maps on scales as

large as 1/25,000 and even town plans in areas covering a wide range of front and depth.

It was of vital importance that armies, corps, and divisions and the air forces should know about, and be able to obtain, the latest current edition of any maps which they required to use. Also in order to prevent misunderstandings and misinterpretation of orders, reports and telephone conversations, it was important to ensure that all map-users changed over from one edition to another at the same time. It was also desirable that survey directorates should know at the earliest possible moment when a new edition was produced anywhere in the theatre of operations, and should receive a few copies of the newly revised map.

By arrangement with the Survey Directorate (War Office) the revision control of all map series in the theatre except those on 1/500,000 scale and smaller had been delegated to the Director of Survey (S.H.A.E.F.). The latter delegated to army groups the right to change the edition of a map, but only in conformity with a definite procedure laid down by S.H.A.E.F., which would ensure uniformity. Any army group making a change had to notify S.H.A.E.F. and neighbouring army groups that the change was being made and, in the case of sheets overlapping an army group boundary, the army group originating the change had to ensure that the adjoining army group received a printed stock of the revised edition in time to distribute to the troops if operations were involved. In the case of sheets not on the boundary, a small number of copies (25 to 50) of the revised sheets were to be sent to the adjoining army group for early air use. Kodak film negatives of the revised sheets were also distributed.

Army groups themselves co-ordinated the activities of armies under their command in producing new editions, and ensured that stocks of revised maps were available before the change-over was made.

Instructions for the change-over were then issued by the general staff of the army group, normally by signal. This was always confirmed later in army group orders. Copies of the signal were sent to S.H.A.E.F. and to adjoining army groups. The signal specified the date and time at which the change-over would be made.

Shortly after "D"-day, map indices for all the western European map series had been given a wide distribution, with overprints showing the number of the current edition for each sheet. Thereafter survey directorates and other interested parties kept their "Current Edition Indices" up to date. About once a month S.H.A.E.F. published map indices with overprints showing the latest edition numbers which enabled everyone to check up the data. S.H.A.E.F. also issued instructions governing the production of new editions. These rules embraced the following main points:—

- (a) Any but the most minor alterations to the face of a map entailed a new edition number.
- (b) The publication of a new edition automatically involved the destruction of all existing copies of the earlier edition unless specifically excepted.
- (c) Therefore, corrections were not to be made till they were sufficiently numerous or important to warrant the destruction of the old stock.

The above system worked well. Its application was not so complicated or cumbrous as it might appear from the above. It needed good will and careful control by all survey staffs. The principal advantages gained from it were twofold. Firstly it tended to eliminate misunderstandings and errors during operations. These might range from mere inconvenience and irritation to

tactical disaster and serious loss of life. It ensured, secondly, that the revision state of any particular map-sheet was easily and correctly stated, recorded, or ascertained. This was most important, and its importance may well become greater as the capacity of the survey service to produce its own maps in the field increases.

It was necessary also to organize a proper control over the preparation and distribution of reproduction material for the revised sheets. When an army, for example, produced and published a revised edition, complying with the various rules mentioned above, they would make one or possibly two kodak film negatives of the map for immediate use, but they would not have had the time or facilities to make enough copies of the kodak for distribution to all the other formations. S.H.A.E.F. therefore arranged a procedure whereby, immediately a new edition had been published, the originating formation sent a master film-positive of the sheet to the War Office. There, by means of a rapid film-processing machine, the required number of film negatives was made for immediate distribution to those formations overseas who already held kodak negatives of the earlier edition. These formations had, in the meantime, been warned that their existing kodak negatives were out of date and should therefore be tagged pending the arrival of the new edition. It will be realized from the above how essential it was that "kodak" record sections should be available at the various Survey headquarters where map revision and other such records had to be kept, where warnings of edition changes originated, and from where kodak negatives had to be distributed to subordinate formations.

A variety of methods was adopted by the different units for carrying out the revision. The basic material at their disposal consisted of kodak negatives of the War Office First Edition which had been distributed to all concerned. The revising units were required to produce a kodak positive incorporating the revision of all detail of tactical importance, with special emphasis on roads and other communications, woods, and built-up areas including isolated buildings. These positives were, as explained above, sent to the War Office, who arranged for the production of kodak negatives therefrom, which were then distributed to formations overseas in accordance with a scale laid down by S.H.A.E.F.

Several of the problems which arose in connection with the revision of this series have been described in Section 2A. The confusion due to the differing origins of the various state systems, and the resulting gaps, overlaps, and discrepancies between the geographical values of common sheet edges of adjacent systems added considerably to the difficulties of the revising units and caused much delay. Technical instructions on the problems involved were issued by S.H.A.E.F. Survey Directorate from time to time to guide the survey units and to ensure uniformity.

Some people felt that a monochrome edition, following the style of the original German map, was unsatisfactory. S.H.A.E.F. therefore authorized the responsible survey authorities with army groups to prepare their own colour overprints so as to clarify water, woods, roads, etc. When time allowed for the extra printing, this undoubtedly made a better map. To standardize results S.H.A.E.F. issued specifications, not only for the revision of detail but also for the preparation of the colour overprints.

To deal with the revision area allotted to him D. Survey 21 Army Group sub-allocated blocks of sheets to the Second British and First Canadian Armies and also set up an air survey group in Brussels by concentrating a number of

General Field Survey Sections under the control of No. 1 Air Survey Liaison Section. Photos were obtained from various sources including A.P.I.S. (21 Army Group) and C.I.U. (Medmenham). It was always a struggle to obtain photo-coverage of the right quality and of the areas required to enable the revision programme to proceed without interruption or delay.

Com. Z. sub-allocated sheets to 6th and 12th Army Groups who, in turn, allotted revision areas to the topographical units with the armies under command. Responsibility for a great part of the American area was assigned to the base mapping units and to the French Institut Géographique.

The standard German series did not extend over Bavaria. This was covered by a separate series at 1/25,000, the sheets of which were rather smaller than those of the main German series. There was, unfortunately, a large gap in Bavaria which had not been mapped at all on the 1/25,000 scale, though there was a 1/50,000 series which gave complete coverage. The task of compiling 1/25,000 maps to cover this gap was assigned to the American base mapping units, but work was delayed for nearly seven months because the air forces had not secured the necessary photographic coverage for Multiplex compilation. When, eventually, the photographs became available in the spring of 1945, the area had already been overrun. This failure to supply essential photography might quite easily have led to a dangerous tactical situation owing to the lack of proper maps.

The revision of the German 1/25,000 maps formed one of the principal tasks of allied survey units during the autumn and winter of 1944, and the early spring of 1945. The production of revised editions just managed to keep pace with the operations leading up to and including the Rhine crossing. Owing to the rapid movement of the allied armies east of the Rhine into the heart of Germany there was a reduced demand for 1/25,000 maps.

MISCELLANEOUS MAPPING

It would be confusing and unnecessary to tabulate all the diversity of mapping jobs that were undertaken day by day by all the various survey units which were serving overseas with the Allied Expeditionary Force. The following items are quoted as representing some of the principal tasks carried out:—

(a) British Survey Units.

S.H.A.E.F. From the moment they arrived at Suresnes (Paris) in October, 1944, 13 Map Reproduction Section and 9 General Field Survey Section were working full out and never had an idle moment. As previously described, their work was primarily concerned with the production of maps of all sorts required by *S.H.A.E.F.* staffs for planning, operations and intelligence, and other staff branches. This was a commitment of some magnitude.

Another major task was the preparation of administrative and zonal boundary maps of Germany to which reference has been made in a previous paragraph. As soon as the Allied Airborne Army began to base its operations on the Continent instead of in the United Kingdom, there was a constant requirement for the urgent printing of 1/25,000 and other maps.

S.H.A.E.F. Survey Directorate published regular and frequent progress reports and survey circulars dealing with standard map publication, revision and other subjects. Many of these were illustrated by

fully coloured index diagrams, and the preparation and printing of these at short notice was always most efficiently carried out.

When the Pas de Calais had been cleared of enemy forces, the V-weapon launching sites fell into allied hands. Amongst these were some of specially complex design and a survey of them was asked for. No. 9 General Field Survey Section carried out the ground surveys and then produced a series of fully detailed plans showing the workings both above and below ground.

21 Army Group Headquarters. The units which worked under the direct control of D. Survey 21 Army Group comprised four map reproduction sections, one field survey company and two (sometimes more) general field survey sections. As with any big headquarters, there was a continuous day-by-day demand for special maps and diagrams, overprints, and index diagrams to illustrate the reports and other documents prepared by the staffs concerned with planning, operations and intelligence, engineers and signals, artillery and air. Probably the biggest task of the map reproduction sections was the printing of medium and small scale maps. By agreed policy the War Office was responsible for sending over bulk stocks of these but the difficulties of supply at certain periods, and the need for insuring against the non-availability of stocks in critical emergency, made it necessary on many occasions to undertake local printing of bulk stocks. There were also urgent demands for stocks of 1/25,000 and other maps for planned airborne operations.

The revision of the German 1/25,000 maps formed one of the principal tasks for the drawing sections, and the reproduction in colour of the German 1/50,000 series of Holland provided a very popular map during the allied operations in that country.

It would be impossible to tabulate all the printing jobs undertaken by the reproduction sections. Averaging about seven or eight million colour impressions each month up to February, 1945, this number increased to over 13,000,000 in March, and continued at that rate till the close of the war. Most of this was on account of standard map bulk printing. Apart from this there were the intelligence maps and diagrams, town and port plans, road information maps, defence overprints, airfield detail maps, flak maps, flooding overprints, airfield location maps, canal and railway communication maps, and so on. The printing of trig lists and triangulation diagrams was a constantly recurring item and, whenever there was a spare machine, there was the never-ending task of printing "cancellation" markings on captured enemy map stocks so as to be able to print our own maps on the reverse and so save paper stocks.

The high output of the map reproduction sections in Brussels and Antwerp during the winter and spring of 1944-45 would not have been possible with the man-power and plant of the sections alone. Each unit added considerably to its resources by using civilian machinery and equipment, and by the employment of Belgian lithographic tradesmen and non-skilled workers. The two principal installations were 15 Map Reproduction Section in a large printing works in Brussels, and 14 Map Reproduction Section in a similar works in Antwerp.

British Second Army. Printing by the survey units with Second Army was limited to what could be put on their demy-size mobile presses. This included all the standard 1/25,000 series which were made up specially for printing on mobile presses in the field, but excluded most of the standard medium and small scale maps which were mostly of a size requiring a double-demy machine.

When the Second Army was pursuing the enemy rapidly through Belgium towards the German frontier D.D. Survey decided to make sure of being able to print his own stocks of maps of Germany to cover the probable initial operations across the frontier, in case there should be difficulties of supply from rear depots. He therefore made up, for monochrome printing, a number of sheets in demy size on the 1/250,000 and 1/100,000 scale by reproduction from the G.S.G.S. standard sheets. As events turned out these were not required.

A period of relatively static conditions on Second Army front which succeeded the pursuit through Belgium again brought demands for the usual variety of special maps and overprints which are incidental to the headquarters and formations of an army in the field, e.g., artillery fire plans, flood- and water-level maps, defence overprints, "Going" maps, etc.

All Second Army survey units took their share in the revision programme of the German 1/25,000 series, and a considerable amount of new large scale mapping was undertaken from air photographs in anticipation of important operations on the Maas and Rhine Rivers. Amongst these was a series of some 20 sheets at 1/12,500 scale along the R. Maas which was ready early in 1945 and, in conjunction with the Canadian survey units, a series at similar scale covering the River Rhine along the army front for use during the assault crossing.

The volume of printing varied from month to month. In September, 1944, a total of over 4,000,000 colour impressions passed through Second Army machines. The monthly average then fell to between two and three million until March, 1945, when it increased to nearly 5½ million.

(b) *First Canadian Army (see also Chapter XIII, Section 1).*

When enemy resistance stiffened in Holland, Canadian survey units were again occupied with 1/25,000 printing. The new series covering western Holland (GSGS 4427) which had been produced in eight colours was not suitable for economical printing in the field and, though it was a well drawn and extremely clear map, it contained many errors due to faulty interpretation. The Canadians, who were operationally concerned with this part of Holland, therefore revised a number of sheets, and in the process they reduced the number of printings from eight to four.

Although Antwerp was captured early on during this second phase, it could not be developed as a major supply port until the approaches up the Scheldt estuary had been made good. This involved the cleaning up of an area north of Antwerp, followed by the ejection of enemy forces from the islands of South Beveland and Walcheren. For these operations Canadian survey units prepared several special maps, mostly on a large scale, from air-photos. These included sheets at 1/10,000 of both islands, and five sheets at 1/5,000 covering the assault landing

area on Walcheren. There were also numerous defence overprints, fire-plan maps, and other special items. They also published town plans at 1/10,000 of many places in Holland which had not already been included in the War Office programme.

The 1/12,500 River Rhine series was another new large scale compilation from air-photos. First of all there were 12 sheets in the Arnhem-Zutphen area, and these were followed by several others covering the R. Rhine from Arnhem to Duisberg. Part of this was done to assist Second Army in their preparations for the Rhine crossing.

A Canadian modelling team became effective during October, 1944, and amongst their productions was a cross-section model of the Walcheren Island Dyke which was required by the Special Service force taking part in the assault.

With the possible need for occupying some of the Frisian Islands, the 1/25,000 maps were checked against recent photographs, and it was found that considerable alterations were necessary, especially with regard to the coastline detail. The sheets concerned were therefore recompiled by Multiplex methods and redrawn. Six new sheets on 1/12,500 scale of parts of the islands were also produced. Finally some beach-gradient determinations were made by measurements on air photographs.

Four sheets at 1/4,000 scale lying along the Maas River were produced in February, 1945, for a special operation undertaken by 4 Canadian Division.

Canadian Survey units published a series of nine sheets on 1/5,000 scale between Emmerich and Rees on the R. Rhine, and another four sheets along the Neder Rhine in the Arnhem area.

In common with the other allied survey units, the Canadian Survey Companies took their share in the revision of the 1/25,000 (GSGS 4414) series of Germany and the preparation of colour overprints for roads, woods, and water, where considered desirable.

From time to time the Canadian Air Survey Company was called upon to determine heights of banks and other objects and construct cross-sections, mainly in connection with river crossings and other such obstacles, in particular the crossings over the Seine and Rhine. The technique included the stereoscopic examination and measurement of vertical and oblique photographic cover, and ground checks which were taken subsequently showed that, where there was good stereoscopic oblique cover, the mean average error for all scales was just under two feet.

Experience indicated that the best conditions for heighting from obliques involved the use of simultaneous vertical and oblique photographic cover. The vertical photos should preferably have a scale of about 1/8,000, with full stereoscopic overlap. The lateral obliques should have a depression angle of 30 to 45 degrees, with full stereoscopic overlap, and be taken from a height not exceeding 2,000 feet.

From just over half a million colour impressions in October, 1944, the volume of monthly printing by Canadian units rose to 3,000,000 in March, which was the peak month. The heaviest single week saw 304,000 maps printed with a total of 1,045,000 colour impressions, giving an average of 37,000 impressions from each machine each day. Estimates

of production were usually based on a figure of 25,000 impressions from each machine each day and this rate was maintained throughout in spite of breakdowns and other difficulties.

(c) *U.S. Topographical Units.*

In accordance with the 1/25,000 revision programme for Germany initiated by S.H.A.E.F. Survey Directorate all U.S. topographical units, both at the base mapping plant and with the field armies, were extensively engaged on the revision of the sheets allocated to them, and the preparation of the colour overprints for roads, woods and water to make the map clearer to read. This work went on throughout the winter months and into the early spring of 1945.

As has been mentioned in Section 2A, a block of some 30 sheets of the new 1/50,000 map of Germany (GSGS 4507) was assigned to Com. Z., and the work of compilation and drawing was undertaken by 660 Topographical Battalion at the base mapping installation. Revised 1/25,000 sheets were used as basic material, six such sheets making up the area covered by one 1/50,000 sheet. The six sheets were fitted up to a grid and reduced photographically to 1/35,000. Blue line prints were then made on which the cartographic detail was fair-drawn for four-colour reproduction. The German symbols were converted to conform to the War Office specification, and the latest available photos were used for incorporating a final revision. As the area concerned fell within the operational zones of both the American and French armies, the marginal notes were bilingual.

To facilitate the reduction of the forts and other defended zones in the Metz area, where part of the U.S. Third Army was temporarily held up, topographical units produced in the first place 19 sheets of an uncontrolled photo-mosaic at a scale of approximately 1/25,000. They were made up from photos taken at 1/10,000 scale, and each sheet was gridded independently. This was followed by a series of large scale maps of the fortified group areas, and models of the forts themselves were also made on which the operational plans for their final capture were drawn up.

When 6th (U.S.) Army Group made contact with the southern flank of 12th (U.S.) Army Group and was fighting in the Vosges and Saar districts, the 1/25,000 map coverage of that area was incomplete. Part of it had been mapped by the French in accordance with their pre-war mapping programme along the frontier regions, and where these sheets had been available to the War Office, reproductions had been made and kodaline negatives distributed to all concerned. In some cases, however, 6th Army Group was able to make its own reproductions from newly obtained French material, and the great advantage of retaining the national sheet line system became manifest. Where a comparison with air-photos showed it to be necessary, revision of these GSGS 4411 sheets was carried out by American and French topographical units of 6th Army Group.

Although the War Office programme of town plan production was a big one, there were local demands for plans of many of the smaller towns, and these were produced by topographical units with armies and corps, many of them being in the form of annotated photo-mosaics.

Before "D"-day, S.H.A.E.F. Survey Directorate had produced a road map of Germany in nine sheets at 1/500,000 scale by reproduction from a road atlas. The result was not satisfactory and, when the allied armies were advancing towards the German frontier, there was a demand for a better road map on a scale larger than the above. In view of the heavy mapping and revision programmes already in hand, it was decided that the only feasible answer at the moment was to make use of the standard 1/250,000 map of Germany (GSGS 4346) and adapt it for use as a road map. There was no comprehensive system of road numbering in Germany as in France, so authority was given to the U.S. army groups to establish their own road-numbering system, and to make their own necessary adaptations of the 1/250,000 map in conformity with a specification drawn up by Com. Z., who allocated tasks to the army groups. Several sheets were published, but the result was not wholly satisfactory.

An arrangement was then made by Colonel Milwit with the Michelin Company for the production by them of a two-sheet road map of Germany at 1/M scale. This followed closely the general style of the well-known Michelin maps of France and proved to be a most useful map for road movement.

The next project was the initiation of a 1/200,000 road-map series of Germany by colour-separation from a German "Strassenkarte von Deutschland." The work was shared between the base mapping units and the army topographical battalions of 6th and 12th Army Groups. Work on this continued during the early months of 1945.

An immense number of special maps and overprints was produced by U.S. army and corps topographical units to meet the day-to-day operational requirements of their parent formations. This demand was specially large when operations were held up by major obstacles such as the Siegfried Line and the various river lines which were encountered. In the case of the former there were overprints on 1/25,000 maps showing in detail the formidable defences, and for the Rivers Roer and Rhine the staffs required maps to study and illustrate the flooding problems. Other maps were needed on which to draw up plans for bridging, traffic control, road and rail developments, and other purposes. Some of these requirements were met by the production of special mosaics and large scale photo-maps, but it was mostly a case of map compilation from air-photos.

Before the Rhine crossings, First U.S. Army undertook an intensive study of the river banks, and several sheets of the 1/12,500 Rhine River series were overprinted with appropriate engineer data. Many of the standard 1/25,000 sheets were overprinted with road and bridge information affecting the river crossings and subsequent exploitation.

For most of the standard map series gazetteers were published by the War Office in conjunction with the I.S.T.D. The War Office programme did not, however, include a gazetteer for the German 1/100,000 map (GSGS 4416). So the topographical engineer with 6th Army group initiated the production of one to cover a group of about 50 sheets affecting his own army group area. Both the 12th (U.S.) and 21 (British) Army Groups agreed to take their share in this work by extending the area of the gazetteer to the north, and the necessary material

was compiled. The 1/100,000 gazetteer had not been published, however, before the end of the war.

It is difficult to arrive at any firm figure for map production by U.S. topographical units within the theatre, but the following represents an approximate estimate of the number of map copies printed by the organizations shown between June, 1944, and May, 1945:—

660 Engineer Topographical Battalion (Base)	18,000,000
French I.G.N. (including civil firms)	28,000,000
12th Army Group topographical units	46,000,000
6th Army Group topographical units	11,000,000
<hr/> Total	<hr/> 103,000,000 copies <hr/>

At an average of three colours for each map this gives a total of over 300,000,000 colour impressions. In addition, close on 80,000,000 maps were received from the A.M.S., Washington, and nearly 50,000,000 from British sources during the period between "D"-day and "V.E."-day.

The final phase. (The Crossing of the Rhine to the final surrender)

OPERATIONAL BACKGROUND

The final operations, starting with the Rhine crossing, developed into a rapid pursuit of the enemy forces into the heart of Germany, concurrently with the Russian offensive from the east and the allied advance northwards from Italy, until the enemy finally surrendered early in May.

Apart from the activities necessary to maintain map supply for operations within Germany itself, there were two major operational possibilities that had to be provided for. In the first place there were strong rumours that the enemy would concentrate their best troops in the so-called "Austrian Redoubt." Secondly, there was a possibility that the Nazis might organize Norway as their last stronghold which would make it necessary for the Allies to mount offensive operations against them in Scandinavia. Both these possible courses of action involved a lot of complicated and urgent last-minute mapping preparations.

The need for affording protection to allied prisoners of war in their camps involved the possible use of airborne forces, and plans were made for them to be dropped over wide areas ahead of the advancing allied troops. This produced the usual urgent demands for large numbers of all sorts of maps to be specially printed. (See also Chapter XIV, Section 11.)

The early defeat of Germany was, however, certain, and all concerned had to anticipate the need for bulk map stocks for occupational purposes, including special maps dealing with administrative and zone boundaries.

With rapid movement following the Rhine crossing the need for 1/25,000 maps became temporarily less, so a policy was adopted of a limited printing of each sheet and rationed issues. Revision activity was switched to sheets covering the R. Elbe and other forward areas where the enemy might stage further defensive action.

In Second Army, overprints showing enemy defences were prepared, printed and issued for the Elbe crossings, the investment of Hamburg, and the clearing

of the Cuxhaven peninsula. Towards the end of April the slower *tempo* of operations and the need to map up a corps for operations in Schleswig-Holstein produced a bigger demand for 1/25,000 maps, especially for an area east of the Elbe and the approaches to Denmark.

The much-advertised "Austrian Redoubt" caused a great deal of extra mapping preparation. For planning purposes S.H.A.E.F. Survey Directorate produced some special maps of the "Redoubt" area to act as bases for the many intelligence and planning overprints which were required to accompany the staff studies. Hitherto Austria had been regarded as being within the operational mapping zone of A.F.H.Q., but it now seemed likely that forces under General Eisenhower's command might be the first to enter that country, and it was essential that maps should be available for all eventualities. By arrangement with A.F.H.Q. reproduction material for maps of Austria and northern Italy on various scales was flown over from Italy to S.H.A.E.F. and stocks were printed to meet the possible requirements of 6th and 12th Army Groups.

At the request of A.F.H.Q. Com. Z. undertook the preparation of some of the 1/25,000 sheets of Austria by Multiplex compilation, using air-photos flown over from A.F.H.Q.

Urgent consideration had now to be given to the revision of the 1/25,000 and 1/50,000 maps of Bavaria, for allied forces moving south into Austria.

To meet the threat of a German stand in Norway, S.H.A.E.F. drew up plans for an offensive into and through southern Scandinavia. This would have been mounted from the Continent, and involved considerable map preparation which had not hitherto been anticipated. Map stocks for the military occupation of Norway under "surrender" conditions had already been arranged for, and had been assembled at H.Q. Scottish Command, under whom the occupational operation would have been staged. A major offensive mounted from the Continent over large areas of Scandinavia was, however, a different matter. As soon as plans were known the Survey Directorate at the War Office undertook the immediate preparation of the maps concerned. Fortunately the final surrender in Germany took place soon after the work had been started.

Map printing overseas continued at a high rate right through to the close of hostilities. At S.H.A.E.F., 13 Map Reproduction Section, during April alone, completed 114 jobs involving the printing of over 635,000 colour impressions, a heavy task for a small unit possessing only two machines. Com. Z. and units with the British and U.S. army groups likewise had their machines running at full pressure during this final phase, dealing with the current requirements of operations, and preparing for the occupation.

SECTION 3. TRIANGULATION AND FIELD SURVEYS

(A) PREPARATORY WORK DURING THE PLANNING PERIOD

Strategical Background

Reference has already been made in Chapter II (Section 3), to the fact that two separate and discordant triangulation systems were concurrently existing in France; an old one which was started in 1792 and a new one which was begun in 1870. This new system extended over certain parts of eastern France, with special emphasis on the frontier districts opposite Belgium, Luxembourg, Germany and Italy. It was only for a very limited area lying roughly to the

north-east of Paris, along the frontier district between Luxembourg and the sea, that the War Office held French co-ordinate lists based on the new triangulation.

When considering survey preparations for a return to the Continent, it was vital to have early information about the probable areas in which an allied invasion force might be required to operate, in order that the long and laborious work of preparing trig lists could be started without delay.

After the allied landings in North Africa in 1942, the whole of France was effectively occupied by German forces and, even though priority attention would have to be given to the selected invasion area and the most probable axes of subsequent operations, it was clear that it would also be necessary to provide for operations which might have to be undertaken anywhere in France to defeat the German armies.

As soon as the planning staff organized by G.H.Q. Home Forces in 1942 under the direction of the Chiefs of Staff, had recommended that the Normandy coast, somewhere between the Cherbourg peninsula and the mouth of the R. Seine, appeared to be the most favourable site for an assault operation, the Survey Directorate at G.H.Q. Home Forces immediately began an investigation into the triangulation situation in that area. The strategical picture at that early date was that allied forces would land on the Normandy coast, establish a bridgehead while building up their strength and resources, and break out from the bridgehead capturing a port or ports such as Cherbourg, Brest, Nantes or Havre. After defeating the German forces arrayed against them they would drive them north-eastwards through Belgium and north-eastern France back into Germany, thus liberating in the process further ports for facilitating supply.

Triangulation data in north-western France

To the west of an approximate line Boulogne-Paris the only available triangulation was the old one established by the *Ingénieurs Géographes*. For this system the War Office held lists of trig points whose positions were quoted in geographical co-ordinates (latitudes and longitudes) to the nearest centesimal second only. Thus a doubt of half a second either way, owing to their having been rounded off to the nearest second, might give a total displacement from the true position of from six to ten metres, which might be a cause of much embarrassment to a field surveyor trying to resect his position from such points. It was more than probable also that many of the list values might be incorrect owing to the destruction of the original trig points, such as church spires, which might have been rebuilt away from their original positions. As there was no opportunity of clearing up these points of doubt with the French survey authorities at that stage, there was no alternative other than to accept the list values as they stood, leave it to the field survey units to check up the work on the ground and, if possible, to obtain more modern data on their arrival in France. The geographical values were therefore converted to rectangular co-ordinates on the appropriate grid systems which it was known the French had adopted for their own maps, and which it was decided to adopt also for use on British military maps.

Grid Zones in France and Belgium (see Diagram 8)

It will be remembered that, when preparing maps and trig lists for the use of the B.E.F. in France and Belgium in 1939, the War Office had agreed to use

the Lambert Nord de Guerre grid. The French had adopted this for war purposes to cover a zone extending over north-eastern France and Belgium into Germany, from a line in the west running north and south roughly through Havre and Le Mans, and whose southern limit was a line running approximately east and west through Orleans. When considering the preparation of maps for further operations in this area it was decided to retain this Nord de Guerre grid zone, which would be extended right into and through Germany. For the rest of France it was decided to use the Lambert grid zones which the French had adopted for their national maps of France. This divided France into three zones known as Lambert Zone I (in the north), Zone II (in the middle), and Zone III (in the south). Without going into complicated technical details it should be realized that, owing to the fact that a map portrays on a flat piece of paper the topographical features which occur on the surface of a spherical earth, it is not possible, except over very small areas, to portray such detail without some appreciable distortion of one sort or another. In order to reduce this distortion to acceptable limits, dependent on the purpose for which the map is required, various sorts of map projections are used by map makers. For military purposes, especially where long-range artillery requirements demand that bearing and range from gun to target shall be determined with as little error as possible from a combination of map measurement and ground surveys, the Lambert projection is suitable. When using such a projection it is possible to extend the grid zone as far as is desired east and west without introducing distortion. There is, however, a limit to the extension to north and south that is possible without exceeding the allowable error of distortion. With the probability of operating over long distances eastwards from the invasion area through Belgium into Germany, the Lambert projection was therefore especially suitable. The limits imposed on the extensions to north and south made it necessary to divide France into the three zones referred to above. The general arrangement of these and the Nord de Guerre zone is illustrated in Diagram 8.

One unfortunate feature of the accepted arrangement of grid zones will be apparent. There was a change of grid between Caen and Havre along the junction between Zone I and the Nord de Guerre zone. This line of junction passed through what seemed likely to be a battle area, and caused complications in the gridding of maps on all scales and also, of course, on the preparation of trig lists. There were other junctions which looked as though they might well fall within operational areas, namely those between Zone I and Zone II, where fighting for the clearance of Brittany might take place, and that between Zone II and the Nord de Guerre zone, which lay on a possible line of advance for allied forces moving towards Germany through eastern France.

The acceptance of these grid zones directly influenced the following:—

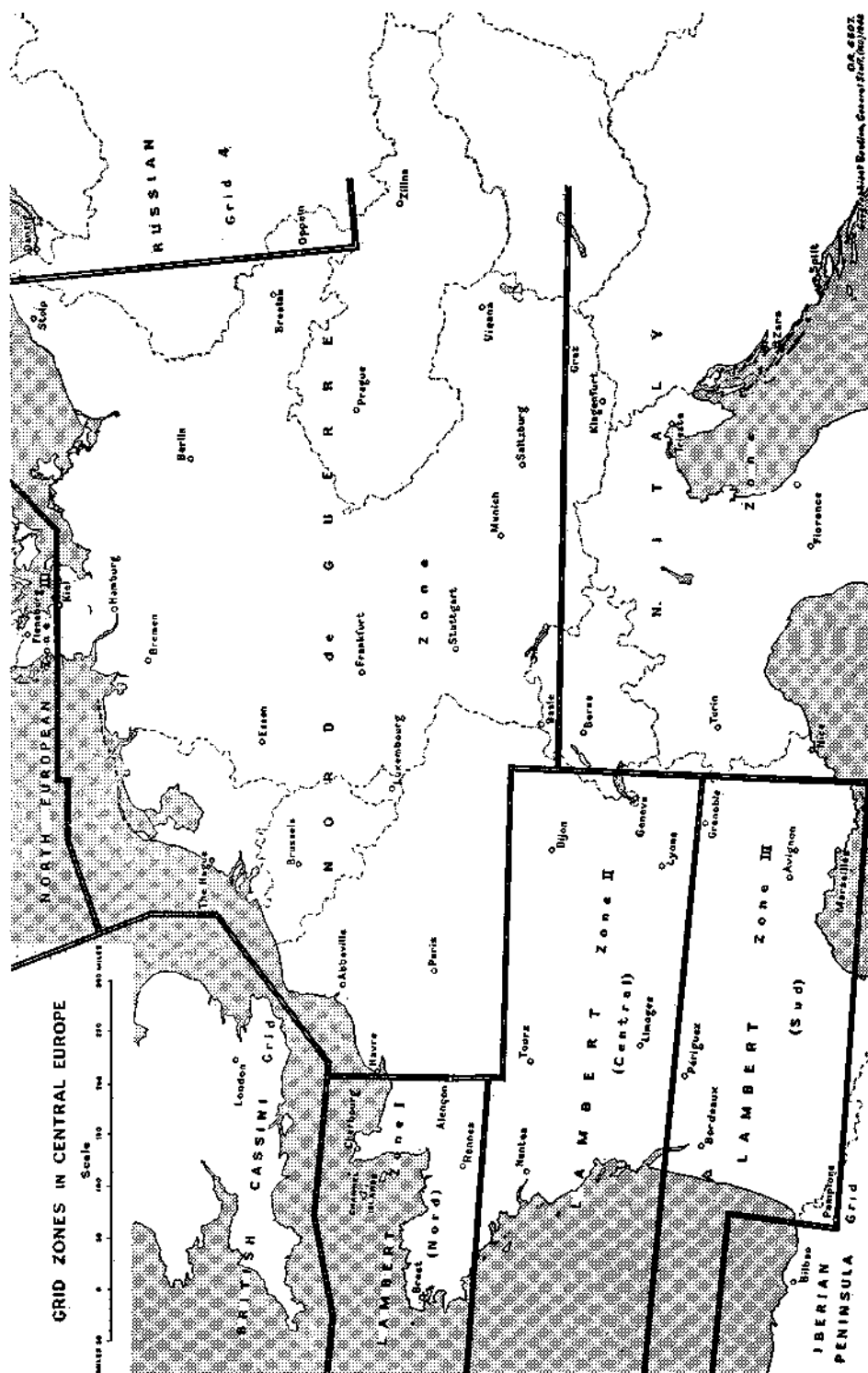
The gridding of maps which either existed or would be prepared for the operations.

The preparation of trig lists, so that the co-ordinates of trig points would be given in terms of the appropriate grid which would be found on the maps. This was of special importance with reference to large scale maps which would be used by the artillery.

Preparation of trig lists

If the values of the French trig points had all been based on one common triangulation, the conversion of their values from geographical to rectangular

DIAGRAM 8



co-ordinates appropriate to each grid zone would have been a comparatively simple matter. As explained above, however, the triangulation situation in France was very confused, being a patchwork of new and old, each based on a different figure of the earth, with different values for their common bases, different azimuths (or bearings) for their basic sides, and different values for their fundamental common "origin" on which the latitudes and longitudes were based.

Recognizing the need for some attempt at consistency, the French had taken their new triangulation and adjusted it to fit the basic fundamentals of the old. In addition, they made further local adjustments on a 1/50,000 map sheet basis so as to make the new values agree with previously published lists based on the old triangulation. This resulted in "cassures," or discrepancies in position, for points lying in the vicinity of the sheet edges, a fact which later on caused a considerable amount of anxiety and annoyance to allied field surveyors when they were working in those areas.

With all this variety and uncertainty about the available data the preparation of trig lists and other survey data for "Overlord" offered many problems. There follows a brief summary of the trig-list situation for western Europe as it existed at the conclusion of the planning period in May, 1944, immediately before the invasion. The work of preparation was most ably controlled by Lieutenant-Colonel W. E. Browne of the Survey Directorate at S.H.A.E.F., and was carried out by a variety of organizations including the S.H.A.E.F. Survey Directorate itself, British and American survey units, the War Office, and the Ordnance Survey.

(a) *North-eastern France and Belgium.* Printed lists of trig points, giving their rectangular co-ordinates on the Nord de Guerre grid, were published on a 1/50,000 map-sheet basis. The values were mostly based on the new French and the Belgian triangulations, but a considerable amount of adjustment and deliberate distortion was introduced. Much of this work had been done by the B.E.F. Survey Directorate in 1939-40, and has already been referred to in Chapter II. Briefly, the procedures which had been involved in dealing with the original data were as follows:—

- (i) The computation of an "undistorted" system in Belgium and Holland as an extension from the French triangulation, using the original triangulation records.
- (ii) Adjustment of this "undistorted" system, and the minor triangulation system in eastern Belgium, so as to accord with the existing Nord de Guerre trig values in western Germany which had been prepared by the French, and also with the Dutch triangulation.
- (iii) Correction of the minor triangulation in western Belgium to accord with the French homogeneous Nord de Guerre values which became available, and also with the Dutch and German triangulations.
- (iv) Correction of the minor triangulation in southern Holland to accord with the Nord de Guerre values in Belgium and western Germany.

The object of all this adjustment and distortion was to smooth out the breaks or "cassures" which would otherwise have existed at the junctions between the various national systems. Such breaks would

have been very disconcerting and awkward if operations developed in such areas. A full description of the work undertaken is given in a pamphlet entitled "Triangulation situation in Northern France, Belgium, Holland, and Western Germany" which was compiled by Lieutenant-Colonel Browne and published by the Survey Directorate, S.H.A.E.F., in 1944.

In the trig lists the points were classified in the following categories:—

- (i) Primary points (French and Belgian classification).
- (ii) Secondary points (French and Belgian classification).
- (iii) Minor points (French and Belgian classification).
- (iv) Points in the *old* French triangulation, or points fixed during the 1914–18 war, of which both the existence and accuracy were doubtful.
- (v) Points fixed by survey units in 1939–40 which were generally of a high degree of accuracy.
- (vi) Other points fixed by survey units in 1939–40 to a lesser degree of accuracy and certainty.

All the points contained in these lists, *except where a cautionary note was inserted*, could probably be used as they stood for R.A. survey fixations or for the establishment of local bearings. It was estimated that bearings between any two such points might be expected to be correct to within about one minute of arc. When observing check rays for bearing, all users were warned that distant points should always be used.

- (b) *Holland.* Co-ordinates on the Nord de Guerre grid were compiled in lists on a 1/25,000 map sheet basis. The values were based on the Dutch records and were, as above described, subjected to certain distortions so as to fit in with the distorted Nord de Guerre co-ordinates for eastern Belgium and the French Nord de Guerre values for western Germany.
- (c) *Western Germany.* The German provinces bordering the Rhine in the Saar region were covered by five booklets which had been published by the French. These booklets were reproduced for issue, the lists having been compiled on a German 1/25,000 map sheet basis. Co-ordinates had been computed on the Nord de Guerre grid as a so-called extension from the French triangulation in the Saar. This was not a true extension from the French triangulation. The German geographical co-ordinates were converted to rectangulars on the Nord de Guerre grid after applying a blanket correction for origin based on a mean comparison of geographical values for common points in the region of the Saar. This simple correction was not a proper one, as the German geographicals were based on the Bessel-Kruger figure of the earth, while the French values were based on the Carte de France figure, and the Nord de Guerre tables were drawn up on the du Plessis spheroid. A further complication arose owing to an azimuth error in the French triangulation. All this resulted in a lack of orthomorphism in the Nord de Guerre values of the German points. The resulting co-ordinates were known as the German "Nord de Guerre," and were the best that could be produced under the circumstances. The above facts should be borne in mind in the event of any future preparation of new trig lists for western

Europe. It might also be considered preferable to adopt the German Gauss-Kruger grid for all mapping and survey purposes in that area. The selection of the most suitable grid system for military purposes in Europe certainly requires careful consideration. S.H.A.E.F. Survey Directorate computed extensions northwards from the Rhine Provinces to Denmark, and also to the east.

- (d) *North-western France.* The unsatisfactory situation existing in north-western France regarding trig co-ordinates has been described in this Section under the heading "Triangulation data in north-western France." As it seemed unlikely that resection in the field from these trig-list values would give satisfactory results they were issued only to R.E. survey directorates and units, with instructions on how best to utilize them for survey work in the field. For those map sheets which lay astride, or just on either side of, a grid junction, lists were prepared and issued on both grid systems concerned. In addition, lists of transformation factors were published so that units could, if desired, convert the values from one grid system to the other.
- (e) *Central and southern France.* Although priority was given to the completion of trig lists covering northern France, where the initial operations would take place, a similar programme was put in hand for the rest of the country. With the probability also that allied forces from the Mediterranean Theatre would eventually make an assault landing in the south of France arrangements were made with A.F.H.Q. for them to take on a share of the trig-list preparation in the south. Thus, in course of time the whole of France was covered with these lists.

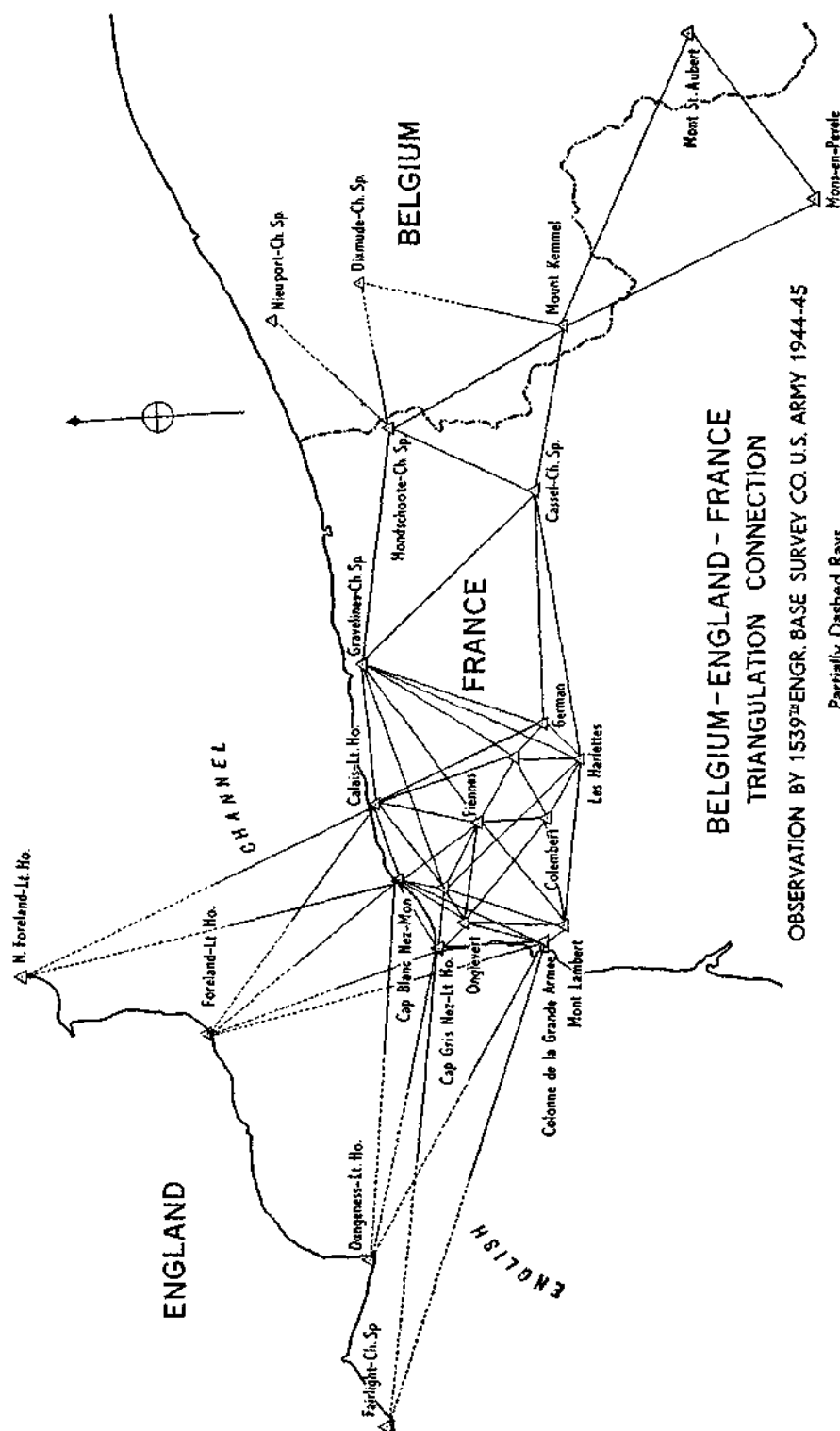
Cross-Channel triangulation connection

When German heavy guns were mounted on the French coast opposite Dover in 1940, there were demands for an accurate connection between the British and French survey systems, so that a relation could be established between points on either side of the Channel. From points in the British triangulation system along the Kent coast, observations were therefore made to prominent points on the French coast such as lighthouses and church spires which were known to form part of the French system. Trig points on the English coast were then converted to the French Nord de Guerre grid system. Later, in 1944, when it was known that launching sites for V-weapon attacks on Great Britain were being developed in the Pas de Calais, the area included within the original cross-Channel connection scheme was extended westwards along the English coast, and also along the French coast towards Le Havre. Details of this work were given in Lieutenant-Colonel Browne's "Report on the Cross-Channel Connection" together with the various addenda thereto. It is of interest to note here that in 1944-45, when the German forces had been driven out of the Pas de Calais, the connection was strengthened by observing back from the French coast on to the English triangulation stations (see Diagram 9).

Connection between Continental triangulations and that of Great Britain

With the development of radar, and an increase in its range of action, it was necessary to establish as accurate a relation as possible between the British and Continental survey networks, extending right into the heart of Germany.

DIAGRAM 9



BELGIUM - ENGLAND - FRANCE
TRIANGULATION CONNECTION
OBSERVATION BY 1539TH ENGR. BASE SURVEY CO. U.S. ARMY 1944-45

Partially Dashed Rays
Indicate Observations from Solid End Only

Making use of the original cross-Channel connection observed in 1862, and working through the first-order French and Belgian triangulations, computations were carried out to connect the British and German systems. All calculations were referred to the "Airy" spheroid, the values for which had been used for the calculations of the British triangulation framework. Advantage was taken of the fact that a common point existed at the junction of the Dutch, Belgian and German systems. The results of this early computation were, of course, prejudiced by the uncertainty of the connections between the national systems along their frontiers but, as will be seen later, this was subsequently remedied by a reobservation of the geodetic connections concerned. The results of the early work are given in a paper entitled "Geodetic connection of the triangulations of France, Belgium, Holland and Germany to the triangulation of Great Britain in terms of the Airy Figure of the Earth," by Lieutenant-Colonel W. E. Browne, R.E.

Training of survey units for field survey work

Although most of the field survey units which took part in "Overlord" had been in existence for some time, it was generally felt that there had not been sufficient opportunity for training their personnel in field survey operations. It was undoubtedly a fact that they had to be employed during most of their time in the United Kingdom on other forms of work. This was especially the case during the few months preceding "D"-day, during which time all available personnel were employed full time on the preparation from air photographs of the 1/25,000 maps of the invasion areas. This was essential work of great urgency and, as events proved later on, was an excellent training for similar work which they had to perform subsequent to the pursuit of the German armies through Belgium. It was always expected, however, that the topographical sections, after arrival in France, would be required to carry out rapid programmes of check surveys, new triangulation to provide control for the R.A. Survey Regiments and other forms of topographical field survey. On the more important training exercises for all arms which were periodically staged in the Home Commands, opportunity had been taken to introduce a survey picture simulating the conditions which would probably be found in France, and the R.A. and R.E. survey units had had these limited opportunities of working in co-operation with each other. But time for more intensive training of this nature was not available.

In the invasion area, where the trig-list values were of such doubtful accuracy, it seemed likely that a new triangulation would have to be observed, most probably on a local area basis, and on a local grid. Methods were therefore devised whereby such a local scheme could be adjusted quickly and readily to the standard theatre grid. Details of one such method are contained in a pamphlet entitled "Triangulation in Areas where existing Trig Lists are of doubtful Value," by Lieutenant-Colonel W. E. Browne, which was issued in December, 1942, and reprinted in October, 1943, by the Survey Directorate at H.Q. 21 Army Group.

Operational Policy Memoranda

To ensure a measure of standardization and co-operation between the allied forces, S.H.A.E.F. issued a series of "Operation Policy Memoranda" on a variety of subjects. One of these, No. 28 (*see Appendix I*), dealt with the

conduct of "Artillery and Engineer Surveys." Although not laying down any standardization regarding technical methods of surveying, it did emphasize the necessity for standardization in such things as the preparation of new trig lists in the field, the numbering and marking of trig points and grid nomenclature.

(B) FIELD SURVEYS OVERSEAS

Within the Normandy Bridgehead (June–August, 1944)

FIELD SURVEYS

Bearing in mind the plan for the development of operations subsequent to a successful assault landing, D.D. Survey Second Army (Colonel A. W. Heap), who was controlling the initial survey operations within the bridgehead, had made a careful advanced study of local topographical conditions from available maps and other material, and had worked out various alternative projects for dealing with the supply of a control framework.

On 12th June, immediately after landing, 519 and 521 Field Survey Companies started work in the Bayeux–R. Orne sector. Their primary task was to check the existing triangulation as given in the S.H.A.E.F. trig lists, and to provide new control where necessary as a firm base for further surveys. Their second task was to provide co-ordinates and bearings where required by the artillery in forward areas, including the fixation of points in enemy territory, carrying these forward day by day as the tactical situation allowed.

From a common base, centrally situated, whose ends were resected from listed up-stations, 519 Company worked to the west in 30 Corps area, and 521 Company to the east in 1 Corps area, their trig schemes being so planned as to incorporate as many as possible of the listed trig points in their observations. Both units concentrated their topographical sections in the actual battle-zone, working in close co-operation with the R.A. Survey Regiments of 30 and 1 Corps respectively, and allotted the coastal strip to the General Field Survey Sections under their command.

During the available training period in the United Kingdom, Browne's method of trig adjustment, referred to in Section 3A, had been further developed by Lieutenant G. L. Thomas, R.E., who evolved an easily worked least-square method which, in calculating the adjustment, made use of all the listed trig points included in the observations. The method was particularly useful for checking listed co-ordinates, as it detected unreliable points at an early stage in the computation. This method was used by the Second Army units in the Normandy operations, and was fully described in a pamphlet printed and issued by Second Army in June, 1944.

It was not long, however, before captured German trig lists became available. These gave co-ordinate values of French trig points to the decimal point of a metre (differing, however, from the S.H.A.E.F. values by about 70 metres), and also of new German points, many of which had been left, marked and beacons, and had already been used by our survey units. Comparison with the Second Army observations indicated that the Germans had indeed already completed the required check of the French triangulation in the coastal belt, and that their work was good. By empirical methods correction curves were then rapidly calculated to convert German values to S.H.A.E.F. values, eliminating the "sliding" discrepancy of approximately 70 metres, and the

Second Army observations were recomputed, using the "Thomas" adjustment, to the converted German values, the intention being that any further captured German co-ordinates could be accepted without further question. Unfortunately, the captured German lists covered only a very small area; nevertheless, it is of interest to note that the empirical adjustment curves agreed to within about $\frac{1}{2}$ -metre with the S.H.A.E.F. correction graphs subsequently published which were based on the Driencourt formula referred to later.

During July the trig work consisted of probing forward to the south and south-east as far as the slow movement of operations allowed, and also westwards to conform to changes in the boundary between Second Army and First U.S. Army. Work in the Caen area was handed over to the First Canadian Army towards the end of July.

It is significant to note the comments of D.D. Survey Second Army during this early period. He observed that the lack of sufficient previous training in field survey, already referred to, was showing its effect on the trig and topographical work being undertaken. Much time was lost by the consequent amount of detail work thrown on the Survey Directorate, and the need to re-observe a good deal of the work. The slow progress of operations during July afforded an opportunity to use the work of the units as training.

The need for close liaison with infantry brigades and battalions was essential as orders had been issued by Second Army that no army troops units should work in the forward areas without permission of the relevant formations.

The Falaise battle and the break-out of the British, Canadian and American armies from the bridgehead took place in August. The U.S. First Army cleared up the Cherbourg peninsula, and U.S. Third Army, having broken out to the south, turned east and, forming the right flank of the allied advance, began the swift pursuit over the Seine and beyond.

519 and 521 Field Survey Companies carried forward a fully observed triangulation towards Falaise, ultimately tying their work together on common points. 521 Company also tied in on common points with First Canadian Army to the east, and 519 Company with First U.S. Army to the west. Canadian topographical sections in the Caen area extended their work south-eastwards towards Falaise, maintaining close co-operation with the Canadian Survey Regiments and, as the latter had suffered serious casualties, the topographical section survey was carried into A.G.R.A. and divisional artillery areas.

Corps topographical units of First U.S. Army at the western end of the bridgehead were primarily engaged in checking the published trig lists and establishing control for artillery uses, working in close contact with the field observation battalions. The Army Topographical Battalion was employed running a traverse control net for tying together the data established by the Corps topographical units. The general area covered by them was in the vicinity of Periers, St. Lo, and Vire.

Towards the end of August the break-out occurred, the pursuit was on and, for the time being, field surveys to provide control for artillery requirements were broken off, owing to the speed of movement.

CROSS-CHANNEL CONNECTION BY OBSERVATION BALLOON

An attempt was made during August to establish a triangulation connection between Normandy and the south coast of England by observing from both

sides on to balloons towed along mid-Channel. This was unsuccessful owing to poor visibility, and the attempt was not repeated.

NEW EDITIONS OF S.H.A.E.F. TRIG LISTS

The trig-list situation during the weeks following "D"-day became somewhat confusing. Mention has been made of the issue of Second Army trig lists after the capture of some German documents. Through Intelligence sources S.H.A.E.F. then obtained a number of modern trig lists covering parts of northern France. These were evidently coming through underground sources from the Service Géographique in Paris. The lists gave values in the form of rectangular co-ordinates to one decimal place of a metre. There was no indication of their reliability but, as the values were given so precisely, it was assumed that they represented an advance on anything already in our possession. As the co-ordinates were given in terms of the new triangulation, it was necessary to convert them to the theatre grid which was based on the old system. Revised lists covering the battle area were prepared by S.H.A.E.F. and issued to all concerned.

As soon as it was known that the Germans were using Lambert Zone I co-ordinates based on the new triangulation, S.H.A.E.F. issued a Technical Instruction with graph giving a quick and convenient means of converting them to the theatre grid. The graph was based on a theoretical correction derived from the Driencourt formula. Similar graphs covering the Zone II and Nord de Guerre areas were also prepared. Hitherto there had been no evidence to show that the new triangulation had penetrated into that part of Normandy.

Two further German booklets which were captured gave a lot of important information. These described German survey activities in France from the date of the occupation in 1940 until May, 1943. A S.H.A.E.F. Technical Instruction was published describing the work undertaken. It appeared that extensions of the new triangulation system had indeed been carried out both by the French and the Germans. This work, as far as was then known, consisted in the main of first-order extensions to the west along the parallel of Paris to Brest, along the Bourges parallel connecting Dijon and Nevers, and along the Toulouse parallel in the south. There was also a considerable amount of second-order work filling the gaps between the main chains.

A few days later some further captured material threw considerably more light on the situation. It was then proved that the French and Germans between them had completed all the originally projected "first-order" nets in France with one or two exceptions. What was of special operational interest, however, was the evidence that the Germans had connected, by a second-order triangulation, the new first-order triangulation at Amiens to the new western extension of the Paris parallel (see above), making a junction at Mont St. Michel. This new second-order work traversed the whole length of the Normandy coast, and had been surveyed by the Germans in 1942. It was established that the recently captured German booklets, which were dated May, 1943, contained definite values based on this new work, and were therefore the most accurate values for the trig points that we were likely to obtain. A new S.H.A.E.F. Technical Instruction was therefore published giving all this further information, accompanied by a graph which gave the subsidiary corrections to be applied to the May, 1943, German lists to reduce them to the same terms as the theatre grid, after conversion through the

Driencourt formula. Revised trig lists embodying the latest values were also published. In this connection it should be explained that, when new trig lists were published by S.H.A.E.F. in the field, they were not issued in printed form. Having prepared the original lists in manuscript, bromide paper negatives were made, and these were distributed to the army groups so that they could make their own plates for reproduction, and print their own stocks of trig lists as required.

All these constantly recurring changes in the trig-list values consequent on the capture of enemy documents were no doubt very tiresome to survey units in the field, but it is inevitable under conditions where low-grade information only is available at the beginning of operations, and where data of greater accuracy are acquired as operations proceed.

When the break-out from the Normandy bridgehead took place in August, and the speed of pursuit put a temporary end to the need for control surveys, the worries incidental to uncertain trig-list values in Normandy came to an end. The rapid move of the allied forces into north-eastern France and Belgium soon took most of them into an area which was covered by the more reliable trig lists which had been published in 1940 by the G.H.Q. Survey Directorate, B.E.F.

Normandy to the Rhine (August, 1944–February, 1945)

FIELD SURVEYS

The First Canadian Army, after crossing the Seine, formed the left wing of the allied advance, and had the task of cleaning up the Pas de Calais, including the V-bomb launching sites, and liberating the Channel ports. During the middle of September, 2 Canadian Field Survey Company deployed near St. Omer in country which was very suitable for triangulation and where several German survey towers proved most useful. Work started near St. Omer and extended west towards Boulogne and east towards Poperinghe, covering a frontage of about 40 miles. The list values for the primary points in this area were found to be reliable. Secondary and tertiary points did not check in so well. As a result of their observations the Canadians issued new values which were used for the battles round Boulogne and Calais and subsequently at Dunkirk. During this period it was found convenient to attach two topographical sections from 2 Canadian Field Survey Company to the artillery survey regiments operating in the area.

In the latter half of September, the Canadian Company moved to the Ghent area, which was not suitable for triangulation. Topographical sections were therefore deployed to check the trig-list values by traversing between Bruges and Ghent, and between Ghent and St. Nicholas, and this was later extended northwards. In all, about 180 miles of traverse was completed, the trig-list values being found to check in well.

Apart from these check traverses, the following special tasks were undertaken by the Canadians:—

Traverse loops were extended into Holland between Phillipine and the mouth of the Scheldt, with bearing pickets established at frequent intervals.

A survey for 107 A.A. Brigade was undertaken in the Dunkirk area, where the Germans were still holding out. This consisted of a traverse loop of about 50 miles linking up trig points, with spurs running into the gun areas.

A survey for a heavy regiment near Phillipine.

The quick moves of British Second Army at the end of August and during September put a temporary stop to control surveys in the field. Even the R.A. Survey Regiments were outpaced, and by the end of September there had been no need or opportunity to resume this type of work. The narrow corridor in Holland running up to Arnhem gave insufficient space for any useful R.E. triangulation work for artillery control purposes. In fact, there was really no need for it, as survey regiments found that the published trig-list points were generally reliable, and they could base their local surveys on them with no difficulty.

A special task was, however, carried out at Bourg Leopold, which was the Aldershot of the Belgian Army. There was a proposal to use the artillery ranges there for training purposes, and a survey was required to check the existing trig points within the range area and establish new ones.

During October several field survey tasks were undertaken by Second Army, including the provision of control for the fixing of sound-ranging bases, for connecting the survey networks of survey regiments, and for the fixation of sites for the chain of radar stations which was rapidly being set up over western Europe as the Allies moved east.

The Canadian Company had several moves during October. About half the unit was employed on the check of trig-list points, the remainder being used either in direct support of artillery survey regiments in an artillery survey role because of the lack of sufficient artillery survey personnel, or on other special tasks. The work in the Dunkirk area was completed during early October. Radar surveys were carried out in the Canadian area under control from D. Survey 21 Army Group.

American topographical units were similarly occupied in checking their listed points, surveying radar sites, and extending control in conjunction with their artillery observation battalions.

Bad weather conditions and increased German resistance slowed down progress during November and December and, during this latter month, the strong enemy offensive was launched in the Ardennes. Then in January came the resumption of eastward movement all along the front, cleaning up the whole area west of the Rhine, and leading up to the assault crossing over that last great obstacle into the heart of the Reich. During all these operations survey units with all the armies were frequently called on to provide control for the strong artillery support which was given continuously. Most of this work was done by resection and intersection using the trig-list co-ordinates.

TRIG-LIST SITUATION

Germany. The rapid pursuit of the German forces shifted the interest and activities of computing experts eastwards so that trig values would be available for operations into the very heart of Germany. Extensions to the existing trig lists covering the Rhine provinces had been added to the north and east. Further extensions were now in hand to cover Germany as far east as the meridian of $15^{\circ} 20'$ (E. of Greenwich), and southwards to the Austrian frontier. Part of this computing work was taken over by the United States.

The triangulation situation in Germany as a whole was complicated by the fact that surveys and mapping had originally been organized and carried out on a state basis, each with its own "origin" and basic fundamentals. During the period between the two wars the Germans themselves had started to unify these separate surveys on the basis of the Prussian (Einheit) system, but it was

still incomplete when the war started, and the result, from a military survey point of view, was complicated and confusing. For military purposes it was necessary that trig values in Germany should be converted to the allied grid system. This meant, in effect, the following action:—

The co-ordinate values for each separate state had first to be converted to the Prussian system.

The triangulation of southern Germany on this Prussian system was then distorted so as to fit on to the surrounding systems of France, Switzerland, Austria, Bohemia, and the French system of Prussian points in the Rhine provinces and in northern and central Germany.

All values had then to be converted to the allied grid system.

The conversion from state values to the Prussian system was effected by means of a blanket correction. The distortion to effect a smooth fit on to the adjoining systems was done by means of a so-called "grand graph" prepared by S.H.A.E.F. Survey Directorate, and the conversion to the allied grid system was done through the published tables. Nearly all this work was centrally controlled by S.H.A.E.F. under the guidance of Lieutenant-Colonel W. E. Browne, who contributed much valuable work in connection with the geodesy of western Europe during the planning and operational stages of the campaign.

There were, unfortunately, some areas in south-western Germany in the states of Hesse, Baden and Wurttemberg for which little triangulation data were available, and all formations were notified of the importance of searching for the missing data amongst captured enemy records. In anticipation of acquiring this, tables were issued by S.H.A.E.F. to army groups, and to the U.S. Communications Zone (Com. Z.), by which transformations to the Nord de Guerre grid of German co-ordinates on their Gauss-Kruger projection could be effected by survey directorates and units in the field.

In a later paragraph the activities of the "T" (target) Force parties for acquiring captured survey records are discussed. Amongst the material obtained was some further information about Baden and Wurttemberg. As soon as this was available, the work of converting the points to the allied grid was put in hand and trig lists were issued. But even by the end of January, 1945, the available trig data for southern Germany were still meagre, and consisted only of the following:—

- | | |
|--------------|---|
| Baden. | About 190 points (primary only). |
| Wurttemberg. | About 550 points (primary and secondary). |
| Bavaria. | About 115 points (primary only). |

This gave an average density of two trig points in Baden, and four in Wurttemberg, to a 1/25,000 map sheet, but in Bavaria there was only one point to about every five sheets.

For Bohemia trig lists were prepared from Austrian triangulation data and included primary points only. The Austrian values were adjusted through a graph to make them fit the German Nord de Guerre in the north and the Austrian Nord de Guerre in the south.

France. After the occupation of Paris, co-operation with the Service Géographique enabled a close investigation to be made into the French triangulation situation which had offered so many complications to date. Although many doubtful points were cleared up, it was obvious that there still remained a good deal of confusion regarding the various existing systems

of divergent co-ordinates, and this persisted throughout the entire period of operations. It seems evident that a great deal remains to be done in clearing up the geodetic situation and putting it on a sound footing, and no doubt this fact will be recognized by those responsible for post-war programmes of collecting and tabulating triangulation data of the Continent.

Amongst the new French material obtained were a number of trig lists covering the Rhine frontier region between France and Germany. Photostat copies were sent to 12th U.S. Army Group for their use. Copies of secret pamphlets containing co-ordinates of points along the Maginot Line were also made available by the French who gave whole-hearted co-operation and assistance in supplying this sort of data, as they did in map production and other forms of survey activities.

Hitherto no trig lists of Luxembourg had been published owing to the difficulty of relating the Luxembourg survey points with the French Nord de Guerre system. French trig lists of Luxembourg were now obtained and issued, and an examination of common points indicated that values were in sympathy to within two or three metres.

SURVEYS IN CONNECTION WITH THE DETECTION OF V-2 LAUNCHING SITES

The Germans fully realized the importance to the Allies of the port of Antwerp. When, therefore, after being driven from their V-weapon sites in the Pas de Calais, they organized a new rocket campaign from sites further east, the Antwerp area became one of their principal targets in the battle-zone. It was an urgent necessity to locate the new launching sites, and this involved the installation of groups of microphone detection stations. The need for an accurate survey of these positions did not at first seem to be appreciated by those responsible for controlling the detection devices, and it was fortunate that 2 Canadian Field Survey Company was in the vicinity at the time. Arrangements were made for this unit to carry out the survey work while awaiting the arrival of the R.A. Survey Regiment which was to install the microphone posts. At first there were 44 microphone positions in four groups. This number was increased later. For the initial lay-out the points were located by map spotting on 1/25,000 maps. All these points were then connected together by closed traverses which were tied in to the local trig framework. Within each group the points had to be sited 10,000 metres apart (± 3 metres), and altitudes were required to an accuracy of ± 1 metre. Having surveyed the positions of the map-spotted points, sketches were made covering an area of 100 metres radius surrounding each point. From these sketches final positions for each microphone could be determined whereby they would all be located at the required distance apart without clashing with a house or other obstruction. Having determined these final positions, their co-ordinates were fixed from the points already surveyed by single-leg traverses.

SURVEY "T" (TARGET) FORCE ACTIVITIES

The acquisition of captured enemy survey data and material, whether in the form of maps, trig lists, or other category, formed a vital part of survey operations. This was especially so when entering the enemy's homeland, where all his main depots and records were located.

Under centralized direction S.H.A.E.F. and the higher field formations organized special parties composed of Intelligence and technical representatives,

whose duty it was to search for, examine, and evaluate all captured documents and other material.

Survey Directorates at S.H.A.E.F. and with army groups arranged for representation with these parties, and their work began in France soon after landing. In this work it was necessary to maintain the closest possible liaison with the Intelligence branches concerned. Mention should be made here of a specialist investigation party of American personnel which was sent over by the War Department, specially trained in geodetic research. On arrival in France they came under the control of the Chief Engineer of the U.S. Communications Zone (Com. Z.). Their work was co-ordinated by D. Survey (S.H.A.E.F.) so as to fit in with that being undertaken by S.H.A.E.F. itself and by the army groups. The party, which was equipped with microfilming equipment, was commanded by Major Hough, who applied to the task remarkable energy and technical skill. During November detachments from his group examined potential sources of survey and mapping data in Paris, Aachen, Brussels, Liège, and Strasbourg. 1,700 feet of 35 mm. film was used to record geodetic material which was found in various universities and other places. These included the triangulation records of Wurttemberg together with some trig data of Baden and elsewhere. At Strasbourg the "Hough" Team found a complete list of bench marks, river-gauge data, and altitudes along both banks of the Rhine, which was of great value when considering the possible flood conditions which might be encountered.

All data obtained by the "Hough" Team were entered upon card indexes, copies of which were supplied to S.H.A.E.F., the Chief Engineer (Com. Z.), and the army groups, so that they were kept informed of what had been found.

All these "T" Force parties were kept busy during the whole period of operations, but especially when Germany itself was entered, and the headquarters of the various German survey organizations were overrun.

The final phase. (The Rhine to the surrender, March-May, 1945)

FIELD SURVEYS

The Rhine was crossed during March, followed by deep, rapid advances into Germany.

In preparation for the assault crossing, the survey units of all three army groups carried out a considerable amount of survey work of all kinds, some examples of which are now given:—

Surveys for artillery control. 14 Field Survey Company, with 3 General Field Survey Section under command, covered with triangulation a belt about four miles wide along the west bank of the Rhine from Emmerich to Wesel. The object was to check the existing trig data, including points on the east bank, to provide additional control where required for artillery surveys, and to fix by intersection new points on the east side of the river. The methods employed included resection, intersection, new triangulation and traverses. The results of the Canadian Army's trig work during their earlier battle between the Rivers Maas and Rhine were found very useful when establishing common points between the British and Canadian Armies. Further common points were fixed between the Second British and the Ninth U.S. Army. For security reasons the erection of beacons was not allowed, though lamps were permitted. Over 40 points were fixed by intersection across the river and these were not confined to the con-

ventional church spires and towers which, as potential O.P.s, are usually listed as targets for destruction by our own artillery. Objects such as prominent trees and gable ends of white buildings were selected.

One topographical platoon of 2 Canadian Field Survey Company continued to work in support of artillery survey regiments until 8th March when operation "Veritable" was successfully completed. This operation, which was carried out by the First Canadian and Ninth U.S. Armies, cleaned up the approach area to the Rhine in the north between that river and the Maas.

Owing to the rapidity of the advance after the Rhine crossing and the adequacy of the published trig lists, very little R.E. survey work to provide artillery control was either asked for or required during April. In fact, several topographical sections of units in Second Army were employed on sorting overrun German map stores, a task which assumed much importance and difficulty during that period. Even for the crossing of the R. Elbe no R.E. control surveys were needed.

In Holland, topographical sections of 2 Canadian Survey Company continued in support of artillery survey regiments during the operations to clear north-eastern Holland, western Holland, and the Canadian area in north-western Germany.

The activities of the American topographical units were of a similar nature to those of the British and Canadian units in the north. The same factor of rapid movement reduced the general need for engineer control surveys but, owing to the dearth of good trig data in southern Germany, the artillery observation battalions were not so well provided for as in the north. The following brief summary of survey activities in U.S. Seventh Army gives an illustration of how their topographical units were employed during the final few weeks leading up to the surrender:—

Survey platoons of 661, 666, and 679 Engineer Topographical Companies operated in support of the artillery with 6, 15, and 21 Corps respectively. Survey platoons of 656 and 649 Engineer Topographical Battalions operated under army control supporting survey platoons of the corps topographical units. During the month of April engineer topographical units confirmed 50 triangulation stations, established 25 new triangulation stations, 5 radar positions and 100 azimuth stations, ran 210,000 yards of traverse, converted 950 points from Gauss-Kruger to Nord de Guerre co-ordinates, and checked autobahn alignments and classification.

Bridge sites. An important task was the provision of survey data for the construction of semi-permanent bridges over the Rhine, Neder Rhine and Ijssel Rivers. The Canadians placed two topographical sections in support of Canadian Army Troops Engineers for the bridge sites at Emmerich and elsewhere, while with the British Second Army, 521 Field Survey Company undertook the survey work for bridges at Rees and Xanten. The work involved at each site was briefly as follows:—

Five lines across the river, specified by the R.E. bridge construction unit, were measured to an accuracy of two inches in plan length and one inch in relative height.

The soundings along these five lines were measured by the Port Construction and Maintenance Group R.E., after which the final bridge alignment was chosen.

The final alignment was marked on two concrete pillars on each bank and the distances and heights between these marks were measured as above.

Large scale plans (1/2,500) were prepared covering the bridge site, including approaches on both sides of the river, and were contoured at 1-foot vertical interval.

The plan distances were determined by base measurement and triangulation using standardized tapes. It was, of course, necessary that the tapes used by the bridge construction units should be compared with the same standard tape as that used by the survey unit. Relative heights were measured by reciprocal vertical angles across the river, and absolute height by levelling from the nearest known bench mark, after checking the relative accuracy of at least two bench marks near each site. Both at Rees and at Xanten, about ten kilometres of levelling were involved.

TRIANGULATION DATA

During the final few weeks of operations the principal trig-list activity concerned the acquisition of captured enemy data for southern Germany, and its conversion to the allied theatre grid system. The states of Baden, Wurttemberg and Bavaria were never adequately covered, but fortunately the speed and nature of the operations during the final stages did not demand anything very extensive in the form of control surveys, so that the lack of data was not of any material consequence. All field formations were by now in possession of S.H.A.E.F. graphs and tables whereby they could quickly convert for use any new material which they might acquire.

A study was made by S.H.A.E.F. at this time of the available trig data of Denmark in case operations should extend to that country. The Danish values were published, accompanied by a Technical Instruction which contained guiding notes on the proper use of the data, and methods of converting the values to the theatre grid.

MISCELLANEOUS ITEMS

Geodetic Surveys (see Diagrams 9 and 10). Previous reference has been made to the unsatisfactory and uncertain junctions between the national triangulations in western Europe, which jeopardized the computation of a reliable geodetic connection between Great Britain and Germany.

During April, 1945, the final connecting rays back from the French coast to England were successfully observed by an American survey party. This completed the cross-Channel connection which had been begun from the English side in 1940.

Other geodetic observations which were successfully completed were as under:—

- (a) A primary chain between Boulogne and Mount Kemmel linking the new cross-Channel connection with the Belgian primary network.
- (b) Observations between Bruges and Jalhay to link the Belgian primary network with the Dutch and German systems.
- (c) Observations to link the Belgian net in Luxembourg with the adjoining French and German triangulations.

The results of all the above work were sent to the War Office.

Radar surveys. Radar surveys had been started during August, 1944, in the Cherbourg area and, as the armies advanced, new stations were surveyed as far forward as possible. During the period of rapid movement some of these stations were used for only a few days, some not at all, and there was a constant demand for fresh sites to be surveyed on the heels of the retreating enemy. The surveys were controlled by D. Survey 21 Army Group until the end of November, 1944, when S.H.A.E.F. assumed general control of the work over the whole operational area.

During the autumn of 1944 the topographical sections of 515 Field Survey Company and 4 and 5 General Field Survey Sections were mainly occupied on this work. Topographical sections from survey units with Second Army, Canadian Army, and the U.S. Army Groups were also employed. In addition to those required by the R.A.F., radar surveys were carried out for the artillery in 21 Army Group and also for the Royal Navy. The latter requirement was in connection with navigation in the approaches to Antwerp. Fixation of position was normally effected by resection from existing trig stations or by traverse from them. In the latter case it was always necessary to provide a check by closing on a second trig point or by resection at some intermediate point in the traverse.

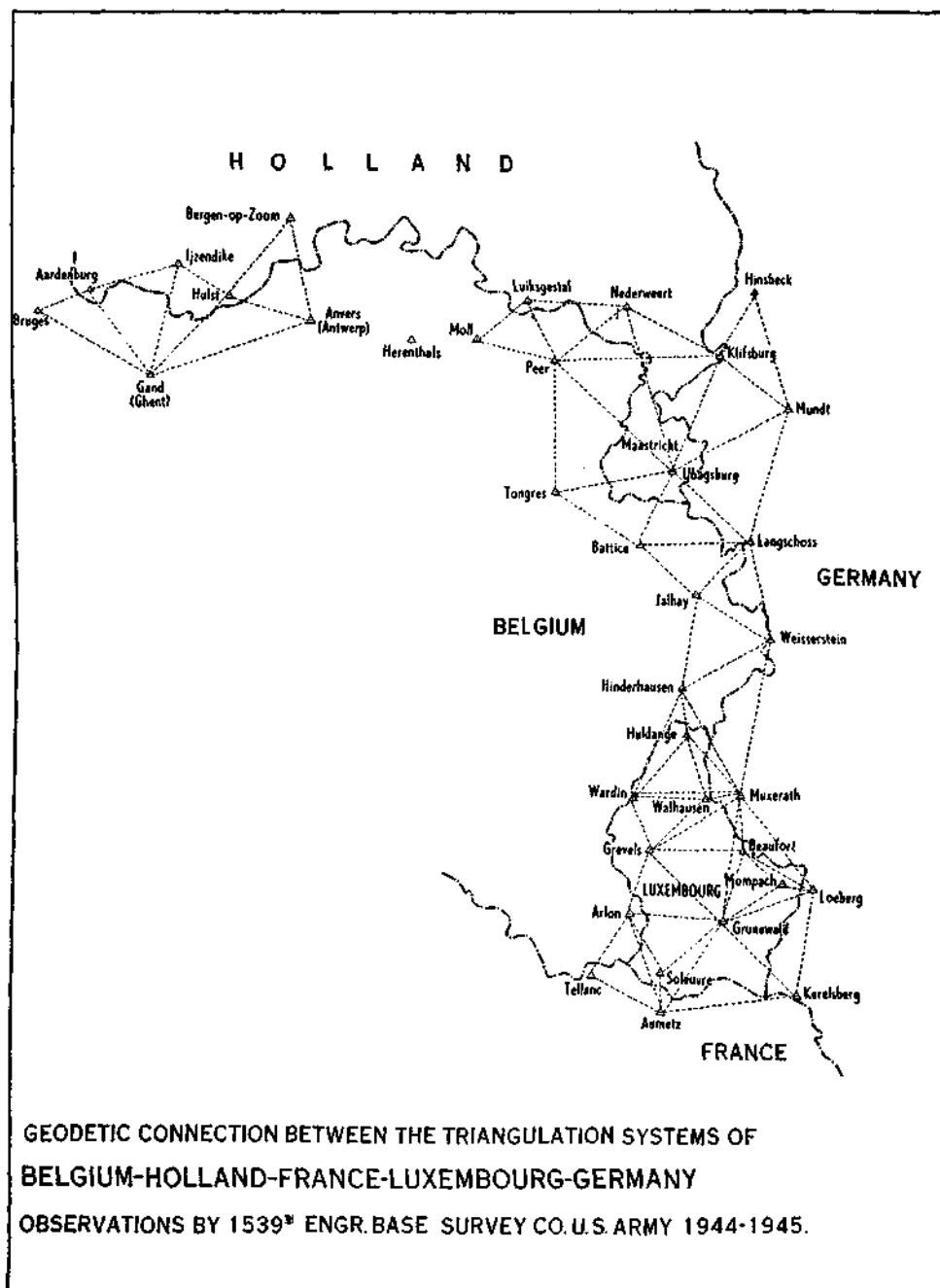
Computations were completed to a decimal point of a metre. Geographical co-ordinates were also calculated to two decimal places of a second.

For certain types of radar stations measured panoramas were also required. These consisted of an outline of the skyline from north to south, through east, plotted to a horizontal scale of 15° to one inch, the vertical scale being exaggerated three times, i.e., on a scale of 5° to one inch. The essence of this panorama was to show abrupt changes in the skyline, such as those presented by isolated woods and escarpments. The measurement of the panorama was made by theodolite, reading both horizontal and vertical angles to selected salient features. These points were then plotted and the skyline sketched in by hand. The accuracy aimed at was to about ten minutes of arc.

In these surveys of newly established radar stations speed was an essential factor, and army groups had therefore to maintain a flexible service with a survey party available to go to a specified spot at short notice, meet the R.A.F. representative, and complete the work in the minimum of time.

German national geodetic records. Amongst the principal survey "targets" for the "T" Force teams (including the "Hough" team) on entering Germany were the headquarters and provincial offices of the "Reichsamt für Landesaufnahme," which was the German national survey organization corresponding to the British Ordnance Survey. Their principal geodetic records were discovered at Friedrichroda, together with the chief geodesist (Herr Gigas) and his staff. All the records, together with some of the key personnel, were moved to Bamberg, in the American Zone, where Major Hough had set up his headquarters. Lieutenant-Colonel Browne (geodetic officer with S.H.A.E.F. Survey Directorate) went to Bamberg to interrogate Herr Gigas, and also to Friedrichroda to interrogate General Volmar, who was President of the Reichsamt für Landesaufnahme. Arrangements were made for the German geodetic staff to carry out certain technical tasks required by the Allies and subsequently to work on a geodetic programme over Germany on which they had previously been employed, and which it was considered would be of value to the occupying forces.

DIAGRAM 10



Connection between the triangulations of Denmark and Norway (see Diagram 11). As soon as Denmark and Norway had been liberated Brigadier Clough (D. Survey, S.H.A.E.F.), accompanied by Lieutenant-Colonel Browne, visited Copenhagen and Oslo and suggested to Professor Norlund (Danish Geodetic Institute) and to the Norwegian Survey Institute that opportunity should be taken of the prevailing conditions, which were not likely to recur, to effect a junction between their respective triangulations. They were invited to contribute technical personnel and other resources to the extent of their availability, while the allied survey organizations would control the work and provide the balance of personnel and equipment required, supplying also the aircraft, wireless parties and transport which would be required. Reactions to this proposal were favourable and, under Lieutenant-Colonel Browne's supervising control, all arrangements were put in hand for the work to be undertaken. Technical planning conferences were held in Copenhagen at the end of June, attended by representatives of all concerned, in order to draw up detailed plans for the project.

The general idea was that aircraft should fly along the centre of the Skagerrak, dropping a series of flares. From selected existing trig stations along the Danish and Norwegian coasts observations would be taken to these flares, the observations being controlled by a programme of wireless signals.

The increasing use of radar for air navigation seemed to make such a connection between the two systems eminently desirable. The use of radar aids depends essentially on the basic use of accurate geodetic data, and an investigation into the existing triangulation networks of the two countries showed that there was no good junction between them. The modern first-order triangulations of Denmark and Sweden were firmly linked by observations across the intervening water-channel, but those of Sweden and Norway appeared to be connected at one point only, and the identity of that one common point was open to doubt. There was therefore no reliable connection of any sort between Denmark and Norway.

The following gave much valuable assistance towards the successful carrying out of the project:—

Lieutenant-Colonel W. E. Browne, R.E., who was the guiding spirit, technical author of the plan, and in control of the whole operation.

Dr. Norlund, of the Danish Geodetic Institute, and his staff of observers and other technical assistants.

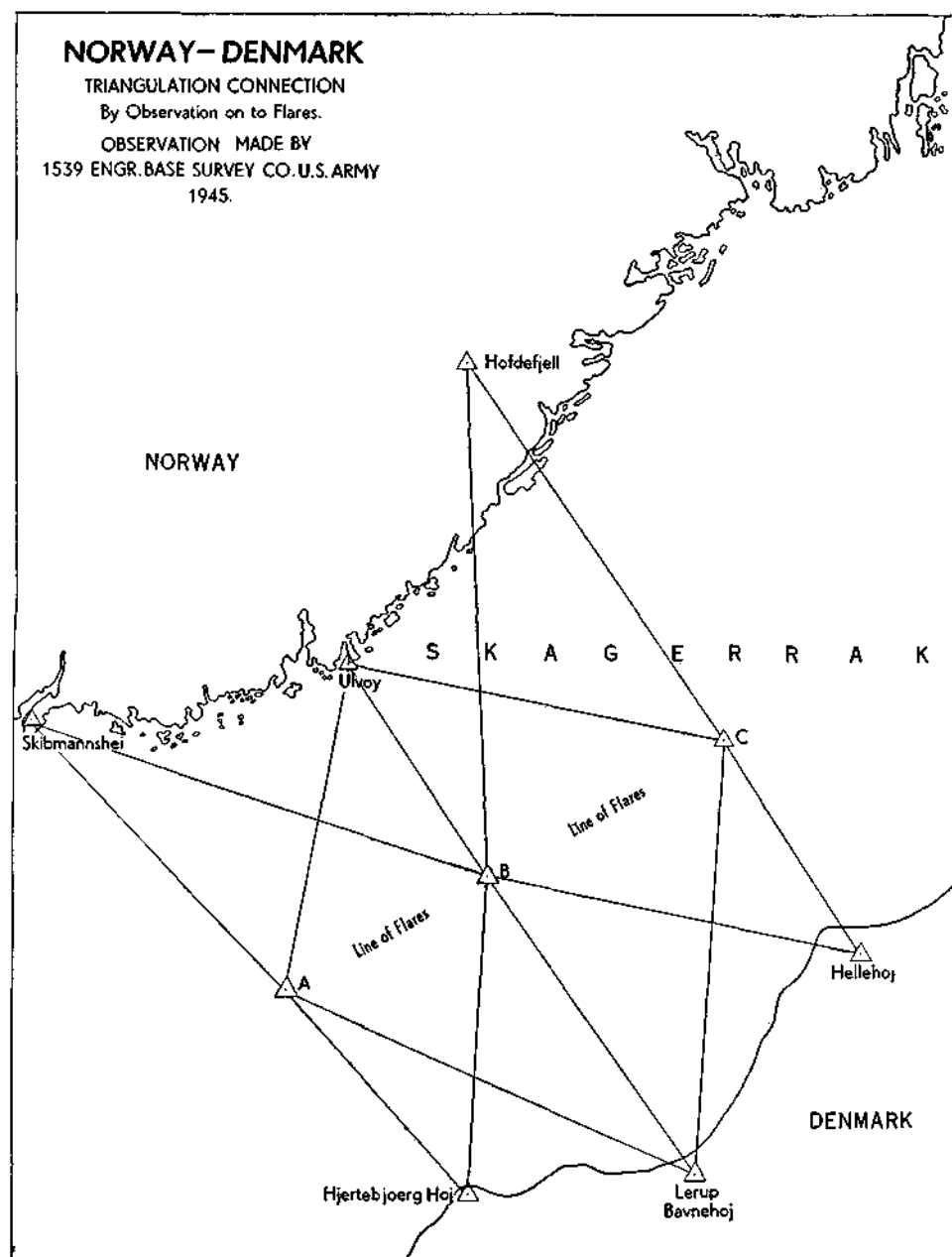
Major Schive of the Norwegian Survey Institute and his staff of observers.

Observing parties from an American Engineer Topographical Battalion serving under the control of Colonel H. Milwit, Chief of Intelligence Division, Office of the Chief Engineer (Com. Z.).

Personnel and radio equipment of the Royal Corps of Signals (21 Army Group). The organization included a centrally controlled broadcast station, with a radio receiving and transmitting station at or near each of the six triangulation stations, three in Denmark and three in Norway.

69 Squadron R.A.F. (2nd Tactical Air Force) with nine Wellington Bombers. This was a night-reconnaissance squadron well experienced in night flying, precision navigation and bombing, all of them valuable assets for the project in hand.

DIAGRAM 11



Detailed plans were drawn up governing everybody's activities so as to minimize the risk of failure, and the success of the operation was due to good organization, and the determined and skilful manner in which all concerned did their job.

Yellow parachute flares, with a candlepower of about 230,000, were dropped at an altitude of about 8,000 feet above the sea at predetermined positions, in a series of successive runs. Warning signals were given by the pilot shortly before the dropping of each flare, and the broadcasting station transmitted radio signals. The trig observers at each station, who were provided with headphones, recorded their simultaneous observations on to the flares when they received the "observe" signal. In some cases as many as four "shots" were observed from any one station on to each flare.

The general arrangement of the triangulation connection is illustrated in Diagram 11. All the observing data were sent to the War Office, only approximate rough computations being made in the field, sufficient to detect any gross errors, and to determine the approximate success or otherwise of the undertaking.

The manner in which the final computations are carried out will no doubt depend on the manner in which it may be decided to deal with the major triangulation systems of western Europe as a whole in order to form a solid homogeneous block.

The success of the project indicates that a similar method might be employed for bridging gaps in existing triangulations where local conditions render it difficult by ordinary ground observations to carry forward normal observations. There are several incomplete meridian and parallel arcs of triangulation which might perhaps be completed by this method. Given good weather, the right equipment, and other conditions, gaps of well over 100 miles could probably be bridged. It is of importance to note that a good system of meteorological information is needed.

A full report of the operation is contained in the publication entitled "Triangulation Connection of Norway and Denmark" (by Lieutenant-Colonel W. E. Browne).

Some comments on field survey practice

It has already been noted that, in order to ensure a reasonable degree of standardization regarding some of the basic fundamentals of field surveys, S.H.A.E.F. published an Operation Policy Memorandum on the subject of "Engineer and Artillery Surveys." It may now be of interest to study the following brief summary of field survey practice, including the important item of co-operation between R.E. and R.A. survey, which was adopted by the British Second Army. There will always be divergent views regarding the ways by which successful co-operation can best be achieved. The personal factor is all important and, without this human touch, the best of plans will run the risk of going wrong.

As a general principle R.E. survey work in Second Army was always kept under the control of the Survey Directorate. Topographical sections were never placed under the command of R.A. Survey Regiments, nor were they attached to them for administration, except on the following two special occasions:—

- (a) In Holland, where two topographical sections were at one time attached to survey regiments for the fixation of forward targets beyond R.A. capacity. This was done after all legitimate R.E. survey work had been finished, and when visibility was so bad that the sections had to be on the spot to seize any fleeting opportunity of completing an observation.
- (b) In the Ardennes, where topographical sections were attached to a survey regiment for administration only because of the distance from company H.Q.

The closest liaison was always maintained with R.A. Survey Regiments whenever survey work by R.E. units was likely to be needed. D.D. Survey kept in touch with operational plans at Army H.Q., but artillery planning was decentralized to corps, and it was the duty of the A.D. Survey (who was responsible for the conduct of field surveys within the army) or the corps survey liaison officer to keep in close touch with the R.A. at corps level. As soon as requirements were known, D.D. Survey decided what work should be done and by which unit.

The unit commander was then briefed by the A.D. Survey, who imparted the intention and plans, but in a broad fashion only, so as not to restrict the unit commander's initiative. The latter normally made contact with the second in command of the survey regiment to find out any special requirements before deploying his sections.

Units were never hampered by having the method to be adopted for any task dictated to them. Technical methods within Second Army were, however, standardized by technical instructions, so that sections from different companies could be engaged mutually on any task, *e.g.* :—

- (a) Observing procedure was clearly defined.
- (b) Computing forms of standard War Office or Second Army pattern were used, and privately constructed forms were forbidden unless approved by the Survey Directorate and ordered for general adoption.
- (c) In order to ensure that nothing should be forgotten, special forms were produced giving instructions to observers and for recording the data required by the R.A.
- (d) Records and results had to be served up on correct forms, in a standardized sequence, and properly clipped together.

In practice, a large number of survey forms were designed by Second Army, and were approved by Survey Directorate, 21 Army Group for use within the Army Group. The War Office forms had been mostly designed for logarithmic computations.

During the war, surveyors found they had to use different methods and types of forms at the Survey Training Centre, in the Middle East, in western Europe and in other theatres. It would appear to be of great advantage if everyone was taught to use the same methods of observation, forms and records.

Some notes regarding the handling of survey units in Second Army and their organization for field survey work are given below:—

PRELIMINARY ACTION

On first indications of an impending battle, a composite 1/25,000 map was prepared to cover the likely area. All trig points were plotted, and the topo-

graphical officers and serjeants were briefed on it and studied it. At a later stage it was used in the "report centre."

Three 15-cwt. trucks were kept loaded with observers' kits ready to move within half an hour from receipt of orders. The remaining topographical stores likely to be required were sorted and boxed into separate observers' kits. Computing equipment and cooking utensils were similarly sorted and kept prepared.

As soon as orders for work arrived from the Survey Directorate, topographical sections were warned and, when circumstances required it, they were despatched to a rendezvous. The company commander, sometimes accompanied by his topographical officers, then visited the survey regiment to obtain final and full information regarding their requirements. Distances were sometimes so great that this visit took a complete day. As the survey regiments were corps troops they were usually able to secure accommodation more easily than independent sections of army troops units. For this reason they often made the accommodation arrangements for the R.E. topographical sections, especially in the winter months when covered accommodation was particularly difficult to find.

If a rendezvous was ordered, it was usually a map spot close to the R.A. report centre, and the time appointed for it was two or three hours after the estimated time of arrival of the R.E. officers at Survey Regiment H.Q. After the meeting one topographical officer made a quick preliminary reconnaissance of the ground, while the other guided the sections to their accommodation.

ORGANIZATION FOR TRIANGULATION

Depending on circumstances, and on the individual wishes of unit commanders, the two topographical sections were either amalgamated into one under the direct control of the O.C., or they worked independently. In the former case both section officers were able to remain permanently in the field. In the latter case the two sections usually worked outwards from a common line, and after about six stations had been reconnoitred, the two officers met to ensure co-ordination, and the six observing pairs were posted to their stations.

For the preliminary reconnaissance each officer usually took one observer complete with truck to assist him, but after the observers had been posted the officer worked alone, using either a despatch rider to send back details of further selected points to be occupied or observed, or returning himself if sufficient points were already prepared to keep the observers busy for some time.

Each observing pair consisted of a surveyor (trig), a surveyor (topographical), a driver, and a 15-cwt. truck. They received their instructions from, and were supervised by, the trig corporal. A despatch rider made a round of the observing pairs, collected observation results, and took them to the report centre after meeting the trig corporal at an appointed rendezvous. This D.R. was either one of the H.Q. drivers, or was borrowed from a reproduction section.

The report and computing centres were in adjacent tents or rooms, as near as possible to the R.A. report centre. No visitors were allowed into the computing centre. At the report centre a medium scale map and a trig diagram were kept up to date to show the progress of the work. A third topographical officer or, if not available, one of the section serjeants, controlled the report and computing centres. He dealt with visitors and supervised the computing.

ORGANIZATION FOR TRAVERSE

If both sections were engaged on one long traverse they worked independently from either end, tying in at the middle.

The section officer usually made the reconnaissance accompanied by an observer. Stations were marked by banderoles, and at each station instructions were given about which points outside the traverse were to be observed as check rays.

The traverse party consisted of six men:—

- 1 forward picket-man for marking and erecting stations.
- 2 observers.
- 2 tapemen.
- 1 rear picket-man, for bringing forward the rear tripod.

The computing centre was sometimes static and sometimes mobile in a 15-cwt. truck, depending on the nature of the ground. Communication with it was by despatch rider as in the case of triangulation.

DATA AND RECORDS

Values, clearly marked "provisional," were given to the R.A. as soon as available. In addition, a report including co-ordinates of the points fixed during the day was supplied each evening, marked either as "provisional" or as "final" list of co-ordinates.

Computing generally kept pace with observing, but the preparation of descriptions and office abstracts was not usually finished until 24 or 36 hours later.

The final records for the Survey Directorate, compiled in accordance with Second Army technical instructions, were not ready for submission until about a week after the finishing of the field work. They consisted of the following documents:—

General information.

- Description of the task, giving full particulars.
- Unit which did the job.
- Dates when job began and ended.
- Short description of the procedure and methods adopted.
- Important technical points for consideration if the job were to be continued or a new one based upon it.

Diagrams.

- A 1/250,000 map to show the area covered.
- A 1/50,000 map to show stations occupied, points intersected, rays observed, etc.
- A tracing, if necessary, in amplification of above.

List of co-ordinates.

Field-work.

- Angle-book sheets in original.
- Field abstract.
- Fair-drawn descriptions.

Computations:—

The "machine" copy.

Computation diary.

Computation index.

Statement of misclosures of triangles (as a check on the unit's classification of points).

ADMINISTRATION OF DETACHED TOPOGRAPHICAL SECTIONS

The transport corporal was detached with the topographical sections. In addition to maintaining the transport in efficient condition, he looked after the general administration including rations, petrol, oil, etc. This freed the technical N.C.O.s for their survey work. The instrument mechanic also accompanied the topographical sections, and was more often than not available to assist in administrative duties.

Wherever possible rations, petrol and oil came direct from Company H.Q. Dependence on other units, which were liable to move with little or no warning, was unsatisfactory, as the section officer then had to make fresh arrangements, thus prejudicing the prosecution of the work. This centralized procedure was, however, a strain on the M.T. resources of the unit because, with the topographical sections out in the field, only the 3-ton vehicles and the utility vehicles remained at H.Q. Experience showed that field parties should be equipped with 4×4 trucks for their work. The jeep, or something like it, proved its worth many times over.

TECHNICAL METHODS

Observing procedure.

Every angle was booked in full.

One round of observations (face left swing right, followed by face right swing left).

A maximum of six observed stations each round.

Rounds closed always to the reference object.

Separate abstracts for each change of reference object at any station.

Vertical angles always observed. Face right and face left observations to follow each other immediately, and to be recorded one above the other in the angle book.

Traversing procedure.

Azimuth observations were taken, when possible, at each eighth or ninth station in addition to check rays. The latter were plotted graphically to enable an error to be ascribed quickly to one leg and observations repeated if necessary.

Computing procedure.

Computations were duplicated by machines working independently. A logarithmic check took too long.

Astronomical observations.

Stars (Polaris) and the sun (hour angle) were used for azimuth observations.

Resection and intersection.

Semi-graphic methods were mostly used. When the number of rays exceeded about eight, or when the trig control was unreliable, the "Thomas" least-square method of computation was used.

It was found that four or five well-placed resections were enough to check 20 or 30 trig points, and to fix six to ten new points by intersection.

SECTION 4. AIR PHOTOGRAPHY FOR MAPPING AND REVISION

Photography in France and Belgium during the 1939-40 B.E.F. operations

In spite of the experience gained during the 1914-18 war, when the technique of mapping from air-photos for military purposes was first developed and proved so valuable, Air Ministry policy during the between-war years did not appear to encourage the use of R.A.F. aircraft or pilots for the specialized form of air photography required for survey purposes. The Ordnance Survey of Great Britain, which required large areas to be photographed for its extensive programme of national mapping, had to depend on commercial flying firms. The effect of this was that, on the outbreak of war, few pilots had had any opportunity of training in the particular technique required, and the aircraft, cameras and other equipment were not suitable for the purpose in view.

It is true that, on mobilization, one flight of No. 53 Squadron (Army Co-operation), equipped with Blenheim aircraft and F-24 cameras (5 inch \times 5 inch) was earmarked for air survey photography as one of its duties but, being part of a normal Army Co-operation Squadron, it was available for other work which might be considered to have greater priority, and its availability for survey photography was at all times uncertain. Apart from this provision no action had been taken to arrange for early and urgent photography in likely overseas theatres where large scale maps were non-existent, where the small scale maps were out of date, and where the advantages of getting the photographs taken early before enemy air opposition became too strong were obvious.

On arrival in France in September, 1939, D. Survey B.E.F. had asked for photography to be undertaken of the concentration area extending from the Belgian frontier westwards to Doullens and St. Pol. The objects of this project were primarily to enable the existing 1/25,000 maps to be revised and some new sheets produced where there were some gaps, but it was also intended to afford training experience to pilots who had no previous experience in this special form of air photography, and to provide training for the survey draughtsmen, many of whom were not well acquainted with the technique of mapping from air-photos. After many delays the photography was carried out, but there was a good deal of wasted time and film owing to faulty navigation.

Owing to the Belgian policy of neutrality it was not possible, during the months before the German offensive, to arrange for systematic photography over Belgium, but limited areas were photographed for intelligence purposes by high-speed aircraft flying at high altitudes, and there were constant missions along the Siegfried Line defences in western Germany. Although not suitable for new mapping these photos were used for defence overprints and for revision purposes.

In anticipation of an allied advance into Belgium in the event of a German offensive, arrangements were made for a programme of photography by the

survey flight of 53 Squadron to take effect from the date on which the B.E.F. crossed the Belgian frontier. The project covered the B.E.F. concentration area along the River Dyle, and westwards from there to the French frontier, with priority given to the successive river lines in between. Most of this photography was completed, and proved to be of great value later when the maps of Belgium were being revised for "Overlord."

When the B.E.F. returned to the United Kingdom in June, 1940, 53 Squadron was transferred to Coastal Command for non-photographic duties, and the special survey flight disappeared. Thus the G.S.G.S., with its increasing responsibilities for providing maps for all possible theatres, was deprived of any special resources for obtaining air-photos for mapping purposes.

The above represents the survey photographic situation for western Europe when, during the early months of 1942, plans were being considered for a return to the Continent, and mapping preparations for such an operation were being initiated.

Photo supply situation from 1940 to 1942

After Dunkirk, when Britain was threatened with invasion, Photographic Reconnaissance Units (P.R.U.) of the R.A.F. were engaged on a big programme of photography largely concerned with the movement of enemy shipping, industrial development, bomb-damage assessment and enemy airfield construction. From the survey point of view these photographs were better than nothing and were, in fact, the only ones available. But intelligence reconnaissance photos are not survey photos, the latter having to conform to certain specifications with regard to the straightness of the runs, scale, overlaps and absence of tilt. They are also required to give complete cover of a specified area, and reconnaissance photography is usually of a patchwork nature. The reconnaissance photos covered only a small part of the area in which G.S.G.S. was interested for its mapping preparations, and were suitable only for a somewhat patchy revision. They were of no use whatever for the production of new 1/25,000 maps of northern France, which were essential for the projected invasion operations.

In April, 1941, a survey officer was appointed to deal specifically with the problem of air-photo supply for survey purposes. He was attached to H.Q., Army Co-operation Command and found that the necessary types of aircraft, cameras and other equipment were not available. Furthermore the Command would not accept responsibility for the provision of special photography for survey purposes.

This situation may have been aggravated by the fact that a particular type of gridded oblique photo, as an aid to artillery technique, was receiving at that time considerable attention, and several squadrons were equipped for photography in connection with this system. The situation was an anomalous one because in any case the system required the use of 1/25,000 maps, and, except for Belgium and Germany, and some very limited areas in the extreme north-east of France, there were no large scale maps available, and air survey photographs were the only possible basic material from which to make them.

For about 12 months no real progress was made regarding policy or action for the provision of survey photography in western Europe, and in the Middle East the Director of Survey was faced with similar difficulties until No. 60 South African Squadron became available from East Africa.

Initiation of the 1/25,000 (Benson) series covering northern France

As part of the early planning in 1942 for a return to the Continent it was decided to initiate the production of 1/25,000 maps of Normandy and other areas in northern France. It will be remembered that the only areas of France which had been mapped by the French on 1/20,000 scale were those along the eastern frontier and those immediately surrounding some of the principal naval bases such as Brest and Cherbourg, and Paris itself.

D. Survey at G.H.Q. Home Forces, by agreement with G.S.G.S., assumed responsibility for this programme, and his first task was to obtain properly flown air survey photos of the area concerned.

140 Squadron R.A.F. and No. 1 Air Survey Liaison Section R.E.

At that time 140 Squadron R.A.F., located at Mount Farm (Benson) near Oxford was employed on photo reconnaissance duties under the operational control of G.H.Q. Home Forces. The operational urgency of the mapping task was recognized and authority was obtained for this squadron to undertake the photography. Seldom was the survey service better served. Though handicapped at first by lack of suitable aircraft for the job, and the absence of previous experience in the particular technique involved, the pilots of this squadron, under the enthusiastic leadership of their then commanding officer, Wing Commander le Mesurier, D.S.O., D.F.C., showed the utmost keenness, gallantry and determination to complete whatever task was asked of them. These tasks included strip photography for mapping, photography for beach-gradient determination, and the photography of potential airfield sites in the invasion area.

To assist in this project, a section of R.E. topographical draughtsmen, which had been formed previously for beach-gradient investigation, moved to Mount Farm in July, 1942, and was located alongside 140 Squadron. Apart from the beach-gradient work which continued, its duties comprised the technical briefing of pilots for the daily survey flights, the plotting of sortie diagrams, and the distribution of photo-prints to the survey units employed on the mapping. In November it was properly established as No. 1 Air Survey Liaison Section R.E., and the happiest relations were at all times maintained with 140 Squadron.

Equipment (aircraft and cameras)

Until the middle of 1943, when it was incorporated in 34 Wing R.A.F., 140 Squadron was equipped with Spitfires (Mark IV and V), and the following cameras:—

		<i>Focal length</i>
Verticals.	K-8 A.B. (Fairchild)	12-inch.
	F-52	36- and 20-inch.
	F-24	5-, 8-, 14- and 20-inch.
Split	F-52	36- and 20-inch.
Oblique.	F-24	8- and 14-inch.

For the first few months of the 1/25,000 (Benson) photography the K-8 A.B. (12-inch) camera alone was used which, at a flying height of 25,000 to 30,000 feet, gave pictures on a scale approximating to that of the finished map. At this large scale, which was admirable for detail interpretation, a large number

of runs and individual photographs was required to cover a given area. At a later date, in order to meet the requirements of the American topographical units with their Multiplex plotting apparatus, K-17 6-inch cameras were used, either alone or accompanied by a 12-inch camera. This provided a more economical coverage.

The aircraft were unarmed, and depended on their high performance for evading enemy opposition. With no observer, the pilot had more than a full-time job trying to keep on his straight photographic course, while keeping an eye open for hostile aircraft and controlling his camera. The Spitfire was in many ways unsatisfactory for this task.

In July, 1943, 140 Squadron was incorporated in 34 Wing R.A.F. and was re-equipped with Mosquito IX aircraft. Eight of these were adapted to take two vertical cameras, one K-17 6-inch and one K-8 A.B. 12-inch. As the Mosquito carried a crew of two, it was well suited for survey photographic work. It had high performance and a good range, the observer was able to assist in navigation, and he was also able to keep an eye open for enemy planes and look after the cameras in operation.

Photographic programme for the 1/25,000 (Benson) series

The area of northern France, over which 1/25,000 maps were required in the first place, extended westwards from a north-south line joining Calais to Paris. This included the coastal district of the Pas de Calais, the whole of Normandy as far south as the R. Loire, and the Brittany peninsula. To conform with the invasion plan which was being developed, this area was divided into three priority sub-areas, and the dates of the beginning and the completion of the photographic sorties were as shown below:—

First priority:—Comprising the Pas de Calais coastal zone and the Normandy invasion assault area to a depth of about 60 miles.

Photography begun	24th July, 1942.
Photography completed	16th September, 1942.
Number of sorties	210

Second priority:—Covering the Brittany Peninsula.

Photography begun	16th September, 1942.
Photography completed	14th April, 1943.
Number of sorties	77

Third priority:—Extending the first priority area southwards to the R. Loire.

Photography begun	15th April, 1943.
Photography completed	17th August, 1943.
Number of sorties	55

The above summarizes the R.A.F. contribution to the "Benson" mapping project. On the arrival of photographic squadrons of the U.S. Army Air Force arrangements were made for them to take a share in the work.

Photography for the determination of beach gradients. (See also Chapter XIV, Section 10.)

In January, 1942, Survey was asked to assist in the problem of determining the gradients of enemy beaches. It was decided, as a first measure, to carry

out experiments involving the photography of selected beaches in the United Kingdom. The horizontal distances between the water-lines at various stages of the tide could be measured on vertical photographs taken at predetermined intervals, and differences in tide heights computed from tide-tables. The experimental results proving satisfactory, a programme of photography along the beaches of northern France was drawn up. For the intricate problem of examining the photographs and measuring up the water-line distances a section of about 12 R.E. draughtsmen was formed. The section officer prepared the timed sortie programmes and briefed the pilots for each flight. Work was begun on 30th April, 1942, the section later moving down to Mount Farm (Benson) where it received establishment status as No. 1 Air Survey Liaison Section R.E., already referred to above.

The photography was shared between 140 Squadron R.A.F. (Benson) and a Photo Reconnaissance Flight based at St. Eval in Cornwall. The technique consisted of photographing the beaches at high and low spring tides and at four uniformly intermediate periods. With the vagaries of the weather, the need for meticulous timing, the necessity for fitting in with other R.A.F. operations in the same areas, and the preservation of security, it can well be imagined that the completion of the necessary sorties over any particular beach was a difficult and sometimes a lengthy job.

Flying began on 6th May, 1942, and was completed on 12th May, 1944. By "D"-day (6th June, 1944) a total of over 200 different beaches had been photographed and their gradients determined. This involved a total of close on 500 sorties of which nearly 380 were flown by 34 Wing (140 Squadron) and the remainder by the squadron at St. Eval. To the former were allotted the beaches between Flushing and St. Malo, and the latter extended the photography along the Brittany coast to the vicinity of St. Nazaire.

In addition to the water-line method some determinations were made by the measurement of wave velocities from air-photos. This involved about 20 sorties during early 1944.

Photography of potential airfield sites

The rapid development of landing strips and airfields in the invasion area after the assault landing was clearly going to be a matter of vital importance. This produced a demand for air surveys of potential sites from which plans could be worked out for the engineering and other work that would be required. The technical aspects of this problem as they affected Survey are dealt with in Section 5 of this chapter.

Mapping photography over north-western France by the U.S. Army Air Force and U.S. policy in connection therewith

When Brigadier Hotine (Director of Military Survey, War Office) visited Washington in May, 1942, to discuss allied mapping problems with the topographical authorities of the War Department (*see* Chapter IV), he asked them to assist in the early preparations for "Overlord" by sending over an officer experienced in modern photogrammetric methods, and the necessary technical personnel to help in the production of 1/25,000 maps from air photographs. The War Department agreed to do this, and agreed also to arrange for the early provision of mapping squadron aircraft.

Colonel H. Milwit (Corps of Engineers) arrived in the United Kingdom

in June, 1942, and, after acquainting himself with the current mapping situation, he drew up a memorandum for his Chief Engineer (E.T.O.U.S.A.) on the mapping problem as he saw it. In this memorandum he described the methods being used by the R.A.F. for obtaining survey photographs, pointing out that, although they might be suitable for the mapping technique at that time being employed by British survey units, they could not be used in conjunction with the Multiplex stereoscopic apparatus with which the U.S. Engineer Topographical units were equipped and for which their personnel was being trained. He urged that, as weather conditions suitable for mapping photography could not be expected after September, immediate action should be taken to provide photographic aircraft in the European theatre equipped with K-17 (6-inch wide angle lens) cameras of the type necessary for Multiplex mapping, with K-18 (24-inch) cameras additional for obtaining larger scale photos required for interpretation of detail and for making up mosaics and photo-maps. He recommended that one photo-mapping company of a G.H.Q. topographical battalion, and one army topographical battalion, should be scheduled for arrival in the United Kingdom not later than mid-August. The Chief Engineer (E.T.O.U.S.A.) endorsed this proposal, which was agreed to by the War Department, who stated that four B-17 aircraft, complete with crews and camera equipment, would be despatched to the United Kingdom for air survey photography. They duly arrived but, before they could be employed on any survey photographic missions over France, they were transferred to North Africa for service on operation "Torch." This was unfortunate, as it meant that the American topographical units in the United Kingdom had no air photographs suitable for use with their Multiplex map plotting equipment. They had therefore to use R.A.F. photographs taken with the 12-inch Fairchild cameras, and they were allotted blocks of sheets in the 1/25,000 (Benson) project.

Company B of 660 Engineer Topographical Battalion, to whom were allotted these blocks of 1/25,000 sheets in the Cherbourg and Caen areas, received the photographs from the British Air Survey Group together with the necessary horizontal and vertical control data. They used the slotted template method of establishing further control, and employed vertical reflecting projectors for plotting the planimetry. The resulting map, as in the case of those sheets produced by the British survey units, was of reasonably high accuracy, and entirely adequate for the purpose in view. It cannot be doubted, however, that the compilation would have been easier and quicker if K-17 (6-inch) photos had been available for use with the Multiplex plotters.

There was no further action regarding photography by American aircraft till January, 1943, when Colonel Milwit again raised the matter with the Eighth U.S. Air Force. The Commanding General indicated his interest and desire to assist in the production of the required survey photography.

Meanwhile, in January, 1943, a conference was held in London, attended by British and American representatives, to discuss future mapping programmes and the air survey photography required in connection therewith. At that date the R.A.F. photography of the first-priority areas including the coastal districts of the Normandy invasion area, was nearing completion, and the Brittany peninsula had been started. Spitfires had been used for this work, and with their limited range it was not anticipated that much additional photography outside those areas could be obtained. It was also clear that the preparation of 1/25,000 maps in the Normandy area could not be completed till the end of 1943 at earliest. The British recommendation was that it was

neither necessary nor desirable to duplicate the photography already obtained by the R.A.F. over Normandy and north-eastern France, and that any photography by American aircraft which might become available should be concentrated outside that area. After due consideration of all the factors involved it was decided that the first priority for American mapping photography, when available, should be the Brittany peninsula, followed by the Atlantic coastal area of western France extending southwards from Nantes.

On 22nd June, 1943, No. 13 Photo Squadron flew its first mission using Lockheed Lightning aircraft fitted with K-17 (6-inch) cameras. During the remainder of 1943 this squadron successfully completed Multiplex photography over more than 10,000 square miles without loss.

It was found, however, that the Lockheed Lightning was not the proper answer to the mapping problem, as it was difficult for the pilot of a single-seater aircraft to maintain accurate flight lines, manipulate his cameras and keep his eyes open for hostile aircraft. This confirmed the experience of the R.A.F. using Spitfires, and was one of the reasons why the latter were replaced by Mosquitoes with a crew of two when they became available.

Once started, the programme for covering the Brittany peninsula, the French western seaboard, and other probable operational areas in northern France went ahead quickly and enabled the 1/25,000 (Benson) mapping, and also an extensive photo-map project, to be completed just in time for "D"-day.

In December, 1943, an effort had been made to insure against the diversion of American photographic aircraft from mapping missions, and a request was made that certain photo squadrons should be assigned for the sole purpose of obtaining mapping photographs. A conference on air-photo requirements was convened by the Commanding General E.T.O.U.S.A. late in December at which, although there was some adverse comment regarding the small amount of air photography being provided for the theatre, there were protests from other quarters against the diversion of tactical aircraft to photo missions. The Engineer of 12 U.S. Army Group and Colonel Milwit stated at this conference what aircraft were needed to provide the necessary mapping photography.

The theatre commander directed that action be taken to provide two mapping squadrons for the theatre. The air force representatives, however, did not wish to allocate squadrons for the exclusive purpose of securing mapping photography for the topographical engineers, and continued to present arguments against such action, coupled with an assurance that all mapping requirements could and would be handled by the existing organization without the need for allocating special squadrons. The theatre commander thereupon reversed his decision.

At that time, as previously described, considerable effort was being applied to photography for the 1/25,000 mapping and revision projects in western Europe, but there was always the fear that conflicting requirements, especially after military operations on the Continent had started, would cause mapping photography to be sidetracked, and the aircraft switched over to other duties. This anxiety was confirmed by later events when, in spite of their commitments for providing the mapping photography required, the entire air photographic resources were employed on intelligence reconnaissance missions during the vital period of good weather between June and September, 1944. The urgent map-revision project for Germany and a new mapping programme to cover an unmapped gap in Bavaria with 1/25,000 maps suffered from the

delay, and all subsequent efforts to catch up were hindered by bad weather and other factors until the latter part of April, 1945, when it was too late.

With a view to the consideration of future requirements, it may be of interest and value to quote the following extracts from a report written by the Engineer 12th U.S. Army Group in May, 1945:—

“In spite of the great importance of maps, the basic mapping photography required for their production has not been adequately provided in this theatre. Mapping photographic projects laid on as early as March, 1944, had not been completed by March, 1945. One project covering a gap in the Bavarian map series was laid on in September of 1944. In March of 1945 only 50 per cent (approximately) of the area had been covered. The failure of the air forces to prosecute mapping photography made it impossible for topographic units to revise the operational maps of much of Germany east of Kassel. Fortunately the advance of our troops was so rapid that large scale maps were not absolutely essential. Had the situation been otherwise, serious repercussions from the field forces would have been felt.

“The Corps of Engineers had long advocated that a certain number of squadrons be earmarked for mapping purposes only. Heretofore the air forces have always insisted that such an earmarking of squadrons was unnecessary and uneconomical and that mapping photography could and would be procured when required. Experience has indicated that such is not the case.”

Although noting the above adverse comments regarding the prosecution of systematic mapping photography, it must be recorded that a great amount of 6-inch (K-17) Multiplex photography was undertaken by American photo squadrons, especially those of 7th Photo Reconnaissance Group. By the close of hostilities practically the whole of northern France, Belgium, Holland and a large part of Germany west of Berlin had been covered. There were, however, many gaps, and much of the photography was too late for use on mapping projects required to keep pace with military operations. Supplementary partial cover was also obtained with 12-inch and 24-inch focal length cameras which was of much value for interpretation purposes.

Western Austria was also covered by 6-inch photography flown by the Provisional Reconnaissance Group of Ninth Army Air Force for the purpose of compiling new 1/25,000 maps of that area.

The control of mapping photographic programmes overseas

In 1942, when the 1/25,000 (Benson) mapping project was started, the photographic programme was drawn up by D. Survey Home Forces, and later controlled by D. Survey 21 Army Group when the latter formation was made operational. Early in 1944, when S.H.A.E.F. and the Headquarters of the Allied Expeditionary Air Force (A.E.A.F.) were established for the command and control of allied ground and air forces for “Overlord,” the responsibility for the organization of mapping photography for the theatre as a whole devolved on the Director of Survey (S.H.A.E.F.).

The advent of American resources in photographic squadrons and topographical units, made it essential that D. Survey (S.H.A.E.F.) should maintain the closest liaison with Colonel Milwit, who was the technical head of the U.S. topographical organization within the theatre. With his co-operation speci-

fications and areas of priority for the photographic programmes were drawn up and submitted through G-2 (S.H.A.E.F.) to H.Q. A.E.A.F. (later S.H.A.E.F./Air), who made the necessary arrangements for the photography to be undertaken by photo squadrons under its control overseas or by units in the United Kingdom.

For "Overlord" the British 2nd Tactical Air Force (T.A.F.) operated with 21 Army Group, and units of the Tactical Air Forces of Ninth U.S.A.A.F. operated with American forces in the field. These air forces included photo squadrons which undertook local missions to meet their own army group and army photographic requirements, mainly for intelligence purposes. In 2nd. T.A.F. was 34 Wing, operating directly under H.Q. 21 Army Group. In this wing was 140 Squadron which, it will be remembered, had produced so much photography of northern France which was used for the 1/25,000 (Benson) map series. 21 Army Group Survey was therefore able to arrange for any specific local missions of mapping photography which were required. Examples of this included the photography of the Seine and Somme defence positions for large scale mapping, the Frisian Islands for their re-mapping, and certain beaches off the German and Dutch coasts for beach-gradient determination.

Speaking generally, however, the mapping photography of western Europe for revision and new mapping on a theatre basis was controlled centrally from S.H.A.E.F. through the Air Staff, with close co-operation from Com. Z. This undoubtedly led to a prevention of duplication and overlap.

Army groups and armies frequently found it desirable to make use of large scale intelligence photos to assist in detail interpretation during their revision and mapping projects, and for this purpose they made considerable use of photography obtained by squadrons under their control. To keep those concerned in the picture with regard to the progress of the theatre photographic programme, reproductions of basic photo-cover diagrams, prepared by Com. Z. on 1/250,000 sheets, were regularly circulated. The photographic library of the Central Interpretation Unit (C.I.U.) at Medmenham was also a valuable source of photographic data.

SECTION 5. RECONNAISSANCE SURVEYS OF POTENTIAL AIRFIELD SITES

Requirement

When planning for "Overlord" one of the principal factors under consideration was the question of air-support for operations subsequent to the assault landing on the Normandy coast. The distance from existing airfields in southern England to the operational area was such that fighter aircraft based on those airfields would have a very limited operational period over the battle-zone owing to the petrol consumption involved during the outward and return journeys. It was essential therefore to establish landing grounds and airfields overseas as early as possible.

To save time on reconnaissance after landing, and to be able to make all possible preparations beforehand regarding the engineer work which would probably be required, it was decided to try and determine the most suitable locations for the landing strips and airfields from a study of existing maps and air photographs. The Director of Survey Home Forces was asked to assist in this work and to prepare detailed maps of the sites.

The specified requirement was for a large scale contoured map of each selected site which would show all relevant natural and artificial features. Along each provisionally selected runway spot heights were needed at close intervals, so that gradients could be determined and estimates made of the amount of excavation and filling likely to be required.

Research

It was in December, 1942, that this project was formulated and, at that time, the mapping company of the U.S. 660th Engineer Topographical Battalion had recently arrived in the United Kingdom with its Multiplex plotting equipment. It was installed at Kew and was working in close liaison with the Director of Survey Home Forces. The plotting of detail and height determination from air-photos by Multiplex offered possibilities of obtaining the required standard of accuracy.

As a result of discussion between British and U.S. survey officers, it was decided to conduct tests from which to draw up specifications for air photography, and to decide on the best method of plotting from the photos. This test was carried out over a specially surveyed area so that a comparison could be made between the results obtained by photogrammetric methods and those obtained from a ground survey in which all facilities existed for getting a correct answer. Photographic sorties were flown at 6,000, 9,000, and 12,000 feet, using a K-17 (6-inch) camera, and test sheets were compiled at scales of 1/5,000, 1/7,500, and 1/10,000. As a result it was agreed that Multiplex compilation was the best method because of its speed and accuracy. It was agreed also that the plans should be at 1/10,000 scale, with contours at 5-foot vertical interval, and spot heights covering the runway areas at intervals of 100 metres.

Procedure

The provisional sites having been selected by the planning staffs from 1/50,000 maps and reconnaissance photos (the 1/25,000 maps had not at that early date been produced), their locations were notified to D. Survey, who instructed his Air Survey Liaison Officer to lay out the necessary flight lines and to brief the pilots for their sorties. Photography was undertaken by the Photo Reconnaissance Unit at Benson which used Mosquito aircraft fitted with K-17 (6-inch) cameras. The flight lines were laid out so as to embrace as many sites as possible in one sortie, and steps were taken to provide security cover. The aircraft flew over the Channel and the French coast at 30,000 feet, then dived to 12,000 feet for the photographic run, and so home. Prints of the sorties were made at once and sent to the mapping company who determined their acceptability. If acceptable, as was the case for over 90 per cent of the flights, prints and the original negatives were delivered to the unit within 24 hours. Occasionally, it was necessary to re-fly a sortie owing to poor photography, or because some vital points of control had been missed. Co-operation between the U.S. mapping unit and the R.A.F. was excellent.

Provision of "control" for the compilation offered a difficult problem. For the planimetry, use was made of enlarged detail from the French 1/80,000 map, and selected triangulation points whose co-ordinates were known. For heighting and contouring it was necessary to depend on spot heights shown on the French maps where these could be related to specific points of detail. Fortunately at the northern end of the Cherbourg peninsula there were available

some French 1/10,000 and 1/20,000 maps whose standard of accuracy was high, and these gave excellent control both for plan and heights.

To attain the highest degree of accuracy when using the Multiplex plotting apparatus, and to eliminate the human factor as much as possible, double sets of projectors were set up, and the work of compilation was duplicated, with special reference to the determination of heights which were of such vital importance. When fair-drawn the manuscripts were handed to the Director of Survey, who had them reproduced and printed in colour. Upwards of 120 sites were surveyed in this fashion. (See Diagram 12 and Plate 55.)

SECTION 6. MAP SUPPLY AND DISTRIBUTION

Issues for the assault and early build-up

(a) ASSEMBLY OF BULK MAP STOCKS IN THE UNITED KINGDOM

As the maps for "Overlord" came off the printing presses they were assembled, under War Office control, in four map depots located at Aldershot, Reading, Towcester and Oxford, the first three of which were manned by War Office personnel. The Oxford depot, being for American use, was manned by American personnel. These stocks included large, medium and small scale topographical maps of potential operational areas on the Continent. The Director of Survey (S.H.A.E.F.) kept himself fully informed of the progress of this assembly, and copies of the weekly map stock reports were sent to him.

The flow of maps into the four depots was regulated at No. 8 War Office Map Depot (Hygrade) where the maps passed through various stages of preparation for easy use and handling, and for the safeguarding of "security." They were first rolled in bundles of 50 (with a proportion in bundles of 20 and 10), and were wrapped and labelled, the series and sheet numbers being shown in code. The rolls were then made up into bales of 10 rolls each which were wrapped in hessian material, firmly secured, and then stencilled on the outside with the coded detail of the contents.

(b) PRE-ASSAULT MAP DISTRIBUTION TO BRITISH FORMATIONS

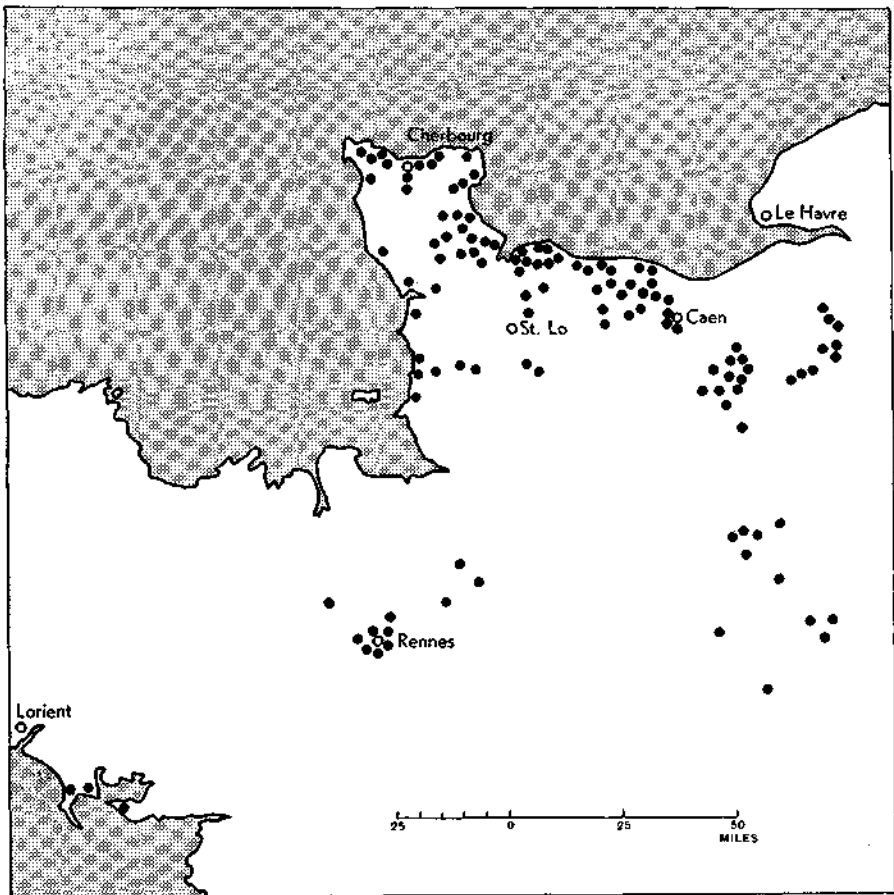
General procedure. S.H.A.E.F. Survey Directorate did not take any direct part in the actual distribution of maps for "Overlord." A training exercise was carried out under 21 Army Group control in connection with various matters concerning the concentration, assembly and embarkation of the assault troops as a result of which plans were drawn up for the issue and distribution of maps to the invasion troops. For the British force detailed arrangements were made between 21 Army Group, Second Army and the War Office. In the case of U.S. forces taking part in the assault, arrangements were made direct between U.S. First Army and the Chief of the Engineer Intelligence Division (O.C.E.) E.T.O.U.S.A., who worked in close touch with D. Survey (S.H.A.E.F.) and the War Office Survey Directorate. The arrangements for assault issues, as will be described below, involved the setting up of a number of special map depots in southern England, and the preparation of a detailed organization for issuing the maps. The successful operation of the map issue plan reflected great credit on all those who planned and carried out the task.

Initial map issues (Second Army). The problem was rendered difficult and complicated by the paramount need for "security." It was ruled that

DIAGRAM 12

SURVEYS OF POTENTIAL AIRFIELD SITES

Location diagram for the Invasion Area



Airfield Sites in Northern France

no maps were to be opened before the expedition had sailed, except by those personnel already briefed during planning.

As stated above, maps supplied by the War Office were in sealed packages, labelled in code. It was, of course, necessary to brief the assault troops for their tasks, and this was done in the marshalling areas on special "security" maps which Survey, Second Army, had prepared. These maps showed correctly the main topographical features, but they carried false names and other devices for disguising the actual location of the assault beaches.

This security aspect applied most vitally to the actual assault troops and the early build-up. For these troops (*see below*, categories A, B, and C), all maps were issued in sealed parcels, with contents marked in code. All lists and schedules were also in code, so that neither the actual issuing staffs in the map depots nor the recipients knew what maps were being issued. Each self-contained unit or detachment which embarked as an entity was given a separate and unique List Index No., and as each of these passed through the marshalling area it collected its own map bundles. There was no difficulty with regard to 8 and 12 Corps who were not due to land until between "D" + 8 and "D" + 12, and they drew their maps in sealed bulk 12 days ahead of their landing dates, for distribution to units from "D"-day onwards. In the case of the R.A.F. also there was no difficulty, as their normal operational stocks already covered the area.

For issue purposes the Force was divided into four categories:—

Category A. Troops embarking in pre-allocated ships.

Category B. Other troops landing up to "D" + 5 (inclusive) who would therefore leave their concentration areas from "D" - 1 to "D" + 2.

Category C. Troops landing from "D" + 6 to "D" + 12.

Category D. Troops landing from "D" + 13 onwards whose concentration areas could not be decided until well after "D"-day.

Category E. Special troops such as "Phantom."

Each category required different treatment as under:—

Category A. The corps concerned drew maps in bulk about "D" - 14. Using personnel already fully briefed, bulk was broken into craft or ship bundles, which were delivered to the O.C. troops of each craft or ship in the marshalling area. Bundles were included for any army troops units who were to sail in pre-allocated shipping. *The maps were not to be opened until after sailing.*

Category B. Troops in this category drew maps according to their List Index No. from the map depots in the marshalling areas. Headquarters of corps drew maps in bulk about "D" - 14 and prepared a bundle for each relevant "List Index No." entitled to draw maps. These bundles were returned, with a list of contents in code, to specified map depots in the marshalling areas. The "List Index Nos." collected their own bundles on passing through the marshalling area.

Army troops, formations, such as A.A. brigades and others, who were in a position to do so, had their maps bundled for them and collected them, as in the case of corps troops.

Category C drew maps, in accordance with a prearranged time-table, from map depots in concentration areas on "D" + 1.

Category D drew maps from map depots in concentration areas as soon as possible after "D" + 2.

Category E drew maps when required from the map store at Main H.Q. 21 Army Group by arrangement with Survey Directorate. Issues were "Top Secret."

Detailed arrangements. A small map depot was established in each of the six marshalling areas and eight concentration areas. Each was commanded by an officer borrowed from the Survey Training Centre R.E., and was manned by personnel from Home Forces survey units. Groups of two to four depots were commanded by a "map subaltern," and they in turn were commanded by a "map captain" who was attached to and located at Second Army Survey Directorate. As a precaution against the destruction of any of the depots by air action a small mobile map depot was held in readiness.

The depots were stocked by the War Office from their main assembly depots about six weeks before "D"-day in accordance with requirements estimated by Second Army. It soon became apparent that the proportion of small rolls (20s and 10s) was insufficient, and the large number of very small detachments who required between two and five sets of maps only made it necessary to break down a quantity of maps into rolls of two maps each in order to avoid waste.

Each formation or unit was provided with a "map issue schedule" showing in detail what it had to draw. Where possible the depot from which, and the time at which, they were to draw was also stated. In some cases it was possible to say only—"from your marshalling (or concentration) area depot on arrival in the area." A duplicate copy of the "map issue schedule" was sent to the relevant depot (and to other relevant depots if the exact one was not known), and also to the Survey Directorate.

There was one major difficulty foreseen which applied to "List Index Nos." in Category B for whom pre-bundling had been carried out. Movement Control could not say with certainty, until 24 hours in advance, into which marshalling area any particular "List Index No." would go, and therefore any individual bundle might easily be in the wrong depot. The following arrangements were therefore made:—

Each marshalling area depot was provided with a "forecast of movement" which enabled the preliminary marshalling of bundles to be arranged in that particular depot which would most probably be the correct one, and also with a "force movement table" which showed the firm movement plan for the following 24 hours. This enabled a final marshalling of bundles to be carried out if any change was necessary.

Each depot was provided with a 15-cwt. truck.

Two liaison officers from units in the late build-up were attached to each marshalling area depot to make sure that units drew their maps correctly. They each had a 15-cwt. truck.

The camp commandant of each marshalling area headquarters was instructed to tell every unit, when reporting to him on arrival, how to obtain their maps.

The operation of the pre-assault map issue plan. As might be expected things went wrong on occasions and difficulties arose which had to be straightened out but, on the whole, the arrangements worked well.

The Second Army planning programme had been governed by a schedule or time-table. In this schedule consideration of map requirements appeared too low down and was, in fact, one of the last items. There was, in consequence, considerable delay before it was possible to reach a reasonably firm conclusion about the numbers of the various maps required. Although appreciating how difficult it was for formations to state what maps they required before their other plans were cut and dried, the delay made it difficult for Survey to place its printing orders and then get the right numbers of the right maps assembled ready for a complicated issue plan.

Some of the formations in Category A failed to inform all their assault units that they would find their maps ready for them in the ships. As a consequence many units went along to the map depots without any "map issue schedules" and demanded maps. A great deal of unnecessary work was caused in checking up that they were in fact Category A troops.

A few units in Category B started to reach marshalling areas before "D"-day, contrary to the information originally conveyed to the Survey Directorate. Maps had, in consequence, to be issued before "D"-day, and the risk of units disobeying orders and opening their map bundles had to be accepted.

Some units in Category C moved from their concentration areas before "D"-day contrary to the original plan of Movement Control. Thus they had to draw their maps from marshalling area depots instead of concentration area depots as planned.

A few units in pre-allocated shipping were reported as having no maps on board, and special arrangements had to be made to issue them with suitable quantities. Similar *ad hoc* arrangements were made for about half a dozen ships which were added to the original concentration at the last moment.

One of the corps omitted all its formation map lorries from its list of requirements for embarkation, so one of the bulk consignments belonging to the Army Field Survey Depot had to be broken in order to make good the deficiency.

One unit, required for early armoured reconnaissance duty, landed in France with insufficient maps for their role owing to the fact that their corps had not demanded enough maps for them. The deficiency was made good by the timely arrival overseas of the Army Field Survey Depot stock.

At 0100 hours on "D"-day a staff officer at H.Q. 21 Army Group informed A.D. Survey that a divisional headquarters had left its maps behind! A.D. Survey obtained the code numbers and other details of the maps concerned and the maps were drawn from a map store in Essex and sent by truck under escort to Southend. They were taken to the end of Southend pier and loaded on to a Naval launch from which they were delivered to the forgetful headquarters in mid-Channel.

In a complicated map distribution plan such as this it will be realized how essential it was to ensure the closest liaison between Survey, the General Staff, Movement Control, and all those others who were concerned with the vital task of seeing that the troops who embarked on their various craft were in possession of everything necessary for the successful carrying out of the operation.

(c) INITIAL MAP ISSUES TO AMERICAN ASSAULT FORMATIONS

Map depots in the United Kingdom. By agreement between the War Office and the War Department, Washington, the former was responsible for providing initial bulk stocks of maps required by U.S. Forces for the early stages

of "Overlord." It was estimated that this provision should extend till about "D" + 90, by which time it seemed probable that direct communication would have been opened up between the United States and French ports. American forces would then assume responsibility for the provision of their own bulk map supplies. In accordance with this programme one of the four main War Office map assembly depots (that at Oxford) was handed over to American control. This depot was stocked with bulk consignments, printed under War Office arrangements, in accordance with a stocking programme which was agreed between D. Survey (S.H.A.E.F.), the Map Distribution Section of the Survey Directorate (War Office) and Colonel Milwit the Chief of the Engineer Intelligence Division (E.T.O.U.S.A.).

This Oxford depot (No. 5), together with another (No. 6) located at Lockerly in Hampshire, were scheduled as Base Map Depots for the assault issues. Two other depots, No. 1 at Cheltenham and No. 4 at Swindon, were scheduled as Transit Map Depots. In addition, nine Marshalling Area Map Depots (M.A.M.D.s) were formed.

The development of the distribution scheme. As plans for the operation became firm, Colonel Milwit, in December, 1943, discussed with the Engineer, First U.S. Army (F.U.S.A.) the formulation of a policy to govern map distribution to units of F.U.S.A. taking part in the assault and follow-up under 21 Army Group control. The policy suggested to the First Army Engineer was that the Chief Engineer (E.T.O.U.S.A.) would supply all necessary maps and transportation, as well as any additional personnel who might be required to effect a detailed breakdown of map stocks for the troops concerned. It was proposed that responsibility for the ultimate breakdown and supply of maps to units and to individual craft should rest with the Army Engineer.

The Engineer (F.U.S.A.) disagreed with this proposal. He maintained that the Services of Supply (S.O.S.) should do the entire job of breakdown and delivery of maps to all units in accordance with an issue plan to be made up by formation Engineers. His argument was that, as S.O.S. was handling all embarkation arrangements, including the assignment of troops to craft, it would be more practical for them to handle also the mapping-up of the assault troops. This threw the entire responsibility back on to E.T.O.U.S.A. This meant that the Chief Engineer would have to be completely informed on operational plans at the earliest possible moment, with all essential information regarding craft loading, including times and points of departure.

Discussion and argument about detailed procedure continued until April, 1944, and the preservation of security presented, as usual, a most difficult problem in working out map issue plans. Finally at a conference held on 14th April, 1944, attended by representatives of the Chief Engineer, the Southern Base Section (S.B.S.), and the Engineer (F.U.S.A.), agreement was reached on the procedure for effecting distribution to the assault units.

The Engineer (F.U.S.A.) was made responsible for preparing detailed map issue lists in code, showing exactly what maps were to be issued to each unit and detachment. The Southern Base Section, which was administratively responsible for the organization of camps in the marshalling areas, indicated which were the camps in which the various units would be marshalled, and which marshalling area map depots would serve individual camps. The detailed issue lists were grouped by camps and marshalling depots so that the Chief

Engineer was able to stock each depot properly and make up bulk orders to fill the requirements of each camp.

In each camp was established, under the control of the static force commander, a camp map depot (C.M.D.) to receive the bulk maps in coded rolls for distribution to individual units within the camp. The mounting plan contemplated that the briefing of assault units would be held before maps were broken down into craft loads. This meant that maps had to be available before briefing time. Unlike the British Second Army, F.U.S.A. did not make use of special "security" editions for briefing purposes. It was arranged, therefore, that the camps would be sealed as soon as the coded bundles were opened. The Engineer (F.U.S.A.) submitted approximately 3,500 detailed map requisitions for units scheduled for the assault, follow-up and build-up. These were received by the Chief Engineer about the middle of May, and the task of breaking them down took one week.

All maps for assault units scheduled for "Omaha" beach were delivered to the marshalling depot at Dorchester, and those for assault units destined for "Utah" beach were placed in a marshalling depot at Totnes. The maps required for follow-up units from "D"-day to "D" + 3 were delivered to a depot at Truro, where Southern Base Section assumed responsibility for further breakdown and delivery.

The requisitions covering units in "pre-loaded build-up tables" were tabulated, and the proper quantities of maps were placed in the nearest marshalling depot, from where they were delivered to the camp map depots. This breakdown took into account the movement of units into camps and areas where they were briefed before being assigned to definite craft.

In general, units scheduled for arrival on the Continent up to "D" + 15 were supplied with all scales of maps for their initial missions, and small scale maps only for missions beyond "D" + 15. Units scheduled for arrival after "D" + 15 were given only maps on 1/250,000 scale and smaller. Larger scale maps were issued to them when their missions had been determined.

Security. Maps were under guard at all times before issue, and all consignments from depots to camps were convoyed by an officer and armed guards, with one guard riding on the actual load to see that nothing fell out on the road. When any coded rolls were opened, all personnel were segregated under strict security control until the lifting of security was authorized. Every issue of maps was made from one officer to another only after proper identification had been established.

Comments. The following were some of the principal factors which complicated the problem of map distribution to U.S. units in the marshalling areas:—

- (i) The late receipt of requisitions from F.U.S.A.
- (ii) The necessity for building up an organization for the preparation and breakdown of stocks and the actual distribution, a task for which there had been no precedent on such a vast scale, and for which few of the personnel employed had any previous experience.
- (iii) A natural confusion caused by the movement of large numbers of men and vehicles in a restricted area.
- (iv) The stringent security measures which had to be maintained.

During the assault phase, the initial map issues for F.U.S.A. involved approximately 1,350,000 maps. Generally speaking, the distribution pro-

cedure worked well despite the many problems that were encountered. It was reported that units arriving overseas between D"-day and "D" + 3 were well mapped, but in the case of some units arriving after that date, and who had been in the marshalling areas for too short a period to secure their maps, they reached France inadequately supplied.

Considering all the possibilities for leakage, the preservation of "security" left nothing to be desired.

Initial build-up of British map stocks overseas

With corps and divisions. The attachment of sub-sections of 3 (Army) Field Survey Depot R.E. with racked map lorries to the headquarters of corps and divisions enabled the assault formations to take with them a limited supply of maps in addition to those which had been issued to them in the marshalling areas. These lorried maps comprised a small reserve stock of the immediate assault area, and a full issue covering their probable operational area immediately ahead.

With H.Q. Second Army. The major portion of 3 (Army) Field Survey Depot R.E. crossed over to Normandy on light scales in eight detachments (excluding the 16 corps and divisional sub-sections) as under:—

- | | | |
|------|--|----------------------|
| 1st. | 2 O.R.s (on "D"-day) with 5 tons of maps | } On separate craft. |
| 2nd. | 2 O.R.s (on "D"-day) with 5 tons of maps | |
| 3rd. | Main Depot—2 officers, 10 O.R.s, 1 jeep, 3 3-ton lorries. | |
| 4th. | 2 O.R.s attached to the Survey Directorate, for Army H.Q. map lorry. | |
| 5th. | 2 O.R.s with 20 tons of maps. | |
| 6th. | 2 O.R.s with 20 tons of maps. | |
| 7th. | 2 O.R.s with 20 tons of maps. | |
| 8th. | Rear Depot—1 officer, 17 O.R.s, 3 3-ton lorries, 2 15-cwt. trucks. | |

The first and second detachments went over attached to H.Q.s 1 and 30 Corps respectively, each with maps of the other corps' front, in case divisions should be switched during the initial operations. This did, in fact, happen, and these two detachments issued quite a lot of maps.

The fifth, sixth and seventh detachments went over with their maps pre-loaded on vehicles of other units (R.A.S.C., etc.). The two men were merely conductors, to ensure that the maps safely reached the Army Field Survey Depot. These precautions were fully justified in the event, for the maps of No. 3 Depot arrived promptly, but other map consignments, which went over consigned as stores, often hung around for days in ordnance depots until found and rescued by Survey search parties.

The residues followed later, consisting of:—

Main Depot—5 O.R.s, 3 3-ton lorries, 1 15-cwt. truck.

Rear Depot—5 O.R.s.

All the Second Army map consignments crossed over safely except for one lorry-load which was "drowned" on landing, though most of the maps were salvaged.

With H.Q. 21 Army Group. Pending the move overseas of H.Q. 21 Army Group, 4 Field Survey Depot R.E. crossed over to France during June and was temporarily under command of D.D. Survey Second Army. 5 Field Survey

(Stores) Depot R.E. followed soon after, both units being accommodated firstly under canvas, and then in buildings.

Consignments of maps and stores were shipped to France by normal convoys, and losses were negligible. Both depots became well stocked and, with the arrival of Survey Directorate 21 Army Group within the bridgehead, the depots reverted to 21 Army Group command. After the capture of Caen, a good factory building on the outskirts was allocated to No. 4 Depot, and stocks of maps from the United Kingdom could be shipped up the canal direct to Caen. This base map depot soon began to accumulate large stocks, both from the United Kingdom direct, and also from 21 Army Group survey units engaged on local map printing.

Build-up of American map stocks in the bridgehead

SUPPLY FROM THE UNITED KINGDOM

The American organization for the shipment of bulk map stocks over to Normandy was different from that used by the British. As stated the latter arranged for early bulk stocks to go over pre-loaded in vehicles, accompanied by survey personnel as couriers, to ensure their early removal from the beach areas to the map depot. The Americans, however, arranged for unaccompanied bulk shipment, the maps being packed in wood cases which, when they eventually reached the beach, tended to lie about until found, claimed, and sorted out for removal.

Two map depot detachments were assigned to the assault forces under the control of First U.S. Army, and they operated beach map depots, one each in the "Omaha" and "Utah" beach maintenance areas. During the early phases of the operation, map supply was extremely critical because of the difficulty first of all in locating the map ships, and then getting them unloaded. The original detachments had to be supplemented with extra personnel and vehicles so as to speed up the collection of the map-cases as they arrived on the beaches, and their transportation to the map depot. Information of ship names and numbers was difficult to obtain, and it was often impossible to locate a particular ship lying off the beach area because of the confusion during the first week of the operation, and rival claims for priority of unloading.

To meet early demands, large quantities of maps had to be flown over to make good the delays due to difficulties of unloading. Officer couriers accompanied these air-shipments, and later went also with the sea-shipments, as it was realized that this was the only way of ensuring prompt unloading and delivery of the maps to the depots. Between "D"-day and "D" + 56 over 150 tons of maps were sent across by air, and over 1,000 tons by sea for use by U.S. troops in France.

In mid-July, the forward echelon of the Communications Zone, augmented by extra personnel to control distribution within the American sector of the bridgehead, took over responsibility for the operation of beach map depots, and the establishment of new ones.

Detailed plans for the shipment of map reserves to support the American invasion forces were now implemented. To start with, an average daily shipment of 15 tons was sent over, increasing later to 30 tons. Phased shipments were designed to provide a moderate reserve of maps in the immediate beach-head area, and an initial issue to meet a 14-day requirement for mobile operations under break-through conditions.

To guard against total loss of any one map sheet, not more than 10,000 copies of any particular sheet were loaded on one ship. The wisdom of this precaution was proved when the sinking of a few ship-loads at a critical period did not cause a breakdown in map supply.

The systematic shipments described above, which were designed to carry through to about "D" + 90, had to be modified in August so as to send over bulk stocks amounting to about 1,500 tons to the U.S. Base Map Depot at Rennes. This was owing to a change of tactical plan involving the rapid exploitation of a break-through, and the erratic delivery of maps on scheduled periodic shipments. Delivery by normal sea convoy could not be guaranteed within any reasonable period of time so air-shipments and "Red Ball" (special priority) transportation were made use of to meet urgent requirements occasioned either by failure in the delivery of map reserves, or unexpectedly high consumption of particular sheets.

SUPPLY FROM THE UNITED STATES

In December, 1943, as stated previously, it was agreed between the War Office and the War Department, Washington, that the former would be responsible for bulk map supply to American forces taking part in "Overlord" during the initial stages of the operation, and that the Army Map Service (A.M.S.) in Washington would assume responsibility for supply to the Continent after "D" + 90. After discussion between D. Survey (S.H.A.E.F.) and Colonel Milwit (E.T.O.U.S.A.) requisitions for map stocks to be printed in the United States were sent to Washington starting in April, 1944. These requisitions called for monthly consignments to be despatched beginning on 15th July which, allowing about four weeks for the journey, would bring the first shipment into European waters about the middle of August (approximately "D" + 70). Probable output was based on a production figure of about 7,500,000 maps each month.

In accordance with the above arrangement, there were about 30,000,000 maps in ships around the coast of Britain and in the English Channel towards the end of August. They were loaded in stores ships, supposedly for priority discharge. At that date the allied armies had broken out from the Normandy bridgehead and were racing eastwards. First U.S. Army was moving through north-eastern France into Belgium, and General Patton's Third Army was racing along south of Paris towards the German frontier. The map supply situation with the above armies was, at that moment, extremely critical, and it was vital that the large stocks of those very maps of eastern France, Belgium and western Germany which were so urgently needed by the advancing armies, and which were afloat off the English coast, should be unloaded immediately. The locations of the ships were established but, though the cases of maps were listed on the manifests as cargo for priority unloading, they had been put in the holds below low-priority cargo, such as locomotives, which required special port facilities for removal. This unfortunate mistake at the port of embarkation completely nullified the advance map-supply planning which should have made the maps available well in advance of anticipated needs. It required most urgent representation to the highest level before an order was given for the ships to be unloaded immediately, and the map stocks were then sent forward.

At the same time action was taken with Washington to speed up the delivery of succeeding consignments which were then loading in New York.

The maps concerned covered areas only a short way ahead of the advancing armies, so these stocks were sent over in fast craft and their arrival considerably relieved the strain imposed on local reproduction facilities.

Supply and distribution during the Normandy operations

As soon as map provision had been made for the security of the bridgehead, it was necessary to stock up the corps and divisional map lorries with maps of areas which lay ahead.

As a precaution against possible difficulties in the printing of 1/25,000 maps in the field during the early operations, a thin spread of sheets covering the area from Troarn in the west to the R. Seine was sent over from the United Kingdom so as to be available if required.

It is of importance to note that the nature of the fighting in the close "bocage" country of Normandy, with its small fields and numerous banks, walls and hedges, caused an unexpectedly high demand for 1/25,000 maps by all arms. Under such conditions this scale of map was found essential, even for tanks, especially when operating in close support of infantry. Formations complained that the 1/50,000 maps were insufficiently detailed, and their use was costing lives. Second Army undertook to maintain 1/25,000 map issues at a scale of 800 copies to a division, 800 for corps troops, and 200 for tank brigades, which was over double the standard scale of issue. For certain set battles these numbers were largely exceeded. The maintenance of this output depended on a large increase in paper stocks and later, when it became necessary to increase the printing output of survey units, an extra printing section was added to each field survey company.

During the first three weeks of August receipts and issues continued normally, stocks being adequate and demands being promptly met. Bulk supplies were obtained from 4 Field Survey Depot and these were supplemented by the local printing of 1/25,000 maps. As a result 3 (Army) Field Survey Depot with Second Army was kept well stocked, and forward supply to corps and divisions presented no great difficulty.

The pursuit from Normandy through north-eastern France

WITH 21 ARMY GROUP

This fast-moving period of operations was marked by events which stretched the survey organization beyond the point where all map demands could be fully met, and it became necessary for the General Staff to warn the armies that the scale of map supply would have to be restricted. A considerable strain was thrown on all the Survey Directorates concerned. Normal procedure of supply and distribution to a large extent broke down, and it was only by the most intense efforts and skilful improvisation that the lower formations were enabled to receive their essential map stocks.

From the moment when the allied armies broke out of the bridgehead until the advance was subsequently checked roughly along the German frontier, most of the activities of the Survey Directorate at H.Q. 21 Army Group were centred around map distribution. The system of map supply had been organized on the following basis:—

- (a) Maps required for the current operation to be in the hands of the users.
- (b) Maps for the next phase to be in the corps and divisional map lorries.

- (c) Maps for the next succeeding phase to be held in the army field survey depots.
- (d) Maps for further use to be in the Base Map Depot, ready for issue to army map depots some three weeks before they were likely to be required for operational use.

Experience in Second Army indicated that army map depots should receive stocks earlier than as stated above. Corps and divisions required a planning issue a month ahead, including 1/25,000 maps, and they started demanding operational stocks for their map lorries about three weeks ahead. The Army Depot, on this calculation, would need to receive its map stocks some six to eight weeks before they were likely to be required for operational use and this offered a difficult problem in map supply.

The pursuit after the Falaise battle was carried out at such speed that the normal map supply organization was completely upset. The enemy did not stand on any of the potential defence lines, such as the R. Somme, as had been anticipated, in order to maintain his V-weapon sites in the Pas de Calais, and movement thus got ahead of bulk delivery from the United Kingdom. The Map Reproduction Sections R.E. had not yet become fully operative in France, so it was necessary to depend very largely on consignments from England. During the later stages of the advance across the Somme and beyond, the required maps were not available in the depots in sufficient numbers, and the business of map distribution became an exacting process of hand-to-mouth improvisation so as to feed stocks forward piecemeal as they were shipped over. Owing to the heavy demands on "pool" transport for carrying forward petrol, ammunition, and other urgent supplies, vehicles from many of the survey units were diverted from their normal use for map transportation.

The reader may well ask at this stage why it was that such a shortage of maps of north-eastern France and Belgium should have come about. It may be well, therefore, to consider briefly the basis on which the printing and supply of bulk map stocks for this stage of the operations had been planned.

At the Washington Conference in May, 1943, the conception of a full scale invasion of western Europe was confirmed, and the spring of 1944 was designated as the target date. By August, 1943, the joint Anglo-American planning staff (C.O.S.S.A.C.) had produced a tentative plan, and this enabled the Survey Directorate (War Office) to concentrate in detail on the preparation of the various map series, already well advanced, which were likely to be required. As it was desirable to incorporate as much up-to-date revision in these maps as possible, and as the numbers to be printed would depend on detailed planning by the formations concerned, it was obviously desirable to defer the printing of bulk stocks until more precise data were available.

By January, 1944, it became clear that the extent of the mapping commitment was such that no further delay in starting the actual printing could be tolerated. At that date, D. Survey 21 Army Group had still not received sufficient information on which to base a precise forecast of requirements other than the approximate number of divisions that were likely to take part in the assault, and the fact that the target date was some time in the spring. Under the circumstances his printing demand had to be based very largely on intelligent guesswork.

As detailed planning proceeded, and the estimates of the British and American Armies for the assault and the period immediately following began

to come in, it was apparent that the numbers now being asked for greatly exceeded the January estimate. This was due to the fact that, when planning the assault and the subsequent break-out from the beach-head, each army expected map provision to be made for possible extensions to either flank and also to the south.

In April, 1944, the planners prepared a phase-line map which indicated the anticipated development of the operation. This showed that, by "D" + 90, the allied armies were expected to reach the Rivers Seine and Loire, and to have cleared the Brittany peninsula. This phase map assumed great importance with regard to planning for map supply. The area covered up to the "D" + 90 phase-line was a large one, and the demand for small and medium scale map cover of this area represented an enormous printing commitment. This was aggravated by the fact that the mobile printing equipment with American units was, in those early days, not of a suitable size for printing 1/25,000 maps in the field. The U.S. Forces asked, therefore, for large numbers of 1/25,000 maps of the Brittany peninsula and of the area north of the R. Loire to be printed for them to take over. The demand for many of the 1/50,000 and 1/250,000 sheets amounted to well over 100,000 copies of each and, in the case of the 1/25,000 sheets, of which there were a very large number, the number required of each varied from 10,000 to 25,000. There was a further unexpected load on printing resources when Second Army demanded 1/100,000 maps at the full scale of issue. The current policy was that this scale of map was to be issued only to armoured formations, but the General Staff ruled that this new demand should be met.

Consequent on the above, very large supplementary printing orders had to be placed with the War Office, and indices were prepared showing the numbers of each sheet which were to be delivered either to the static map depots, the marshalling area depots, 21 Army Group depots for onward transmission, or to be forwarded as freight after 21 Army Group depots had gone overseas. Dates by which delivery was required were also given.

The available printing resources in the United Kingdom were extensive but not unlimited. They were quite unable to meet the demands that had now been submitted to the War Office. D. Survey 21 Army Group was therefore informed in April that he must either reduce the quantities asked for of the assault area and just beyond, or accept later delivery dates for the maps of north-eastern France, Belgium, Holland and Germany. On receipt of this communication, the General Staff, 21 Army Group, made the following two decisions. Firstly that the maps asked for by the assault and follow-up troops must be provided in the quantities required, and nothing was to prejudice this. Secondly that Survey should plan for subsequent requirements on an assurance that the advance would not go beyond the "D" + 90 phase-line before that date.

While considering the question of map stocks in the assault and break-out area it must be realized that, instead of going more rapidly than forecast, as in fact it did, the operation might have gone more slowly, and in that case many of the apparently redundant stocks of maps west of the R. Seine would have been in considerable demand.

For an estimate of map requirements beyond the "D" + 90 phase-line, no indication was available at the early planning stage of the probable rate of advance beyond that line. It was therefore assumed that, after a short pause on the R. Seine, the advance to the north-east through France and

Belgium would continue at about the same speed as shown by the phase-lines leading up to the Seine, about 50 miles a month. As events turned out the pursuit proceeded at the rate of about 40 miles a day during a period of about six days. The Guards Armoured Division entered Brussels on 3rd September and 11 Armoured Division entered Antwerp on 4th September. Second Army was therefore about 200 miles ahead of schedule by "D" + 90, and had entered an area which, according to the planned estimate, would not have been reached until about "D" + 210.

Returning now to April, 1944, the War Office printing programme was re-examined in the light of the decisions made by 21 Army Group, and it was estimated that requirements could just about be met. The phasing of the post-assault consignments was based on the assumption that stocks must reach 21 Army Group Base Depot in France about four weeks before they were likely to be required for operational use, and it was assumed that the transit time from the War Office Map Depot to the Base Depot would be about 10 to 14 days. On this assumption maps of the R. Somme area should have been arriving in 21 Army Group Depots about "D" + 70, say mid-August. On the phase-line estimate the maps of more forward areas had not been planned to reach France till about mid-September. When that date arrived the maps of those areas were, in some cases, only just coming off the machines, and the only stock available in France was a small quantity which War Office allotted to 21 Army Group from an early printing which had been run off for use by the planning staffs. This allocation was very small as War Office had to hold back a small reserve for possible use by airborne forces.

In the light of events as now known, the quantity of maps of the area west of the Seine might have been considerably reduced, with consequent speed-up of production of maps further to the east, but this would have been a bold and unjustifiably rash decision to make in April or May, 1944. In any case, despite the shortages recorded above, it is satisfactory to chronicle a statement made by Field-Marshal Montgomery to D. Survey 21 Army Group to the effect that at no time did map supply fail or prejudice the conduct of operations.

On several occasions it was necessary to interchange map stocks between British and American Army Groups. Each was in possession of stocks not required by themselves but urgently needed by the other, and 12th U.S. Army Group gave valuable help when supplies were dangerously low in Second British and First Canadian Armies. The advantage was mutual.

A labour difficulty arose in connection with the hand-to-mouth procedure of feeding maps forward from the base map depot. Large consignments arriving from the United Kingdom had to be sorted and re-consigned with the utmost speed. For this the personnel authorized for a standard field survey depot were quite inadequate. During most of August, the labour employed at the depot was of the order of 100 persons including French civilians and typists, British and other pioneers, and all available survey reinforcements. Three officers were always necessary instead of the one allowed by war establishment.

During the latter part of August, Nos. 14 and 15 Map Reproduction Sections R.E., equipped with double-demy printing machines, were installed close to H.Q. 21 Army Group in Normandy and they, together with 515 Field Survey Company R.E. and its mobile demy printing plant, were able to supplement the bulk stocks received from the United Kingdom. No. 25 Field Survey Depot R.E. arrived in France at the end of August. Its task was to function

as a L. of C. depot, handling both maps and survey stores sent forward from the base depots, and feeding them further forward to the British and Canadian Armies.

WITH THE BRITISH AND CANADIAN ARMIES

Anxious though the situation was at Survey Directorate, 21 Army Group, the D.D.s Survey at the headquarters of Second British and First Canadian Armies had a greater anxiety. They were closer to the fighting troops, and were responsible directly for their map supply. During the rapid advance from Falaise in late August it was apparent to D.D. Survey Second Army (Colonel A. W. Heap) that normal methods would not cope with the situation. At one time, for example, one of the corps rapidly advanced 100 miles ahead of Army H.Q. and the field survey depot. When the advance began corps and divisions were carrying in their map lorries map supplies which would take them up to and across the R. Seine. Map coverage up to the R. Somme was carried by 3 (Army) Field Survey Depot, and indents for maps extending from the Somme into Belgium had been sent to H.Q. 21 Army Group. Stocks of these were not available, and a map crisis rapidly developed. Matters were not made any easier by the fact that 3 Field Survey Depot was constantly on the move in order to keep pace with Army H.Q.

Emergency action was taken by allotting to 3 Field Survey Depot the personnel and transport of two topographical sections and two general survey sections to speed up movement, and by obtaining 20 3-ton R.A.S.C. lorries and a platoon of pioneers. At the same time a mobile map dump consisting of three 3-ton lorries and a topographical section from a field survey company was sent forward to H.Q. 30 Corps with a load of 1/50,000 and 1/250,000 maps of forward areas. Formations were instructed to demand direct on this mobile dump. To speed up the forward move of the main depot all redundant maps of rear areas were progressively dumped at locations which were notified to H.Q. 21 Army Group so that they could be salvaged.

This emergency procedure continued till the end of August. Depot accounting had to be dispensed with, and maps were issued to formations before they had been checked in to the depot. This naturally produced a chaotic situation with regard to stock records, and it was essential to return to normal methods as soon as possible.

The Canadian Army experienced much the same difficulties in its advance up the left wing through the Pas de Calais and they found it necessary to augment considerably the transport with their field survey depot so as to effect the quick deliveries that were necessary day by day.

WITH THE AMERICAN ARMIES

For the assault, and the subsequent operations within the bridgehead, First U.S. Army was under the command of 21 Army Group. As soon, however, as the Third U.S. Army became operational and the break-out from the bridgehead began, 12th U.S. Army Group assumed command of the First and Third U.S. Armies, and the topographical detachment of the Engineer Section at Army Group H.Q., under Colonel W. D. Milne, took over general control of their map requirements. A few words on the organization for supplying maps to American field formations are advisable, as it differed from the British method whereby the survey service was responsible for all mapping

and survey matters. In the American Army the responsibility for map supply and surveys rested with the Engineer at the headquarters of each formation. Shortly before "D"-day the engineer sections at army group and army H.Q.s were strengthened by the addition of a Topographical Detachment which was responsible to the Engineer for all mapping and survey matters.

The topographical engineer at an army group H.Q., after consultation with the Operations (G-3) and Intelligence (G-2) staffs, decided what maps were likely to be required for future operations, and notified the Engineer Intelligence Division (Communications Zone). The latter was responsible for ensuring that bulk map stocks, including those for the air forces, were assembled in the base map depot on the Continent. These stocks, as mentioned previously, came first of all from map depots in the United Kingdom, and subsequently direct from the United States. The ordering of these stocks was generally arranged after discussion between D. Survey (S.H.A.E.F.) and Colonel H. Milwit, Chief of the Intelligence Division, between whom there was at all times the closest of liaison.

From the base map depot stocks were transferred to advanced map depots, one of which was located just behind the rear boundary of each army area. These advanced depots were manned by map depot detachments provided by Com. Z. The topographical engineer at each army H.Q. organized his own map depot in which to hold map stocks for operations immediately ahead, and he obtained these from the Com. Z advanced map depot. Map stocks were also transferred from the base map depot to an air force map depot, from which maps were supplied to the various air force commands.

The general organization as finally developed is shown in Diagram 13, but it is necessary now to look back to the period before this organization was fully functioning on the Continent.

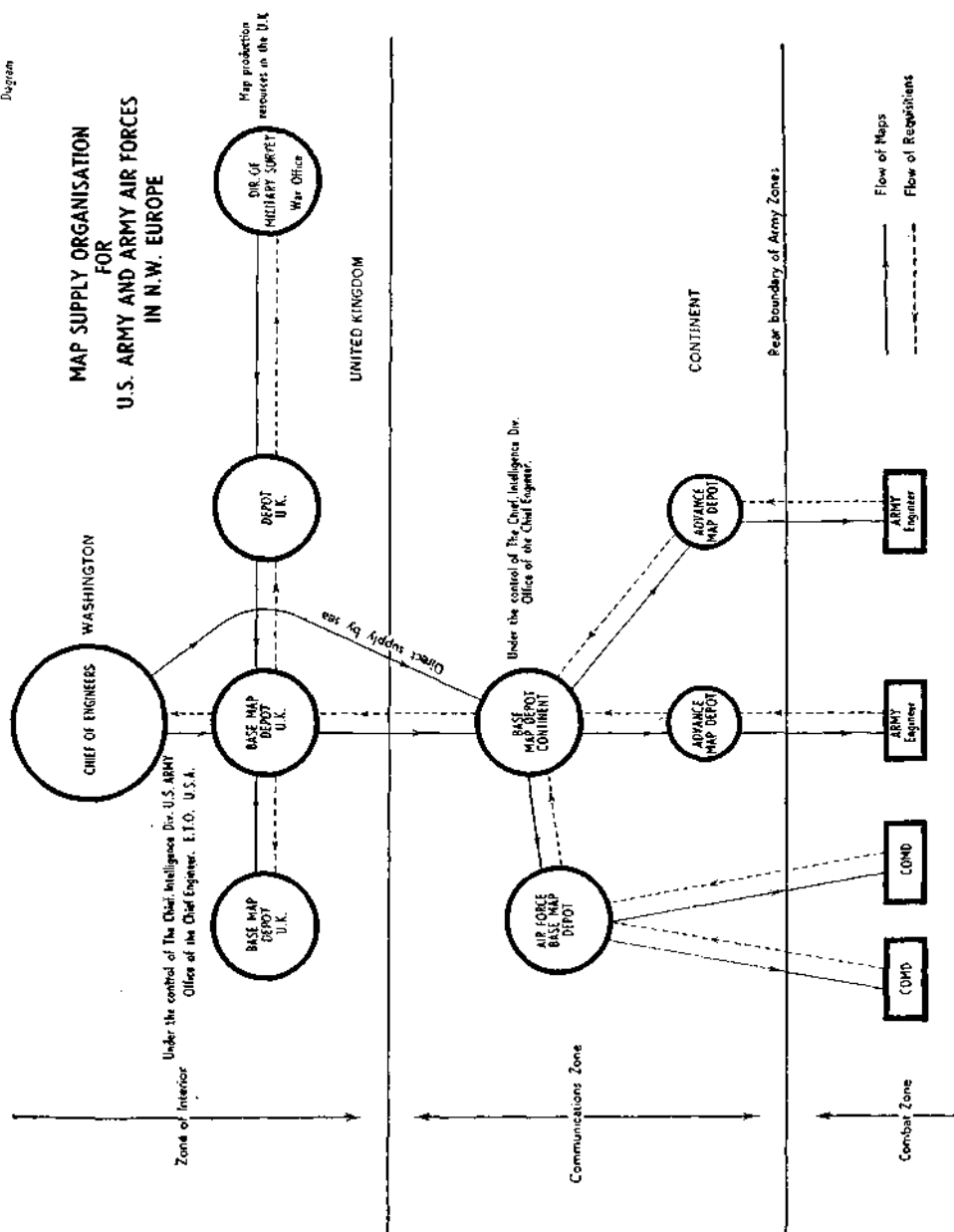
Until 1st August all American map depots on the Continent were under First Army control. Segregation of stocks by areas had not been made, and maps were scattered between several small depots which had been established as part of the emergency organization within the bridgehead. When, therefore, H.Q. 12th U.S. Army Group became operational, its Engineer Section was faced with the task of providing maps for both First and Third Armies. Areas of primary interest were assigned to each of the two armies, and a division of stocks was begun.

The initial stocks available did not meet the phased requirements of H.Q. 12th Army Group, and it was soon apparent that, unless immediate action was taken to increase stocks overseas, map supply to the armies would fail. Arrangements were made to move all stocks from E.T.O.U.S.A. depots in the United Kingdom to France. This was started on 7th August and was completed by the 24th, by which date the maps had been concentrated at the base map depot at Rennes. Their arrival enabled issues to be made to First and Third Armies at a critical moment of the pursuit battle and, as previously stated, there was close liaison with the Survey Directorate at H.Q. 21 Army Group which facilitated an interchange of map stocks between the two.

On 21st August H.Q. 12th Army Group asked for maps of western Germany, as the armies were racing towards the German frontier. Owing to urgent printing commitments for other needs, the full requirements could not be met from War Office supply but fortunately, with the liberation of Paris, it was possible to arrange with the French Service Géographique for printing to be undertaken there, making use of civilian lithographic resources in the city.

DIAGRAM 13

Diagram



Stocks of Michelin road maps were also found in Paris, which proved invaluable at a time when the standard military map series were in short supply.

Although, during this difficult period, map supply was undoubtedly restricted and on a hand-to-mouth basis, operations were never at any time held up or endangered by an absence of essential maps. Supply was rendered difficult by five main factors:—

- (a) A failure to segregate map stocks by areas before the active entry of Third Army.
- (b) Delays in meeting the phased map requirements of H.Q. 12th Army Group, partly because of the delays in unloading the shiploads of maps on arrival from the United States.
- (c) The unexpectedly rapid movement of the armies.
- (d) Changes in tactical plans.
- (e) Shortage of transportation for moving map stocks forward.

The pursuit towards the German frontier

WITH 21 ARMY GROUP

The situation during September continued to be source of much anxiety to survey staffs who were responsible for supplying maps to quick-moving formations. The ever-lengthening lines of communication, congested roads, demolished bridges, and difficulties of port clearance all adversely affected the problem. There was always the difficulty of obtaining sufficient vehicles for map transportation in the face of heavy competition for other commodities, and it was often necessary to make use of survey unit transport and personnel to help maintain the forward flow.

The provision of suitable accommodation, especially for map and store depots which required considerable storage space, was always a difficult problem which caused much anxiety and delay. It sometimes appeared as though the operational necessity of having map stocks promptly and efficiently housed in the right place was overlooked by those responsible for allocating accommodation, and that priority was given to other claimants whose activities seemed of far less operational urgency and importance. After the liberation of Brussels, for example, it took several weeks before accommodation was provided for 25 Field Survey Depot with its stocks of maps and stores, and later on, when 4 Field Survey Depot moved into Germany, several months elapsed before it was properly housed.

When No. 16 Map Reproduction Section R.E. arrived in Brussels, it was quickly in production, using plant which was made available by the Belgian Military Cartographic Institute, who gave much valuable help. No. 15 Map Reproduction Section also moved to Brussels, and these units considerably eased the supply situation, especially as stocks of printing paper were found in Brussels.

With Second Army, the map supply crisis was at its height in the early part of September. The corps were advancing so rapidly that they required new maps daily. Army H.Q. was moving forward about twice a week in an attempt to catch up, and became completely out of touch with H.Q. 21 Army Group. Telephone communication was non-existent, and "Immediate" signal messages took anything up to four days to get through. This resulted in an unfortunate

lack of touch between the two survey directorates, except for personal visits over long distances, at a time when close touch for map supply was most desirable.

3 (Army) Field Survey Depot was continuously on the move till 22nd September, when it had the good fortune to spend one whole week in the same place. It was getting further and further away from the Army Group map depots, and yet had to maintain forward issues all the time without a pause. At the height of this critical period, urgently needed map supplies on order from 21 Army Group depots either failed to arrive or did not arrive in time. This was owing partly to the slowness and congestion of communications and transport difficulties, and partly to a shortage of the required maps covering north-eastern Belgium, Holland and Germany, in No. 4 Depot which was still back at Caen.

Rapid movement reduced the need for 1/25,000 maps, so no further stocks of these were printed north of the Somme during the pursuit period. The resources of the mobile printing equipment with Second Army were therefore switched over to the printing of 1/50,000 sheets of Belgium to make good the deficiency. In addition a special Second Army edition, in demy size, of 1/250,000 and 1/100,000 sheets of immediately important areas of western Germany, was published in monochrome, as an insurance against a possible failure to obtain stocks of the standard series if Germany was entered in the near future. Orders were also placed with the Belgian Cartographic Institute for the local printing of standard 1/250,000 and 1/100,000 maps of northern Belgium and Holland to meet the immediate demands of the fighting troops.

The emergency distribution methods adopted during the early days of the advance, although they allowed formations to get their essential maps quickly, resulted in uneven allocations, and the more pushing formations tended to get more than their fair share of rapidly dwindling stocks. It was decided, therefore, to exercise a more rigid control, so as to eke out the available stocks to the best advantage. Corps were notified that no more map demands would be accepted for the time being, but that stocks of essential sheets would be delivered to corps H.Q.s who would sub-allot them to divisions.

On 7th September, in the course of a telephone conversation between D.D. Survey 21 Army Group and Survey Directorate, War Office, the latter suggested sending maps to Normandy by air as they came off the printing presses, to save the time spent in shipping them. As the maps were urgently needed right forward in Belgium by both the Second and Canadian Armies, and as the cross-Channel air trip to Normandy, plus the time necessary to get them forward, would involve so much delay, it was decided to fly the maps from the United Kingdom direct to airfields in the two army areas. On 10th September, the first daily air consignment of two tons arrived. This was increased to four tons daily on 13th September and continued until 2nd October. By 21st September the supply position had eased sufficiently to enable the normal system of distribution to be reinstated, but with restricted issues.

There is no doubt whatever that the introduction of direct air delivery to armies, cutting out the base map depot and the long overland journey through France and Belgium, saved the situation at a very critical moment, and showed the need for flexibility of methods during a crisis.

Air supply from the United Kingdom to army group depots in Brussels continued until about the end of December, 1944, by which time the United Kingdom printing programme had got ahead of immediate needs. Direct supply by sea *via* Ostend, and later Antwerp, was then able to meet requirements,

though frequent use was made of Naval Despatch and "fast freight" services. Consignments of maps were escorted all the way to prevent their getting sidetracked or lost.

WITH 12TH U.S. ARMY GROUP

The critical map supply situation with the American Armies during the early part of the pursuit has already been referred to. The situation was eased by the receipt of about 200 tons of maps which were flown from the United Kingdom, the unloading of the ships containing bulk stocks from the United States, and the immediate utilization of printing resources in Paris as soon as it had been occupied. Colonel Milwit lost no time in augmenting these resources. He took over a factory building on the outskirts of Paris which had been working as a high-class commercial printing plant and was already equipped with lithographic printing presses. Here he installed his G.H.Q. Engineer Topographical Battalion, which was a finely equipped unit capable of high output, and it remained in this location for the remainder of active operations.

By the end of September, the supplies were again under control and working well. Large stocks of enemy maps, including those prepared for the invasion of Britain which were found in Paris, were used for printing on the back to help out the paper supply.

On 15th September H.Q. 6th U.S. Army Group assumed command of the Seventh U.S. and the First French Armies which had landed in southern France and fought their way northwards to make contact with General Eisenhower's forces in the Belfort area. A.F.H.Q. continued to send air shipments of maps from the Mediterranean to supply these two armies, and also despatched a fast sea shipment of about 200 tons via Marseilles. By the end of September the stocks available with 6th Army Group were sufficient to meet their minimum needs on the battle-front with small reserves in the rear. Topographical units were printing most of the 1/50,000 and all the 1/25,000 maps which they required. On arrival in the Belfort area, 6th Army Group came under S.H.A.E.F. command, and Com. Z. then assumed responsibility for their map supply.

The winter pause (October, 1944, to the end of February, 1945)

GENERAL

In comparison with the rapid pursuit from Normandy, the fighting during October and succeeding winter months was of relatively static nature. Increased German resistance and bad weather conditions slowed up operations, and afforded a welcome opportunity for survey staffs to overhaul their map supply arrangements and build up stocks. The increased length of communications made it necessary to deploy map depots well forward and, in the case of 21 Army Group, to take advantage of the opportunity for using ports further to the east for the disembarkation of map stocks, such as Ostend and finally Antwerp, thus cutting out the long road-haul from Caen. The use of air freight for urgently required stocks was continued with great advantage, every consignment being accompanied by a conducting officer.

The need for these conducting officers cannot be too highly stressed. Maps were not carried by air in bulk unless they were very urgently needed. Time and again it happened that, but for the forceful efforts of the conducting officers, air consignments would have been lost or delayed. Cases often occurred of

aircraft being diverted, for operational reasons, from the airfield to which they were originally routed. In such cases the maps were usually dumped on the edge of the airfield where, if unaccompanied, they would have remained. Without the personal efforts of the conducting officer in collecting transport, and finding his way, possibly 50 miles or more, to the army or army group depot, the maps would not have been traced for days or even weeks.

WITH THE BRITISH FORCES

H.Q. 21 Army Group

Amongst the many other increases in war establishment which were approved for the survey organization at this period was the provision of an extra captain with the Survey Directorate. He acted as liaison officer with H.Q. L. of C. to ensure a proper map distribution to L. of C. units who were located over a wide area between Normandy and the Dutch frontier.

The war establishment of No. 4 Field Survey (Base) Depot was largely increased during November, providing two extra officers, upgrading the rank of the O.C. to captain, and adding several extra storemen, drivers, and vehicles, including five 10-ton lorries. This put the unit in better shape to carry out its functions efficiently, and enabled it to shift map stocks more easily when it had to move. The depot was installed and was functioning in Antwerp by January, 1945.

By the end of November, map stocks in hand with the two 21 Army Group depots were as under:—

With 25 Field Survey Depot (L. of C.)	19,525,000
With 4 Field Survey Depot (Base)	14,726,000
Total	<hr/> 34,251,000 <hr/>

By the end of February, just before the final allied offensive, this total had risen to over 50,000,000 maps. Stocks now appeared to be adequate for any likely operations for some time to come and, with all the map reproduction sections in full production at Antwerp and Brussels, assisted by Belgian civil labour, local production was now greatly assisting and augmenting bulk supply from the United Kingdom. The survey units operating in Antwerp had to work under most trying conditions during the height of the enemy rocket attacks.

As a precaution against complete loss of stocks by enemy action (V-weapons) the contents of the depots were split and located at different places.

In preparation for a further advance into Germany an advanced map depot was organized in January from Nos. 4 and 25 Depots. Its function was to move forward with essential stocks at short notice, and to deal with demands from field formations until 25 Field Survey Depot had moved forward complete and was ready to resume issues again.

When the enemy counter-attacked in the Ardennes in December the First U.S. Army map depot at Stavelot was overrun. To make good this loss without delay, pending replacement from Com. Z. sources, some 750,000 maps were transferred from 21 Army Group stocks to form a nucleus for a new map depot which was opened by First Army. This interchange of map stocks between British and U.S. Army Groups was frequently arranged, and indicated the sound co-operative spirit which animated the allied survey staffs at all levels.

With Second Army

Map distribution from October to the end of February was, in general, on a normal basis. Owing to the lack of a 1/50,000 map in Holland, increased quantities of 1/25,000 sheets were printed and issued. Formations stated that the 1/100,000 map was not a large enough scale for tactical use in a country of dense and complicated water obstacles, which formed an important tactical feature in that area.

When the enemy counter-attacked in the Ardennes, there was a rush of map demands consequent on the move of Second Army formations to take over part of the First U.S. Army sector, and it was necessary to attach a topographical section to 3 (Army) Field Survey Depot to assist in the handling of these rush issues.

During January, information was received on the probable future boundaries between Second Army and neighbouring formations. This enabled the stock position to be examined and it was found possible to return to 21 Army Group depots a considerable quantity of redundant maps. This still left over 4,000,000 maps in stock and, in the interests of mobility, the holdings with 3 Field Survey Depot were reduced still further during February.

It is of interest to note some figures covering map issues and turnover at the depot. From June, 1944, to January, 1945, average issues amounted to 31,500 a day, with a peak figure of over 105,000 a day during August. The figures for turnover worked out at an average of 147,000 a day over the period, with a peak of 351,600 a day in August during the advance from Normandy.

With First Canadian Army

Approximately 4,000,000 maps were held in stock by 1 Canadian Army Field Survey Depot, and the position being regarded as satisfactory, the normal system of map distribution was employed. As in the case of 21 Army Group, stocks were split so as to reduce the chance of total loss by enemy action. The depot was of the "Army" type, very similar to that with Second Army, with sub-section map lorries at the headquarters of corps and divisions. Two extra sub-sections were added in December, making a total of two corps and seven divisional sub-sections.

WITH THE U.S. FORCES

With more stable conditions along the fighting front from October onwards, there was an opportunity to consolidate the map position. The docking and unloading of ships carrying stocks from the United States, together with further shipments from the United Kingdom and expanding Continental production, helped to brighten the general map supply picture.

To reduce the road-carry to the advanced map depots serving the armies, a new base map depot was opened just north of Liège early in December. In Paris, a French-operated map store was opened holding maps on all scales for supplying French formations.

The German break-through in December tested the effectiveness of the Com. Z. map supply and distribution system. The rapid German advance overran the First Army map depot at Stavelot, the stocks of which were temporarily lost. The advanced map depot under Com. Z. control, which was located just behind the rear army boundary, was left intact and the losses at Stavelot, which had temporarily been made good by transfers from 21 Army

Group stock, were rapidly replaced by Com. Z. who organized an urgent printing programme in Paris. With the threat of further German thrusts westwards, the advanced map depots for First and Ninth U.S. Armies were moved to safer areas to prevent the possibility of capture.

By the end of January the following map depots were in operation under Com. Z. control:—

Base Map Depot No. 1	Cheltenham, England.
Base Map Depot No. 7	Rennes, France.
Base Map Depot No. 8	Paris.
Base Map Depot No. 13	Paris.
Base Map Depot No. 17	Bacour, Belgium.
Advanced Map Depot No. 12	Verdun (Third U.S. Army).
Advanced Map Depot No. 22	Darnieulles (Seventh U.S. Army).
Advanced Map Depot No. 23	Chalons (Fifteenth U.S. Army).
Advanced Map Depot No. 20	Tongres (Ninth U.S. Army).
Advanced Map Depot No. 21	Tirlement (First U.S. Army).

The stock held in the above totalled about 55,000,000 sheets on all scales.

During January, the German offensive had been defeated, the bulge in the battle-front had been eliminated, and map supply conditions returned to normal. Over 30 vehicles of a truck company, which had been diverted from map transport duties when the enemy attacked, were restored to their proper use, and losses in maps were more than made up when the First Army Map Depot, which had been overrun, was again made available, with its stocks practically intact.

The disposal of surplus and salvaged maps was a big problem, owing to a shortage of personnel for sorting, and the lack of vehicles for removing them. Large quantities were being handed in to the advanced depots and, with no pulping facilities in the forward areas, it was necessary to send them to Paris by rail.

A new system governing map issues from the advanced map depots to armies was introduced in January. The Engineer 12th Army Group authorized certain stock credits for each of the armies, and they were entitled to draw only up to the amount of such credit. These credits were frequently revised as found necessary, and the system provided a definite check against extravagant demands.

The receipt from the A.M.S. in the United States of stocks asked for by monthly requisitions, and of "cushion" stocks, continued satisfactory, though there were occasional delays due to shipping and unloading difficulties.

The tactical situation on the fronts of both 6th and 12th Army Groups did not involve any extensive movement during February. In view of the large stocks which had by now been accumulated in the advanced depots, there was a reduced volume of map issues from the base map depots. All the advanced depots were, by the end of February, in an excellent condition for dealing with future operations. To render them more mobile in anticipation of a forward move excess stocks were transferred back to the base.

At the request of D. Survey (S.H.A.E.F.) an advanced map depot was opened by Com. Z. at Maison Laffitte near Paris in support of the First Allied Airborne Army, whose operations from now on were to be based on the Continent.

The final stage (March to May, 1945)

GENERAL

The allied offensive was resumed early in March and, by the end of the month, the British and American Armies had crossed the Rhine on a broad front and were driving deep into Germany. During April, the operations took the form of a series of rapid armoured thrusts involving advances of from 20 to 30 miles a day, closely followed by mobile infantry columns. Canadian forces advanced through Holland on the eastern side of the Zuyder Zee, British forces captured Bremen and were investing Hamburg, and U.S. Armies in the centre had practically encircled the Ruhr and had linked up with the advancing Russian forces on the R. Elbe. Further south the 6th U.S. Army Group had entered Austria and had crossed the frontier into Czechoslovakia.

In spite of all this rapid movement, survey staffs were able to provide the advancing armies with all the maps they required until, with increasing pressure from all quarters, the German Armies finally surrendered on 7th May.

WITH SECOND ARMY DURING THE RHINE BATTLE

The system of map distribution remained normal till the latter end of March, when special arrangements were made for the Rhine battle as described below.

Corps were instructed to stock up their units and map lorries with as deep a coverage of maps astride the planned axis of advance as they could reasonably carry. It was found that, apparently for security reasons, corps and divisions had been given little information about future movements beyond their immediate bridgehead objectives, so they had difficulty in formulating an intelligent map plan. This no doubt accounted for many of the apparently absurd map demands which were received from formations who were doubtless trying to insure against all possibilities.

D.D. Survey, Second Army, notified headquarters of corps that map deliveries across the Rhine would at first be difficult and slow, and that formations must be mapped up beforehand in case of a quick break-through. Accompanying this notification were index diagrams giving a suggested map plan for all formations, and the survey liaison officers with each corps helped formations with useful propaganda and advice. This action met with an enthusiastic response and all the troops concerned were mapped up before "D"-day with maps of all scales as far as Osnabrück.

Three general survey sections, after a few days' training in map issue work, were organized as mobile map sub-depots. Their task was to deal with rapid advances after crossing the Rhine, one sub-depot being attached to each corps H.Q.

Each sub-depot had three 3-ton lorries filled with maps, and four 15-cwt. trucks for transporting maps and moving the personnel and stores. Details of the maps to be held in these mobile sub-depots were prepared in advance by the survey directorate. Briefly the stock consisted of small quantities covering the approaches to Osnabrück, and adequate though not lavish quantities for an initial corps issue on all scales from Osnabrück as far as and including the R. Elbe.

The anticipated break-through occurred earlier than had been expected, and the mobile sub-depots were attached to corps together with the survey liaison officers. The latter supervised the working of the sub-depots, the procedure being as under:—

Divisional demands came to corps H.Q.

The corps "G" staff decided, with advice from the survey liaison officer, whether to supply the maps in whole or in part from the sub-depot, or to send back to the main depot.

The sub-depot was not intended to be used as an overflow for the corps map lorry, and the liaison officer had to watch this carefully and, under "G" control, to direct the maintenance of stocks.

Map stocks were held in the 3-ton lorries only. The 15-cwt. trucks were for the transport of maps to divisions or from the army field survey depot.

The above arrangements worked well, and continued till the close of hostilities. Steps were taken to move forward 3 Field Survey Depot as quickly as possible, so as to keep it reasonably accessible to the sub-depots when they sent back for more maps.

This was the second time, in the case of Second Army, that a break-through occurred necessitating abnormal map distribution arrangements, the essential feature being that *the map stocks had to be mobile*. If this type of quick-moving battle is likely to be normal in future campaigns, it may be necessary for war establishments to provide for really mobile map depots instead of leaving it to survey staffs to improvise on the spot.

When hostilities ceased, the sub-depots were converted to static map depots near the final locations of their respective corps.

WITH THE U.S. FORCES

The rapid advances of the armies during late March caused a sharp rise in issues from base depots to the advanced map depots. By the end of March, four of the latter had moved into Germany, and were making every effort to keep pace with the advancing armies and so reduce delivery distances to a minimum.

Consignments from the United States continued to arrive in accordance with the monthly requisition programme. A total of 960 tons of maps were landed in Continental ports during March. It was found that many of the rail-wagons carrying these maps from the ports tended to get lost *en route* if not closely checked. Many found their way into engineer supply depots and were mixed up with bridges, timber and other engineer stores, causing much delay.

The task of keeping the quick-moving formations well supplied with operational maps covering ever-widening areas during April was not an easy one. A record total of 800 tons was issued from the base to advanced map depots. The wheel southwards of 6th Army Group towards Austria involved the rapid production and issue of maps of Austria and even of northern Italy. These were printed in Paris from reproduction material received from A.F.H.Q. by air.

The ending of hostilities early in May eased up production, but introduced new problems of supply and distribution to meet the needs of redeployment for occupational duties.

It may be of interest to quote a few figures indicating the scope of map supply to the American forces during "Overlord." The total supply for the campaign amounted in round numbers to 210,400,000 maps. Of this number, base facilities under the control of the Chief Engineer furnished 163,900,000,

the remaining 46,500,000 being produced by units under the control of U.S. Army Groups.

The source of supply for those furnished through the base organization was as under:—

Army Map Service (United States)	79,830,000
Institut Géographique National (French)	28,449,000
Base Topographical Battalion (660 Engineers)	17,560,000
British sources	38,061,000
Total	<hr/> 163,900,000 <hr/>

They were issued or disposed of as follows:—

Issued to U.S. Armies	62,000,000
Issued to the Air Forces, Com. Z., 21 Army Group, etc.	11,678,000
Salvaged or converted to pulp	31,429,000
In stock, June, 1945	58,793,000
Total	<hr/> 163,900,000 <hr/>

The above figures represent, over the period of the campaign from June, 1944, to May, 1945, an average daily supply of 486,000 maps from base sources, and 165,000 produced by topographical units in the field.

SECTION 7. MAP SUPPLY FOR THE ALLIED EXPEDITIONARY AIR FORCE

Historical introduction

The principal roles of the R.A.F. during the European war of 1939–45 may be summarized as under:—

Bomber Command—Strategic strikes against the enemy's vulnerable military and economic centres.

Coastal Command—The protection of shipping and the keeping open of the sea lanes.

Fighter Command—The defence of Great Britain and co-operation with ground forces and other Air Commands.

On occasions, aircraft of the above Commands were used outside their normal role as, for example, when Bomber Command was used tactically to assist the ground forces in offensive operations.

For Bomber Command some special "air maps" and "plotting series" had been provided in anticipation of a European war, and special target maps were rapidly produced after the declaration of hostilities.

For Coastal Command, in addition to the above maps, there were Admiralty Charts available, and these were supplemented later by special marine-contoured series of 1/250,000 scale, which were used in connection with mine-laying. Other special series were also produced to meet arising demands.

Before the war, no special maps had been prepared for the use of Fighter Command. It was intended that aircraft engaged in a defensive role should be controlled by wireless from the ground, and it was presumed that aircraft engaged in co-operation with ground forces would use those maps normally used by the Army. Not until the Battle of Britain had been fought and won was action taken to provide special maps for use by fighter aircraft engaged in operations over the Continent and for other offensive action. By the end of 1942 the publication of an Army/Air series covering most of western and southern Europe on a scale of 1/250,000 had been planned (see Chapter XIV, Section 3). Thereafter, the history of special map provision for the air forces was influenced by developments in the tactical handling of aircraft, the production of special aircraft for particular operational purposes, and the increase of radar aids to navigation.

Maps for use with radar aids to navigation (see Plate 56)

Chief among the radar aids was the development of "Gee" for which, early in 1942, the Directorate of Military Survey was producing a series of "Lattice" charts on Mercator's projection covering Great Britain and most of France and Germany on a scale of 1/500,000 (at 56° N. Lat.). They carried hyperbolic curves denoting "Gee" values, each set of curves being based on a particular transmission station. These charts, which had been produced for the use of Bomber and Coastal Commands, were also used by photo-reconnaissance units of Fighter Command, and before long the light bombers of Army Co-operation Command (later the 2nd Tactical Air Force) were equipped with "Gee" boxes, as were also the carriers and tugs of both 2nd T.A.F. and Transport Command.

The problem facing the light bombers, which were employed mainly during daylight, was one of precision bombing at relatively low altitudes. After discussions between users and producers, it was agreed to publish for "Overlord" a series of topographical air maps with overprinted hyperbolic curves relating to wireless transmission signals from mobile "Gee" sets. These latter were established on the Continent as soon as pre-selected sites for them had been cleared by the ground forces. Early in 1944, some sheets based on the 1/500,000 air maps were produced for trial and training, and were successful. Subsequently 13 series totalling about 70 different sheets were produced for operations on the Continent.

They differed from the standard air maps in that the basic detail was printed in a broken black, layer tints were omitted, pastel tints were used for woods, water and roads, and the hyperbolic curves were overprinted in strong colours.

Soon after "D"-day transmission signals from the mobile "Gee" chains were utilized by the heavy bombers of Bomber Command and Eighth U.S.A.A.F. and by the carriers of both Ninth U.S. Troop Carrier Command and Transport Command R.A.F., who found the "Gee Lattice Topo." maps, as the new series was called, of immense value. For the faster and lighter bombers, night fighters and reconnaissance aircraft, whose missions were of long duration, and whose small cockpits made it difficult to change maps during flight, other maps known as "Gee fixing charts," on a scale of 1/1,000,000, were produced.

High-altitude maps for fighter aircraft

For some months before "D"-day, heavy, medium and light aircraft of all air forces located in the United Kingdom were striking at the enemy's com-

munications and centres of production. For these operations standard air maps were used as well as other special maps described above, but, with all this production it was found that provision had not been made for everyone. Single-seater, long-range fighters of the Eighth U.S. Fighter Command were accompanying heavy bombers on daylight raids, travelling very long distances at high altitudes, and for these a series of "High Altitude Fighter" maps at 1/1,000,000 scale was hastily produced.

Lighthouse recognition charts

Many squadrons of Fighter Command and 2nd T.A.F. were striking at the enemy at low level, "hedge-hopping" from their bases to the target. Only the most careful pre-flight study of maps and photographs could bring them to their objectives, and to assist pilots in checking their landfalls and so correct their course, the series of 'Lighthouse Recognition' charts, first designed by Coastal Command, was extended by the addition of sheets covering the English Channel and the North Sea.

Maps for use by close-co-operation squadrons

The assault on the Continent of Europe involved the employment of all air forces and all types of aircraft. Those most directly concerned with the land fighting were the close-co-operation squadrons of 2nd T.A.F., the Tactical Air Forces of the Ninth U.S.A.A.F., and the carriers and tugs of Ninth U.S.A.A.F., 46 Group R.A.F. (Transport Command), and 38 Group R.A.F. (2nd T.A.F.).

Until within a month or two of "D"-day, the squadrons of the Tactical Air Forces co-operating with the ground forces had intended to use the 1/250,000 Army/Air maps, although experience had shown that they were by no means ideal, or indeed adequate, for pin-pointing targets or for communicating with the ground troops whom they were supporting. When the various topographical series at 1/100,000 scale began to be known, more and more pilots felt that they would complete their missions with greater success if they used maps on a larger scale than 1/250,000. A decision was therefore taken that 1/100,000 scale maps should be used and they were published in Army/Air style. There were, in fact, many occasions when even 1/50,000 scale maps were used by pilots during close-support operations over limited areas.

Dropping-zone maps for airborne forces (see Plate 57)

For the carriers and tugs, whose task it was to transport the airborne troops to their dropping zones and landing fields, a special type of dropping-zone map was designed and published. Several trial maps of areas in the United Kingdom were drawn, printed and tested until final agreement was reached on the design and colour. For the airborne operations early in the morning of "D"-day, near the R. Orne in the east and at the base of the Cherbourg Peninsula in the west, special maps on a scale of one inch to one mile were prepared. They were printed in grey and black with magenta roads and town areas, so as to resemble as nearly as possible the appearance of the ground as seen from the air in semi-darkness. As the campaign developed, more of these were produced for the many planned airborne operations, few of which were actually carried out.

Other requirements

Operation "Overlord" involved the preparation of many special maps for the air forces other than those for the use of pilots and navigators. These were required for Air Staff use, for operational control, and for purposes such as briefing and security.

Large numbers of maps dealing with a multitude of subjects were required as appendices to staff memoranda and directives. The Air Staff required also an immense number of display maps for use in conference during planning.

Those required for operational control were few in number but large in area. The four principal "Sector Control" rooms in the south and east of England were equipped with plotting tables on which maps of special design were mounted. The "Headquarter Ships" and "Fighter Direction Tenders" which exercised control in the actual battle-zone during the invasion had to be similarly provided.

Survey organization at H.Q. Allied Expeditionary Air Force

After the evacuation of the B.E.F. from Dunkirk, a system of survey representation with the R.A.F. had been built up. A survey officer was attached to each of the principal R.A.F. Commands in the United Kingdom (*viz.* Fighter, Bomber, and Coastal) to look after their mapping interests, and to form a close liaison between those Commands and the Geographical Section, General Staff (War Office) which was responsible for providing their mapping and survey needs.

When the headquarters of the Allied Expeditionary Air Force was organized, a map section was formed, with Major E. G. Godfrey R.E. as D.A.D. Survey, and an American officer as his deputy. This section was responsible for co-ordinating the supply of maps to the British and American Air Forces, and the preparation and supply of maps for special purposes. It had its own small drawing office and map store. When first organized, the section was under the control of the Chief Navigation Officer, but was later placed under the Deputy Chief of Operations and Plans to whom Major Godfrey became directly responsible on all matters of policy affecting air force requirements. At the same time he was under the general technical control of the Director of Survey, (S.H.A.E.F.), with whom he maintained at all times the closest liaison.

Responsibility for the actual physical supply of maps to air formations within the A.E.A.F. lay with the following:—

D. Survey (S.H.A.E.F.) (through D.A.D. Survey, A.E.A.F.)—for H.Q. A.E.A.F., and formations operating directly under its control.

The Engineer, 9th U.S. Air Force—for all units of 9th Air Force.

D. Survey 21 Army Group—for 2nd T.A.F., R.A.F.

In October, 1944, H.Q. A.E.A.F. ceased to function as a separate entity and was absorbed into Supreme Headquarters as S.H.A.E.F./Air. The Map Section then became S.H.A.E.F./Air/Maps.

Pre-invasion activities

The period preceding "D"-day was one of intense activity and some anxiety to the Map Section. Late policy changes regarding map distribution to the air forces, delays in making operational requirements known, and belated

demands to meet current needs, taxed the map distribution centres and the drawing office to the utmost.

While the survey depots of 21 Army Group were packing and moving to their marshalling areas, and while the 9th U.S.A.A.F. map store was being re-established, the A.E.A.F. Map Section accepted the additional commitment of supplying maps to 2nd T.A.F. and to certain Commands of 9th U.S.A.A.F.

There were also demands for many special maps to be drawn and printed for the operations branch of H.Q. A.E.A.F., for airborne operations, and for use by controllers in headquarter ships during the assault.

Move of A.E.A.F. Map Section overseas

The Map Section remained in the United Kingdom until late September, when it moved over to France to join H.Q. A.E.A.F. located with S.H.A.E.F. While in the United Kingdom the Section had been fully employed serving the needs of home-based A.E.A.F. formations, including the Carrier Commands. For the many airborne operations that were planned, the Carrier Commands submitted urgent demands for 1/25,000 maps and town and village plans, which required special resources for their immediate production. In August, it was agreed that the Military Survey Directorate (War Office) would assume responsibility for map supply to the Carrier Commands so long as they were based in the United Kingdom. The fact that most of the planned airborne operations were cancelled at the last moment did not affect the need for urgent preparation of the maps as soon as planning for each operation was started.

Although bulk supplies of standard ground and air maps for the allied air forces on the Continent came from War Office and War Department sources, the Map Section undertook the preparation of large numbers of special maps, indices, etc., for use by Air H.Q. and by the allied air forces. Much of the drawing was done in its own drawing office. For reproduction and printing D. Survey (S.H.A.E.F.) arranged that 13 Map Reproduction Section R.E. would assist, and much help was received from 942 U.S. Topographical Aviation Battalion which, with its reproduction train, formed part of the U.S. Army Air Forces on the Continent. There were in addition several reproduction sections of American topographical units assigned to the 9th Air Force.

Transport of maps by air

During critical periods, such as the rapid advance through Belgium and the German offensive in the Ardennes, when normal map distribution arrangements were severely strained, S.H.A.E.F./Air/Maps arranged for map stocks to be flown direct to air formations on the Continent. This followed a procedure similar to that adopted for the ground forces during such periods, and enabled an adequate supply to be maintained at all times.

CHAPTER XII

MISCELLANEOUS THEATRES

The following maps are relative to this chapter:—

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<i>Sketch Maps</i>	13. <i>Iceland</i> 480
	14. <i>Malay Peninsula</i> 484
	15. <i>Greece</i> 488
	16. <i>Sicily</i> 498
	17. <i>The Pacific</i> facing 528

SECTION 1. ICELAND (*See Sketch map No. 13*)

Strategical Background

Early in April, 1940, German forces invaded Norway. A small British Expeditionary Force which was sent over to assist the Norwegians had, by early May, been forced to evacuate, and the enemy was left in control of Norway and its seaboard.

The maintenance of sea communications between the United States and the United Kingdom was vital to the prosecution of the war and, with Norwegian ports under German control, it was essential that the enemy should not be permitted to occupy Iceland and establish air-bases there, from which the convoy routes would be threatened.

In May, 1940, a British force landed in Iceland where, in conjunction with U.S. forces, they ensured its protection from German occupation.

Survey and mapping data available

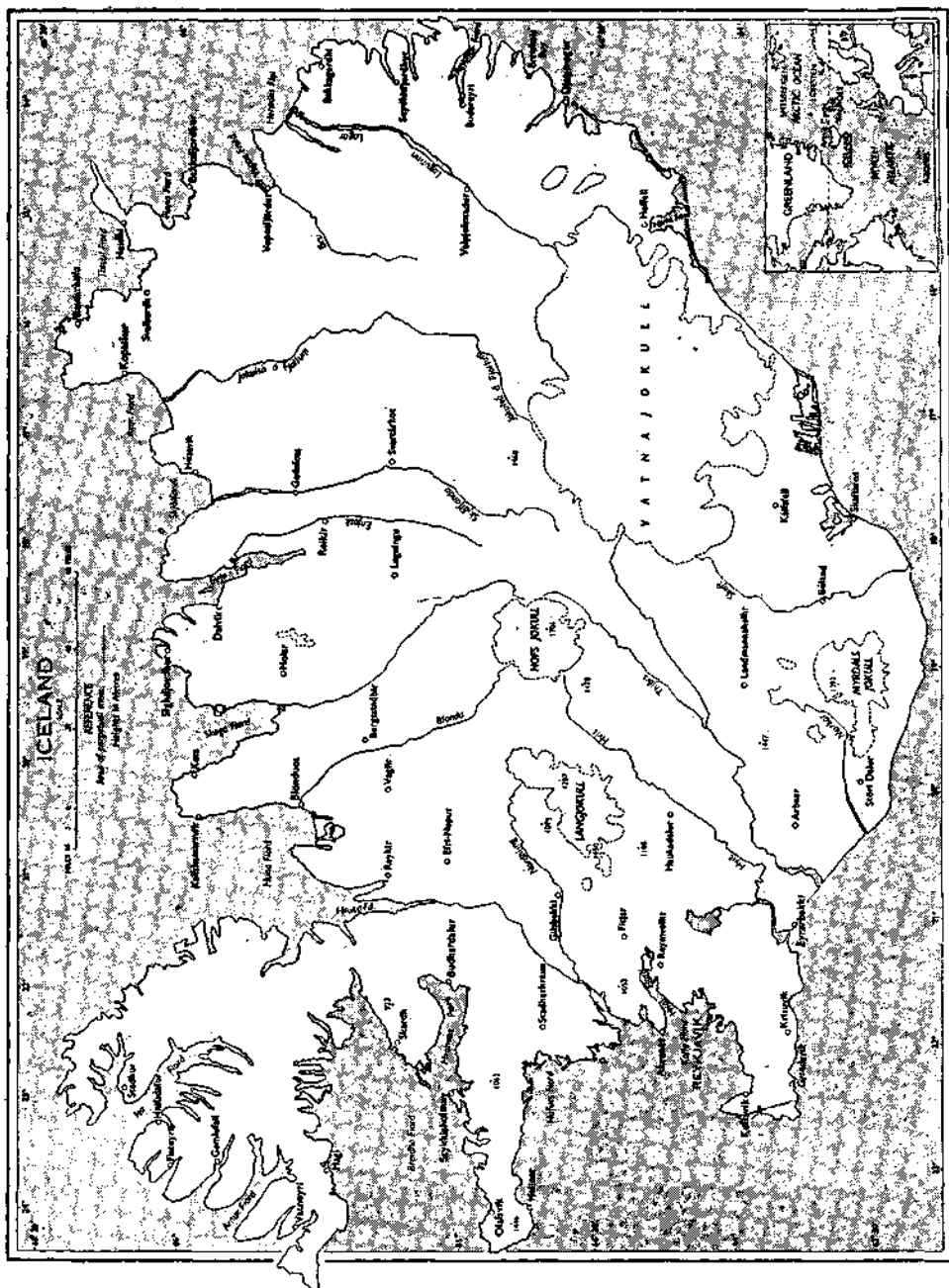
There was little available in the way of maps or survey data. Some copies of Icelandic maps on 1/50,000 and 1/100,000 scale had been reproduced by the War Office in one colour from multi-coloured originals.

The origin of the projection used by the Icelandic Survey was known, but otherwise there were no triangulation data in our possession. The War Office had prepared tables so that the geographical co-ordinates of trig points, when they were known, could be converted to the rectangular grid system which was to be adopted for the island.

Arrival of 19 Field Survey Company R.E. in Iceland

In view of the lack of maps and other survey data, it was decided to send out a survey unit. At that time 19 Field Survey Company, which had been serving in France as a G.H.Q. (Army type) survey unit, had been evacuated from Dunkirk with the remainder of the B.E.F., and was being re-formed. It was reorganized on a reduced establishment for duty in Iceland, and landed there at the end of July, 1940, under the command of Major R. H. Denniss, R.E.

SKETCH MAP 13



Drawn by Ordnance Survey 1951

The unit was organized as follows:—

Headquarters

2 Topographical sections.

1 Drawing section.

1 Printing section.

Transport

1 Utility car.

5 Motor-cycles.

22 Cycles.

Accommodation was scarce, and there was much competition for what little there was. Eventually a suitable building with a concrete floor was obtained and, as soon as the technical equipment arrived, the printing machines and ancillary plant were installed. For some time the personnel of the unit lived under canvas. Later on they erected Nissen huts on an open site adjoining their working accommodation.

Triangulation data and field surveys

Early contact was made with H.M.S. *Challenger*, which was engaged on survey work off Reykjavik, the capital, and a most useful liaison was established. Through the Commander, access was obtained to a book which contained a complete list of all trig points on the island, with their positions given in latitudes and longitudes. These values were converted to rectangular co-ordinates on the local grid, and they proved to be a sound basis for all subsequent survey work.

A conference was then held with the artillery staff to decide on a programme of survey work which would be of assistance to them. The fixation of gun positions, and the lay-out of bearings in terms of the map grid, was the first task undertaken by the topographical sections. Survey and levelling were also carried out in connection with airfield construction and the development of Naval Base projects and artillery ranges.

Most of the trig points listed in the book were well marked by cairns, were easily found, and their reliability and accuracy were found to be satisfactory. Unfortunately, some of the cairns were tampered with and damaged by the occupying troops, who did not realize their significance, and orders were issued from H.Q. warning all concerned not to interfere with them.

Mapping

1/25000 maps of the Reykjavik area. The first task was to produce 1/25,000 maps of the Reykjavik area. For this work the trig control formed a sound foundation, and the topographical sections surveyed the area, mainly by plane-table methods. The personnel of these sections, as was found in most other theatres, had little skill or experience in plane-table work, and progress on the first two sheets was very slow. The contouring in somewhat difficult country seemed to be the main source of difficulty and delay. The experience gained whilst doing these first two sheets was, however, invaluable, and succeeding sheets went much more quickly.

The drawing section was employed at first on hut erection until field sheet material became available from the topographical sections, after which they were fully employed on fair-drawing and map compilation.

Air photographs. When 19 Field Survey Company first arrived in Iceland, there were no R.A.F. units. There was, however, a detachment of the Fleet

Air Arm which undertook a small programme of air photography for mapping purposes. After covering the town of Reykjavik itself, they photographed other small areas including the site for a proposed airfield. These photos were used for the preparation of a town plan of Reykjavik and, in combination with the plane-table field sheets, greatly assisted in the compilation of the 1/25,000 maps of the area around the capital.

1/100,000 maps of eastern Iceland. The H.Q. staff was anxious to have maps covering the eastern coastal area of the island. While on a visit to the State Engineer's office, the O.C. 19 Company saw some new-looking map sheets lying on a table. These were proofs, which had been received from Denmark, of a survey covering the area in question which had not yet been published. After some persuasion the State Engineer lent him the material, and this enabled two 1/100,000 sheets to be prepared. When the State Engineer was given proofs of these new sheets, he was so delighted with them that any previous hesitation there may have been to co-operate was at once removed, and material for about 20 more 1/100,000 sheets was forthcoming immediately.

Other mapping projects. Once the unit had got into its stride, and had shown what it was capable of doing, there was the usual demand for the production of special maps, overprints, administrative diagrams, technical sketch maps, etc.

Amongst the many topographical maps published were the following, additional to those referred to above:—

- 1/50,000. 13 sheets, gridded.
- 1/250,000. 5 sheets (ungridded).
- 1/600,000 (Air). Compiled by the Air Ministry.
- 1/1,000,000. Compiled, printed and issued.
- 1/5,000. Town plan of Reykjavik.

Reproduction

When the printing equipment was received, it was found that the driving motors were not suitable for the local power supply. Apparently the unit did not take its own power generator with it, and was not, therefore, independent of local variations of voltage. A new starter coil had to be ordered from the United Kingdom and the unit electrician was able to carry out the necessary adjustments to the motors.

In the case of the guillotine, which was packed up in two separate cases, it was found that the parts contained in each case belonged to two different types of guillotine with the result that it could not be assembled.

Graining marbles proved a source of difficulty. The small quantity taken out with the equipment soon wore small, none could be obtained locally, and a new supply obtained from home arrived only just in time to prevent a complete breakdown in the printing programme.

Transport

The transport with which the unit was equipped was quite inadequate for the tasks it had to undertake in Iceland. The push-cycles certainly served a useful purpose for local recreation and for work on the town plan of Reykjavik, but they were quite useless otherwise. The R.A.S.C. were most helpful, and did their utmost to provide truck transport when it could be spared. In a country where the weather was very uncertain and where, in winter, the days

were so short, the provision of suitable transport for quick movement over difficult country was essential.

Eventually the unit received further transport though, by the time it arrived, most of the work had been completed.

Final remarks

19 Field Survey Company returned to the United Kingdom from Iceland in the spring of 1941. During its short stay in the island it had, by its working achievements, and by establishing cordial relations with other units, won its rightful position as an essential and popular unit of the occupational force.

There was no survey officer on the staff of Force H.Q., and at first there was, somewhat naturally at that early stage of the war, a certain amount of ignorance and doubt about why a survey unit had been sent there, and what were its functions.

Some of the early difficulties might possibly have been avoided or eased if the unit commander, in addition to his duties as such, had been nominated as a survey staff officer at Force H.Q.

SECTION 2. MALAYA (*see* Sketch Map No. 14)

Introduction

Until the Japanese occupation in February, 1942, Malaya consisted of the following:—

- (a) The Straits Settlements—Singapore, Penang, Malacca, and Province Wellesley.
- (b) The Federated Malay States—Perak, Selangor, Pahang and Negri Sembilan.
- (c) The Unfederated Malay States—Johore, Kedah, Perlis, Kelantan and Trengganu.

Pre-war survey organization

PERSONNEL AND FUNCTIONS

The Federated Malay States and Straits Settlements Survey Department, under the Surveyor General, was responsible for all Title Surveys.

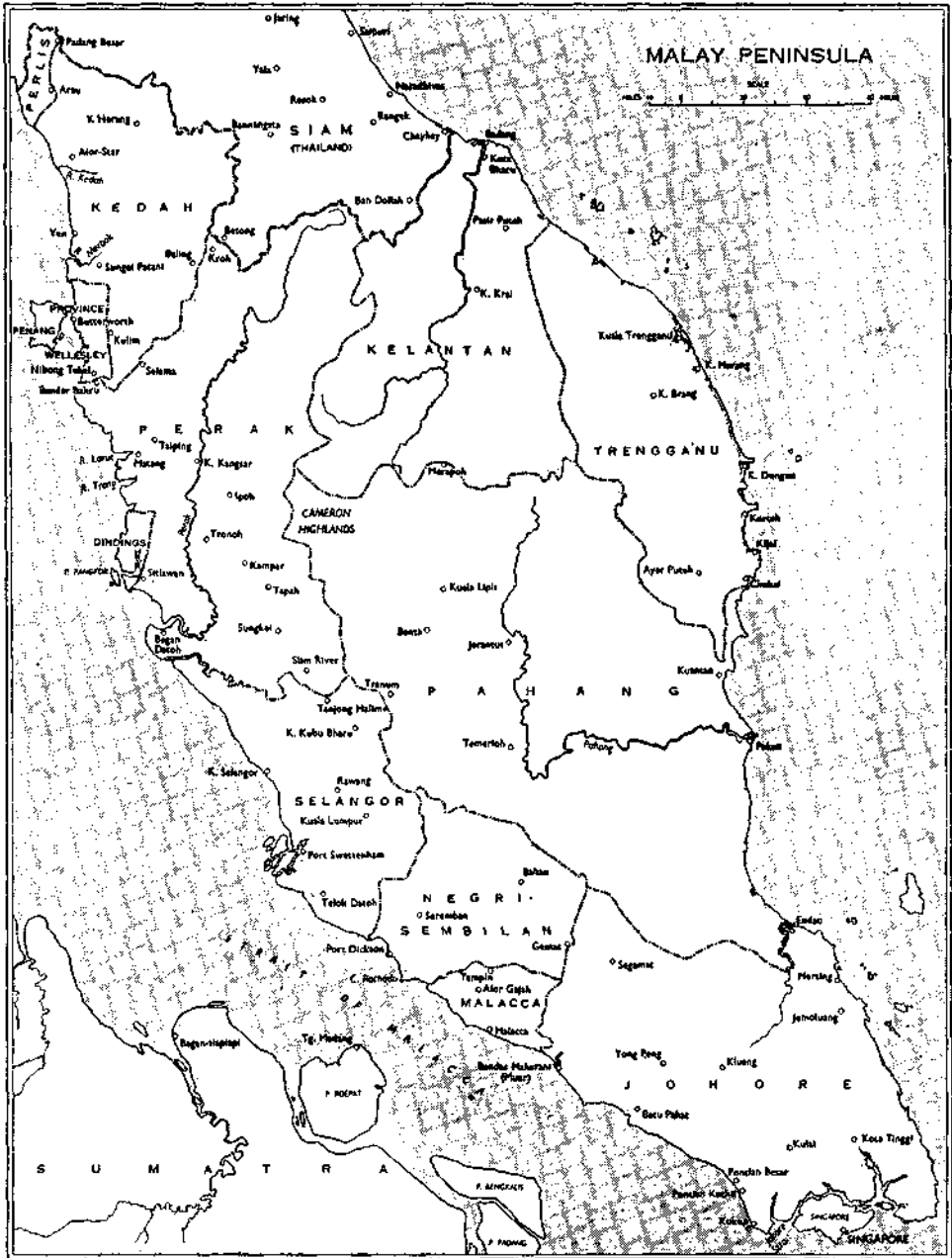
For each of the Unfederated Malay States an officer of the Survey Department was appointed by the Surveyor General as Chief Surveyor. As a result, all surveys in Malaya were, in effect, controlled by the Surveyor General who had his H.Q. at Kuala Lumpur.

The personnel of the department consisted of some 65 Europeans, about 800 locally recruited personnel, and nearly 2,000 temporary employees and coolies.

The principal functions of the department were:—

- (a) The execution and maintenance of the trigonometrical framework.
- (b) Cadastral and topographical surveys.
- (c) Map production.
- (d) Provision and custody of survey records for land administration.
- (e) Meteorological service.
- (f) Security printing (bonds, currency notes, stamps, etc.).

SKETCH MAP 14



Drawn by Ordnance Survey, 1951.

TRIANGULATION AND TOPOGRAPHY

Most of the geodetic work had been completed before 1941, and the department was chiefly engaged in cadastral and revenue surveys and topographical mapping.

The completed geodetic work had left well-constructed beacons on all the prominent hill and mountain tops, and permanent marks along many roads and railways, thus providing an accurate and fairly dense framework control for local surveys.

About 60 per cent of the country had been topographically surveyed and covered with published maps.

PREPARATIONS FOR WAR

In 1939, when war in Europe seemed to be a foregone conclusion, the Surveyor General issued a memorandum outlining action that should be taken in the event of hostilities spreading to the Far East.

The Military Command in Malaya was notified with regard to the following:—

- (a) The existing map position for military purposes.
- (b) The potential production output of the map production branch.
- (c) The situation regarding stocks of paper and other printing requisites.
- (d) The steps planned to be taken, if necessary, to deny maps and reproduction material to an enemy.
- (e) The Department's resources in the way of instrument repair and recovery.
- (f) The proposals to form a military survey section from personnel of the Department.

SURVEY CONFERENCE AT NEW DELHI

In January, 1941, the Surveyor General attended a Survey Conference in New Delhi where plans were discussed for co-operation and the co-ordination of survey and mapping resources between India, Middle East and Malaya. The Surveyor General agreed to send mapping material to India for the production there of certain maps on various scales and of certain types not produced locally. He stated at the conference that, unless extensive military reinforcements arrived in Malaya, it could be regarded as entirely self-supporting in respect of Malayan maps.

Survey activities during the campaign (December, 1941–February, 1942)

The Japanese opened hostilities against the United States when they launched their air attack against Pearl Harbour on 7th December, 1941, and declared war against Britain. During succeeding days they attacked many British and American possessions in the Far East, and Dutch possessions in the East Indies. Japanese forces landed in north-eastern Malaya on 8th December, and started their drive to the south.

Allied operations in Malaya and the Dutch East Indies were co-ordinated by South West Pacific Command with Headquarters in Java, to which Colonel G. Bomford (from Survey of India) was appointed as D.D. Survey. The following gives a brief summary of the principal survey activities in connection with the short campaign which ended with the surrender of Singapore on 15th February, 1942.

- (a) Various surveys were undertaken for the Army including the fixation of a large number of bearing pickets for artillery use. These pickets were numbered and tabulated so that bearings could be rapidly obtained.
- (b) Practically all the senior officers of the Survey Department were members of the local volunteer force, local defence corps, or other auxiliary service.
- (c) Four senior survey officers were sent to India to study air survey mapping methods, and an air survey expert was recruited who undertook the training of selected locally engaged survey officers.
- (d) Towards the end of December a Malayan Field Survey Company was formed. This was recruited from personnel of the Survey Department and was intended to serve as a unit of the F.M.S. Volunteer Force.

The establishment of the unit was as under:—

H.Q. section,
General section,
2 ground survey sections,
Air survey section,
Reproduction section.

numbering 10 officers and about 400 other ranks.

Embodiment and training began in December, but the rapid development of the campaign at that time prevented it from being used in its intended capacity. However, with an officer establishment specially increased to 20 and some 200 O.R.s, it served efficiently with the British force in Malaya during the fighting retirement through the mainland. On reaching Singapore, a detachment worked on co-ordinating anti-aircraft battery positions, and manned observation posts for flash spotting and counter-battery work.

Map production was carried on in Kuala Lumpur until the tide of war necessitated a withdrawal to Singapore. At Singapore, maps were rolled off the presses until a few days before the surrender, when production was stopped so that the plans for denying maps and machinery to the enemy could be carried out.

The Survey Company was then disbanded, and a large number of the native O.R.s found their way back to their homes on the mainland and managed to evade the prisoner-of-war camps. Almost all the officers were taken prisoner.

In January, 1942, an attempt was made to set up a map production branch in Java, and certain senior officers were sent there for that purpose. Some seven tons of survey records were crated, loaded and despatched to Java. But the end came too quickly, and fortunately the survey stores and records were never uncrated. They were sent to Australia for safety, and were handed over to the Australian forces. At the end of the war in 1945, they were returned to Malaya, and their preservation was of inestimable value towards the post-war reconstruction of the Survey Department.

SECTION 3. GREECE (*see* Sketch Map No. 15)

Summary of survey activities during the campaign

The Italians attacked Greece in the autumn of 1940, and during the winter months of 1940-41 the Greek Army put up a gallant fight. Then, in the first

week of April, 1941, just at a time when the German counter-offensive was launched in the Western Desert, German forces invaded Yugoslavia and moved through into Greece. A small British Expeditionary Force had, at that difficult moment, to be sent across from Egypt to assist the Greeks.

The mapping preparations which were undertaken for the campaign, and the arrangements for map distribution, are described in later paragraphs. Colonel M. Hotine, who had been D.D. Survey with the force in East Africa, was assigned to the Greek Expeditionary Force for survey duties and the following survey units were included in the order of battle:—

Survey Directorate.

Mobile Echelon, 512 (Army) Field Survey Company R.E. (less two sections).

517 (Corps) Field Survey Company R.E.

9 Field Survey Depot R.E.

1 Australian (Corps) Field Survey Company.

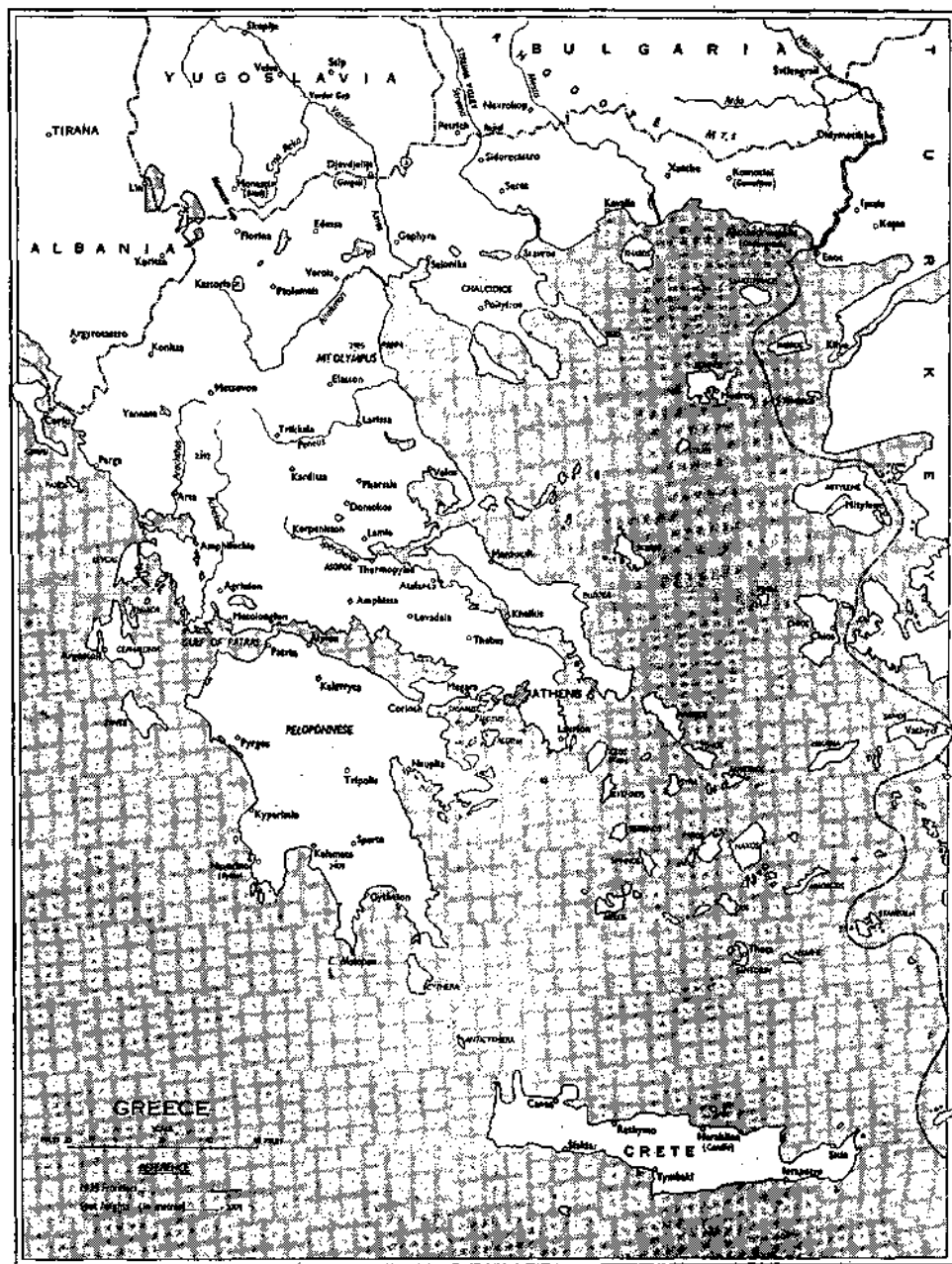
1 Australian Field Survey Company, though it never actually reached Greece, was intended to function as Australian corps troops, but it was agreed in principle that it should remain in the base area under Force control. The reasons for this decision were the inadvisability of sending heavy trailer-borne printing equipment forward on bad roads in a campaign which was most likely to prove very mobile, the necessity for spreading survey resources over the needs of the whole Force, and the fact that local map production would require material at very short notice from the Greek Survey Department in Athens. Actually this unit, which arrived in Egypt too late and without full equipment, did not sail to Greece which, as events turned out, was just as well.

Preceded by a small advanced party, the main body of the Mobile Echelon of 512 Field Survey Company landed in the Piraeus at the end of March. The topographical sections were employed on anti-aircraft gun-position surveys near Athens and the Piraeus, Greek officers assisting in the identification of trig points. Miscellaneous drawing and computing tasks were undertaken, and some of the personnel was used as reinforcement to the map depots. Air photographs of the Struma Valley were sorted out and indexed, and existing maps were revised. Photographic mosaics of selected areas were made up. If the personnel of these topographical sections had been given fuller training as draughtsmen and air-photo plotters, more could have been achieved during the campaign. Continued experience during the war in other theatres indicated that trig surveys, though often essential, do not as a rule provide full-time employment, and a wider basis of training for topographical section personnel on less specialist lines was found to be necessary.

512 Field Survey Company packed up for evacuation on 23rd April, but the German advance was so rapid that many of the personnel were taken prisoner.

517 Field Survey Company R.E. had arrived in Egypt without its printing equipment, but provisional arrangements were made for the use of local plant in Athens. The unit (less conductors for the technical lorries) sailed in one of the later convoys to Greece. Unfortunately, the technical stores of the printing and drawing sections were loaded in another ship and were lost at sea by enemy action. Leaving its topographical sections to continue work in Greece, the unit was sent back to Egypt a few days before general evacuation was ordered. Many of the topographical section personnel were taken prisoner.

SKETCH MAP 15



Drawn by Ordnance Survey, 1951.

Mapping preparations by the War Office

For possible operations in Greece the following maps had been included by the War Office in their mapping programme:—

- (a) International 1/1,000,000.
- (b) GSGS 4088 (1/250,000). 23 sheets covering the Balkans between approximately the latitudes of Volos and Sofia.
- (c) GSGS 4087 (1/100,000). 31 sheets between the latitudes of Volos and the northern frontier of Greece.
- (d) 1/500,000 air maps covering the Balkans.

Preparation of the 1/250,000 and 1/100,000 maps was started in December, 1939, and it was proposed to forward initial stocks of 3,000 copies of each sheet to the Middle East, together with black pulls for local reproduction. Some of the sheets and reproduction material had not arrived when the operations in Greece began.

Local mapping investigations in the Middle East

When the Italian offensive started in the autumn of 1940, it seemed possible that Greece, and perhaps the Balkans as a whole, might become a major theatre of operations with German forces coming down from the north.

A British Military Mission was sent to Greece to study conditions and collect information. It was unfortunate that no survey officer accompanied this mission. G.H.Q. Middle East did, however, send over a survey officer on short hurried visits to enquire into the latest Greek mapping situation. He obtained some valuable data from the Greek General Staff and Service Géographique, but a good deal of essential information was necessarily missed in the course of these short visits for which the officer could with difficulty be spared from the overworked Survey Directorate in Cairo. It seems a pity that a qualified survey officer could not have been sent out from the United Kingdom to accompany the Mission to Greece. He could have thoroughly examined the mapping situation, and eventually have been appointed to the Survey Directorate which operated there during the campaign. Wisdom after the event is easy, but the lesson should not be overlooked on future similar occasions.

The visiting officer from Cairo obtained reproduction material for four sheets of the 1/400,000 Greek staff map covering Albania, East and West Macedonia, and western Thrace. Material for local reproduction of the Greek 1/100,000 series was also acquired. It should be noted here that the GSGS 4087 edition of the 1/100,000 series was made up on sheet lines which were different from those used by the Greeks themselves. This aspect will be enlarged upon later.

The Greek maps were, of course, printed with the names in Greek characters. As, however, British forces might have to use these maps, arrangements were made to have the names transliterated. This work started in November, 1940, under a specially appointed gazetteer officer who had experience of similar work in Greece. He completed the four 1/400,000 sheets before being transferred to other duty. The work was then carried on by local Greek personnel.

In January, 1941, a signal from the War Office stated that revised name-traces had been completed and were being flown out. G.H.Q. Middle East

was asked to adopt these transliterations so as to avoid differences in names on published maps. The maps for which revised name-traces were being sent out from the War Office included three sheets of the 1/400,000 series and the 1/250,000 series. The name-traces arrived in Cairo at the end of January, 1941, by which time many copies of the current printed stock had already been issued. It was obvious that many corrections were necessary but the late arrival of the black pulls delayed the start of the revision programme.

In the meantime, at a conference between the General Staff at G.H.Q. and the Director of Survey, it was decided that the map policy for any operations which might take place in Greece would be as follows:—

- (a) To use reproductions of the Greek maps as the main supply. These were to include the 1/400,000, 1/100,000 and 1/50,000 (where the latter were available).
- (b) Names would be transliterated into English. The War Office version would be used when time permitted, but the Survey Directorate version would be adopted to save time in emergency.
- (c) Until the local reproductions from the Greek maps were ready, the War Office 1/100,000 and 1/250,000 series would be used. These would be superseded by the Middle East edition when published.

The action taken in Cairo to reproduce the Greek maps consequent on the above decisions will be described later.

Comments on the G.S.G.S. maps of Greece

The following comments may afford some lessons for future guidance.

Comparison between the G.S.G.S. map series and the mapping material obtained from Greece itself showed much discrepancy in detail, and the situation was disturbing even before the operations started.

As in the case of Belgium and Holland, who before the German invasion in 1940 preferred the myth of neutrality to co-operative action, it seems that the War Office found that Greece also was unwilling, before the war, to supply up-to-date mapping material. The G.S.G.S. maps, which were begun late in 1939, had therefore to be compiled from whatever Greek maps were available in the War Office map library and these were in many cases sadly out of date.

As a result the maps were inaccurate with regard to communications. Not only were several important roads omitted, but certain roads were included as apparently important ones which never existed at all. In any country, especially the Balkans, where good roads are not numerous, it is obvious that accurate road information is of particular importance. The G.S.G.S. sheets had apparently not been subjected to any road revision based on recent intelligence information.

The first troops to move forward to the concentration area in Greece were an armoured brigade, which commented unfavourably on the 1/100,000 maps, and asked that they should be supplied with copies of the national Greek series. There is often a tendency for British troops operating in a foreign country to jump to the conclusion that the local maps must necessarily be better than those specially prepared for them. Generally speaking this criticism is quite unjustified. In this particular case, however, the complaint, which soon became universal, was a fair one. In fact the G.S.G.S. 1/250,000 and 1/100,000 maps of the same area often disagreed between themselves.

It is probable that many of the defects were caused by using provisional one-colour editions as basic material, when clearer material in colour was available in Greece. The peace-time system of relying solely on the open map market, or the part-time service of a non-technical Military Attaché, to obtain cartographic material of a foreign country was also probably to blame. This is a lesson which will, no doubt, be taken note of when considering post-war policy for collecting map material.

With regard to the sheet-line system for a map series, there have always been two schools of thought on the subject. One opinion favours an alteration of the sheet lines bounding the national map sheets so as to conform to the grid system adopted for the British military maps. By this means the shape of the sheet is recast so as to become truly rectangular and bounded by exact grid lines. This conversion from graticule to grid sheet lines undoubtedly has certain conveniences, and amongst these is the fact that large sheets can be made up which economize in paper and printing time. The opposite school of thought favours the retention of the original national sheet lines as they stand. This means that, in some cases, uneconomically small sheets have to be used, and the grid, when incorporated or overprinted on the face of the map, will often lie askew to the sheet edges.

Considerable experience during the war has shown that, generally speaking, it is better to retain the national sheet lines. The overriding advantage is that, if and when a more recent edition of a national sheet is obtained, it can be rapidly reproduced and used in conjunction with the other sheets of the G.S.G.S. series by simply suppressing the out-of-date sheet concerned.

The decision to discard the national Greek sheet lines made it very difficult to improve the series by the rapid substitution of newer and better sheets when they became available. The arguments in favour of altering sheet lines, namely the convenience of grid as opposed to graticule edges, and the saving of paper and machine-time by making up larger sheets, do not work out in practice. There is no convenience in being forced to use out-of-date maps for military operations, nor is there any economy in drawing, printing and shipping an entire series of maps which may have to be almost immediately superseded. In Greece, the effects of this error of judgment went even deeper than mere waste. Until a sufficient extent of the area of operations had been completely covered by the newly reproduced Greek sheets, it was necessary to keep both series in issue concurrently which, as may be imagined, involved much confusion.

The order in which the sheets were received in the Middle East did not, unfortunately, conform to the changing military situation. Maps of western Thrace were available early, although operations in that area by British troops were not contemplated, and those of the Struma, Vardar and Aliakmon valleys were either not in time, or only just so. For southern Greece no G.S.G.S. maps were produced at all.

Production of Greek maps in the Middle East

When active preparations for the campaign in Greece were initiated, the discrepancies between the G.S.G.S. maps and those obtained from Greece were not at first fully appreciated. This was owing to the fact that some of the most important sheets of the 1/100,000 series had not been received from the United Kingdom.

A comparison between available G.S.G.S. sheets and the latest obtained Greek material was not reassuring. For this reason, as well as to ensure that

maps of some sort should be available to cover the areas of those War Office sheets which had not yet arrived, local production started on a new 1/100,000 series, on Greek national sheet lines, by direct reproduction from black pulls obtained from the Greek Survey Department. These new sheets carried transliterated names and the British grid.

It was decided to extend this new series rapidly so as to replace the G.S.G.S. maps in all likely operational areas. Although this was not done in time for the concentration period, it was, for the most part, completed in time for active operations.

Action was also taken by the Survey Directorate to cover southern Greece with three new 1/250,000 sheets, priority being given to a large sheet extending the G.S.G.S. 1/250,000 series south-eastwards to include Athens. Until this sheet could be made available, stocks of tourist and motor maps were purchased locally in Athens for the forward moves of units to the concentration area. There was no time to grid these, which were intended solely for unopposed movement.

Road sketch maps on a scale of 1/750,000 (with certain forward areas on 1/100,000) had been prepared in Athens immediately before the despatch of the Expeditionary Force to Greece, and they were reproduced in Cairo. They were naturally assumed to be correct and were widely issued. When complaints about these maps from the armoured brigade had been investigated, it was found that they had not been based on actual reconnaissance, either by the Military Attaché or by the Military Mission. Road information had been obtained from the Greek Survey Department who, apart from hearsay, did not claim to possess any positive information later than the last topographical revision. Immediate action was then taken by the Survey Directorate in Athens to obtain all available stocks of the Greek Ministry of Communications road maps on 1/500,000 scale, and to issue these maps, in necessarily limited quantities, to all headquarters pending reprint with the British grid. This map was compiled from annual reports of road engineers and could have been brought up to date by calling for special reports. By then, however, it was too late to take such action.

On future similar occasions it would seem advisable that a competent survey officer should be included in any Military Mission which may be sent to effect liaison with an allied government. Not only would he be well placed to obtain the most up-to-date road information possibly checked by personal reconnaissance; he would also, by close continuous touch with the local Survey Department, be able to secure information and material vital to the formulation of a proper mapping programme and survey plan. It has been proved from much war experience that these matters are outside the sphere of the normal Intelligence organization, and the importance of obtaining the most reliable technical survey information both for planning and for the subsequent conduct of operations can hardly be over-emphasized.

Air photography and large scale mapping

A few odd strips of vertical photographs had been taken for general reconnaissance purposes before the arrival of the Survey Directorate in Greece. Copies of these were sent to Cairo to assist map revision, and strip-maps were plotted from them in Cairo.

Arrangements were made for 113 Squadron R.A.F. to photograph probable target and counter-battery areas in accordance with the original plan to occupy a defensive position behind the Aliakmon River between Veroia and the sea.

1/25,000 maps were plotted from these photographs in Cairo, and were distributed just in time. They were not, however, much used because, owing to the main axis of the German offensive being directed through the Monastir Gap, no serious attempt was made to defend this position. Arrangements had also been made for photography in the Ptolemais area and for certain sections of the Olympus-Aliakmon position, which was seriously defended. But although some of the photographs were taken before the outbreak of active hostilities they were not available in time.

The sudden change in the Yugoslav political situation resulted in preparations being ordered for a defensive position west of the R. Struma covering Salonika, and photography of this area was about half-completed. 1/25,000 plotting from these photographs in Cairo was, as it turned out, rightly given priority below the Aliakmon area and was not taken up. The photographs were, however, used for the revision of 1/100,000 and 1/50,000 maps. Photographs astride the Axios River, which had been extensively canalized, were also used for map revision.

The above photography was carried out by a bomber squadron. The pilots had not been specially trained for the special type of strip navigation that is required for survey photography, and there was, in consequence, the usual waste of effort on this account. The ground organization of the squadron also was inadequate to deal with large areas of photography. If a suitable and properly equipped unit had been available for survey photography at the proper time, that is, well before the emergency arose, all likely areas could have been efficiently photographed long before the despatch of the Expeditionary Force. As it was, photography had to be improvised too late, and no amount of keen and willing co-operation, which was most certainly afforded in full measure by the squadron, could make up for this. This lesson was a recurrent one in all operational theatres.

In Greece there were no resources for local mapping from air photographs. In any case it would not have been right to have included heavily equipped survey units in the early convoys.

Provision of 1/50,000 maps

As an insurance against lack of photography for 1/25,000 mapping and possible non-arrival of new 1/100,000 sheets, it was decided to attempt the provision of a 1/50,000 series. The original Greek surveys were carried out on a scale of 1/50,000, with some areas at 1/20,000. Some of the 1/50,000 sheets, mainly in the frontier areas had already been drawn in various styles and issued in limited quantities to the Greek Army. These were reprinted, where required, by the Greek Service Géographique, with an overprint of the British grid, captions, and a few transliterated names, the overprint drawing being done by the few draughtsmen available to the Survey Directorate. Where the sheets were in one colour only, considerable clarification was obtained by red overprints on a steel-grey base. Where no 1/50,000 sheets had been drawn, the original plane-table sheets were assembled and photographed. In all cases, revision from any available photographs was added either on the base map or on the overprint.

About 50 sheets on 1/50,000 scale were produced in five weeks, and, for the most part, were used in active operations. They were an instant success. Much praise and credit was due to the spirit of co-operation and technical skill

displayed in the publication of this makeshift series by the Greek Service Géographique, in spite of its poor equipment.

Air maps

The Air Ministry 1/500,000 series of the Balkans had been prepared primarily for navigational purposes. Topographical detail had been simplified and generalized almost to diagrammatic form. In war, however, there is more than ease of navigation to be considered. Pre-war ideas regarding the employment of air forces, particularly in connection with army co-operation, were, by 1941, undergoing radical changes. It was necessary, at little notice, to identify small villages or minor cross-roads, whether as targets for air attack, or as keys for reconnaissance. In France and Belgium, during the B.E.F. operations of 1939-40, the air component had largely discarded the use of the 1/250,000 Air Series of north-western Europe in favour of ordinary detailed topographical maps. Largely for this reason the 1/500,000 Air Ministry maps were not used in Greece. Another reason was that they carried inaccurate air information, and showed Greek and Turkish airfields, which was prejudicial to security.

The 1/400,000 Greek air map had been reproduced in Cairo and supplied to the Air Force during the Albanian campaign, since this was the only up-to-date map of Greece on small scale that was then available. For operations against the Germans, however, ordinary military maps on scales ranging from 1/1,000,000 to 1/50,000 were mostly used by the R.A.F.

Map distribution

For security reasons, no initial distribution of maps of any sort whatever was allowed before the embarkation of units from Egypt during the first week of April, 1941. Consequently, it was necessary to arrange for initial issues to be made immediately the units disembarked in Greece, and before the headquarters of subordinate formations were installed. The initial plan covered disembarkation at the Piraeus, Volos and Salonika; but this was altered, and the force landed principally at the Piraeus, making map issue somewhat easier. If early disembarkation had taken place at Volos and Salonika as well as at the Piraeus, map distribution would have offered a very difficult problem, and it might have been necessary to press for initial pre-embarkation issues in sealed bundles at Alexandria, as was done for later operations involving a sea journey. Later, however, owing to heavy air attacks on the Piraeus, certain units did have to be diverted to Volos and Khalkis, and the necessary arrangements to issue them with their maps on landing were made by the Survey Directorate and No. 9 Field Survey Depot. Neither organization was then up to strength, and the dispersion of effort was a heavy strain on their resources at a time when, owing to air attacks on the ports, map consignments had to be cleared quickly, and duplicate map depots established to minimize the risk of total loss of stocks.

Owing to scanty supply, the initial issue was at the rate of about 15 per cent of the then current War Office scale of map issues. This allowed about one copy of each map sheet to each officer. When units had moved forward, issues of fresh sheets were made through headquarters of formations in the normal way. An advanced map depot was set up in the Australian Corps area and was controlled from Corps H.Q. where there was survey representation. This

facilitated a decentralization of distribution to the forward troops, and worked satisfactorily during the period of initial contact, the retirement to the Olympus-Aliakmon position, and the ensuing battle. With the prospect of a further withdrawal to the Thermopylae position a fresh problem arose. Units were not in possession of tactical maps of southern Greece, as these were only just coming into production. Roads were congested and, even if bulk supplies could have been got through to the advanced map depot, it seemed unwise to rely on this procedure with the situation changing so rapidly. The moral effect of issuing tactical maps of back areas in the middle of a battle also had to be considered. It was felt that the proper time and method for issue should be decided, probably at very short notice, by the General Staff at Advanced Force H.Q.

A mobile map depot was therefore improvised from personnel and transport of 517 (Corps) Field Survey Company R.E. and placed under the direct control of the General Staff at Advanced Force H.Q. This mobile depot was provided with bundled maps of the rear positions ready for rapid emergency issue. While the operations were in progress, new and better maps were being produced to replace the original issues, and stocks of these new editions were arriving at the base depot. Contact was maintained with Advanced Force H.Q. so that it should receive consignments of these new maps, but provision was also made for a floating detachment of 517 Company to proceed forward to a focal point on the lines of retreat, so that direct issues could be made to the units as they passed through. To provide for further emergencies, 517 Company was authorized to despatch forward, if considered necessary, further personnel and transport of the unit with fresh consignments of maps as they arrived. Under the circumstances this worked as well as might be expected, but it involved throwing in most of the surveyors and their transport available in the country. This temporary misuse of technical survey personnel and its transport was fully justified here, as elsewhere, on an occasion when map issues to the fighting troops were of such vital importance.

No. 9 Field Survey Depot, which accompanied the Survey Directorate to Greece to handle bulk map stocks and storage, was partly overrun during the later stages of the German advance into southern Greece, and lost many of its personnel as prisoners-of-war.

Triangulation (*see also* Chapter 5, Section 4)

Values for the Greek triangulation stations in northern Greece had been made available to G.H.Q. Middle East some months earlier. Those for southern Greece were obtained early in the campaign. These were based on independent azimuthal projections for each 1/100,000 sheet. Lists of co-ordinates on the British Mediterranean Grid had been compiled in Cairo under G.H.Q. arrangements and were available in time for operations.

The density of the trig control supplied to R.A. headquarters was such that it was unlikely that any assistance from R.E. survey units would be required. 4 Survey Regiment R.A. had trained their flash spotters and sound rangers to undertake minor triangulation observations, with the result that 60 pairs of good observers were available in that unit alone during the initial occupation of defensive positions.

SECTION 4. SICILY (OPERATION "HUSKY")

JULY–AUGUST, 1943

Strategical background

Soon after the launching of operation "Torch" by allied forces in North West Africa, and taking into consideration the rapid advance of Eighth Army through Libya towards Tunisia, it was necessary to come to a decision regarding subsequent strategical policy when enemy forces had been driven out of Africa.

At the Casablanca Conference in January, 1943, the following basic major issues were considered:—

- (a) It was agreed that the defeat of the enemy in Europe should hold first priority, and that all possible allied resources should be devoted to this object before concentrating on the defeat of Japan.
- (b) It was essential to open up the Mediterranean for allied convoys, and to make secure the lines of communication to the Middle and Far East.
- (c) Italy should be defeated as soon as possible, thereby reducing the threat of hostile naval and air action in the Mediterranean.
- (d) It was necessary to cause a diversion of German troops from the Russian front so as to reduce pressure against the Russian armies.

As a first step to attain the above objects it was decided that Sicily should be captured, and that planning for such an operation should be started without delay.

On the assumption that Tunisia would be freed by the end of April, 1943, a provisional target date for the Sicily operation was set. This was to be in July on a date when moon conditions would be favourable.

Operational considerations

The Sicilian operation was under the command and control of General Eisenhower at A.F.H.Q. in Algiers. Brigadier R. L. Brown, the Director of Survey at A.F.H.Q., controlled the mapping and survey arrangements for the operation and had at his disposal the technical survey resources of the Middle East under its Director of Survey, Brigadier R. E. Fryer.

In February, 1943, an allied planning headquarters was set up at A.F.H.Q. known as Force 141. This was the embryo of what eventually became H.Q. 15 Army Group, and to start with was a sub-section of G-3 (Operations) at A.F.H.Q. It became an operational staff headquarters on 15th May, independent of, but subordinate to, A.F.H.Q., and a Survey Liaison Section was attached to look after its mapping interests.

Meanwhile a British planning staff was set up in Cairo and was known as Force 545. Unfortunately it was not found possible to attach its own Survey Directorate to Force 545 in the early stages. D.D. Survey Eighth Army was not able to join the planning staff until 29th April, as Eighth Army was engaged in operations in Tunisia. He was joined later by his A.D. Survey. Until then, survey planning for "Husky" was organized and controlled by the Survey Directorate, G.H.Q. Middle East.

There were to be two Task Forces. The eastern force (545) was to be the British Eighth Army, and the western force the U.S. Seventh Army (Force 343). The original plan was that Force 545 should assault in the south-east of the island, and that this would be followed a few days later by an assault by

Force 343 in the south-west to secure the port of Palermo. Shortage of landing craft was, however, a vital factor, and eventually the plan was altered so as to concentrate the whole force for an assault landing in the south-east of the island. This plan embodied a series of simultaneous seaborne assaults which would be assisted by airborne landings to seize the ports of Syracuse and Licata, and airfields near the south-east coast. These latter would establish a firm base for subsequent operations against Augusta, Catania and Gerbini airfields. The landings were to cover about 100 miles of coastline extending from Cap Murro di Porco (south of Syracuse) westwards to Licata. The airborne operations were to include parachute and glider landings by a brigade of 1 (British) Airborne Division just south of Syracuse, and a parachute drop by 82 (U.S.) Airborne Division in the area behind Gela.

The projected operation involved complicated organization and co-operation between various widely separated theatres, as it was necessary to employ formations which would come from the Middle East, from North West Africa, and also from the United Kingdom. This wide dispersal of mounting added greatly to the difficulties of mapping up the force, as may be realized from the mounting plan given below:—

Eastern Force (British)

Assault—5 and 50 Divisions and 231 Brigade to be mounted in the Middle East, the mounting ports including Port Said, Alexandria, Haifa, Beirut, and Benghazi.

1 Canadian Division to be mounted from the United Kingdom.

51 Division to be mounted from Tunisia, partly staging in Malta.

1 Airborne Division to be mounted from Tunisia.

Follow-up—78 Division and Canadian Army Tank Brigade to be mounted in the Sousse-Sfax area in Tunisia.

Western Force (U.S.)

1, 3 and 9 Divisions to be mounted from North West Africa.

2 Armoured Division and 82 Airborne Division to be mounted from North West Africa.

45 Division to be mounted from U.S.A. but staging in North West Africa.

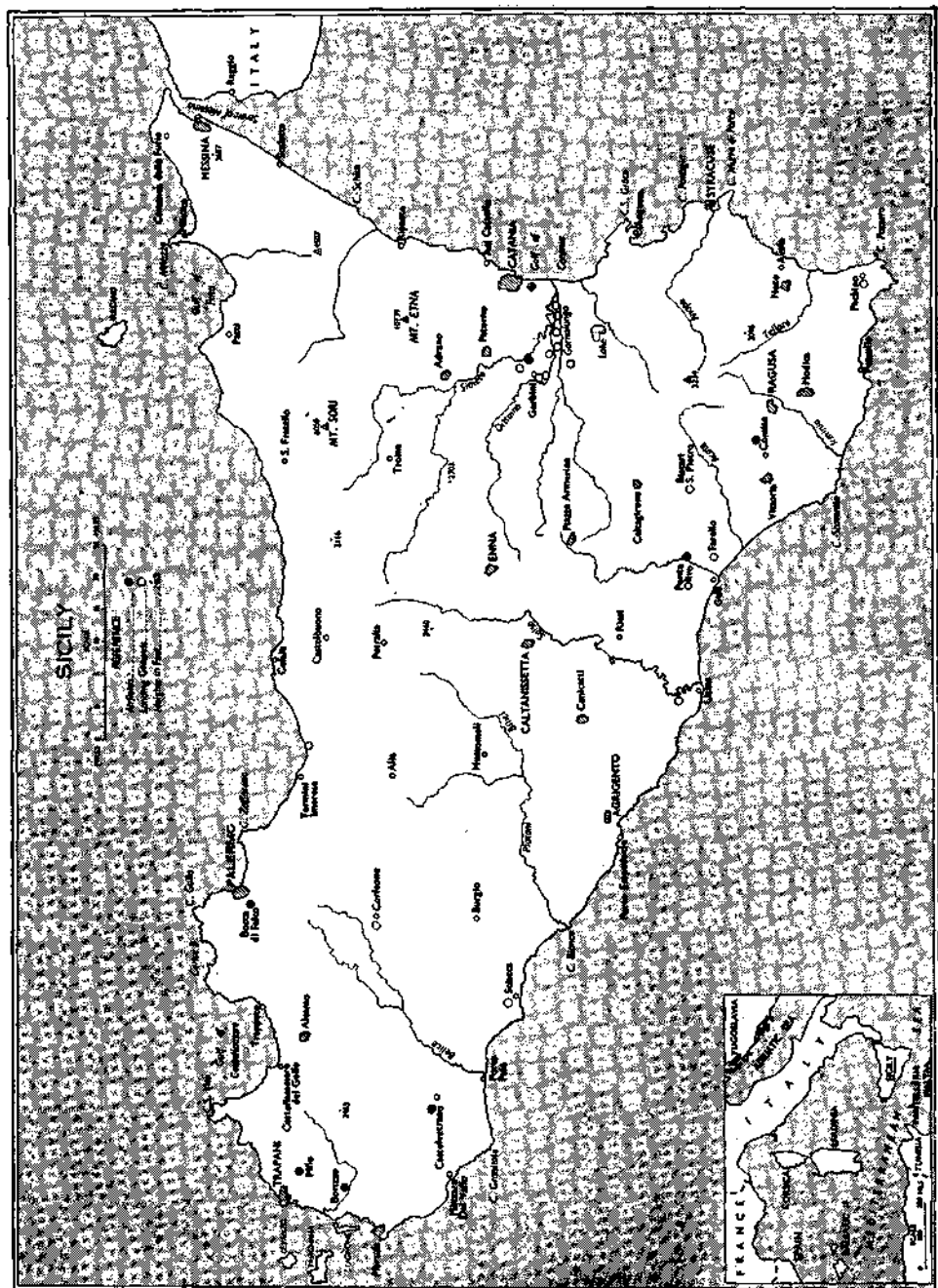
The reduction of the island of Pantellaria, which contained important enemy air bases, formed an essential preliminary to the main operation.

The course of operations

The seaborne assault was successfully carried out early in the morning of 10th July, and beach-heads and airfield were established. The planned objective for Eighth Army was Messina, the U.S. Seventh Army protecting its left flank by a limited advance only. Within ten days, however, the roles of the two armies were reversed. Eighth Army was held up at the east end of the island on the Catania plain, while Seventh Army pushed rapidly to the north and north-west, cut the island in two and, by 22nd July, had captured Palermo.

Early in August, Eighth Army were on the move again and captured Catania and Troina. Seventh Army meanwhile was pushing east from Palermo along the northern coast road and carried out a series of amphibious landings towards

SKETCH MAP 16



Drawn by Ordnance Survey 1961

Messina. Finally, on 17th August, American and British forces entered Messina, and within 38 days of the initial landing, the whole of Sicily had been secured.

Survey organization

Full details of the Survey organization at G.H.Q. Middle East (Brigadier R. E. Fryer), where so much of the planning and other preparations were carried out, are given in Chapter V.

The Survey organization, apart from that in Cairo, was as follows:—

A.F.H.Q.	Survey Directorate (Brigadier R. L. Brown). 649 Engineer Topographical Battalion (U.S.). 516 and 518 Field Survey Companies R.E. 11 and 12 Map Reproduction Sections R.E. 7, 10 and 12 Field Survey Depots R.E. Detachment 46 Survey Company (South African Engineer Corps). Atlantic, Mediterranean and Eastern Base Sections (U.S.).
H.Q. 15 Army Group	Survey Directorate (Colonel R. P. Wheeler).
Eighth Army (British)	Survey Directorate (Colonel V. E. H. Sanceau). 13 and 517 Field Survey Companies R.E. 20 (Army) Field Survey Depot R.E.
Seventh Army (U.S.)	Engineer Section. 62, 66 and 661 Engineer Topographical Companies. Engineer Map Depot Detachments.

In the case of Eighth Army, each staff branch of Army H.Q. was split before the landing. Colonel Sanceau and Lieut.-Colonel Hudson (A.D. Survey) were with the planning staff in Cairo till the end of June. On 24th June, the D.A.D. Survey went to Malta as survey representative with Army H.Q., followed later by Colonel Sanceau, Lieut.-Colonel Hudson and a small H.Q. detachment. Three days after the assault Colonel Sanceau accompanied advanced Army H.Q. to Sicily, the remainder of the Malta detachment arriving two days later. Main H.Q. of the survey branch went over from Tripoli by instalments.

With H.Q. Seventh U.S. Army there was no separate survey staff organization. In accordance with American practice, the Engineer Section at Army H.Q. was responsible for all mapping and survey activities.

Map production and supply

(a) *War Office.* Though the invasion of Sicily was mounted mainly from North West Africa and the Middle East, 1 Canadian Division, plus certain British elements, sailed direct from the United Kingdom, and their map supply was handled by the Directorate of Military Survey, War Office. The procedure followed the same pattern as that for the invasion of North West Africa ("Torch"), and the experience gained in that operation resulted in very smooth working. Unfortunately, however, some of their map stocks were lost by enemy action on the way out, and had to be made good.

(b) *Middle East.* With certain small exceptions, all maps for units of

Eighth Army which were mounted in the Middle East were printed in Cairo, and details are given in Chapter V, Section 2. Printing of stocks started on 10th April, about three months before "D"-day, but the bulk of the printing was done during June. Distribution offered many problems. Not only had sheets of the normal series to be put on the right ships for distribution after sailing, but special arrangements had to be made to deliver late editions of defence overprints to ships at sea.

All maps were in sealed and coded bundles, and distribution for Eighth Army was made to units and formations in almost every port from Suez to Algiers and also to units in Malta. There were many anxious moments, but all went well, the only troops who were at any time really short of maps being those of 1 Canadian Division, who sailed from the United Kingdom direct, who lost a great part of their map stocks by enemy action on the way out. This loss was quickly replenished.

The total number of maps printed in the Middle East for the operation was approximately 4,000,000, of which issues to troops before "D"-day numbered about 400,000.

Maps were made up in rolls of 50 and, for security, the rolls were completely wrapped in old linen-backed maps and securely gummed at the ends and in the centre. The top map of each roll of 50 was put face downwards so that, in the event of the linen-backed covering coming off the end of the roll, it would not be easy to detect what the map was.

The rolls were then taken in sacks to a coding hut at G.H.Q., the sacks being labelled so that the coding officer could identify the contents. This officer then allotted code letters for each sheet, and these were clearly marked on the rolls by personnel who had not previously handled the maps. The rolls were again placed in sacks and taken to a special issuing department some ten miles from G.H.Q. and four miles from the base map depot. For this journey, both transport and escorts were found from non-survey sources. At the issuing depot, the rolls were taken out of the sacks and stacked by sheets according to the code-list to facilitate the rapid and accurate making up of the consignments. The personnel of the issuing depot and coding hut were kept apart, and were not changed during the course of the work.

The details of distribution to ships were compiled by the survey planning staff in conjunction with the formations concerned, and lists of requirements were passed to G.H.Q. Middle East for executive action by the Survey Directorate. These lists gave details of the maps required for each ship and the ship's official code number, the latter being marked on the sacks to assist the distributing officer at the port.

No attempt was made to prepare consignments for individual units owing to constant changes in the allocation of troops to ships because of enemy action, breakdowns and delays in ports.

A total bulk consignment was prepared for each ship, to be distributed subsequently by the O.C. troops on that ship. Distribution was based on the table of "Scales of Issue," the figure for each ship of any one sheet being rounded off to the nearest "50." Except in the case of defence overprints, in which there was some variation, all ships carried the same maps in varying quantities, irrespective of their place of landing.

G.H.Q. Survey Directorate coded the lists of map requirements and gave them to a "security depot," who made up each ship's consignment from the coded rolls, which were put into good-quality double sacks, one inside the other

and sewn up at the mouths. No binding or banding was used and no wood crates were available.

The safe movement of maps from the security depot to personnel ships was effected under the control of survey officers using their own transport. Fortunately the South African Survey Company had just arrived in Cairo from the Tunis battle, and was able to assist greatly with both officers and transport. The conducting officers were, as usual, given precise instructions that they must obtain receipts for their consignments from the O.C. troops on each ship. With high security at stake no risks could be run, and it was vital to check up thoroughly to ensure that every consignment reached its destination complete and in order.

Some of the ships were small, and the issue of all maps in rolls of 50 was wasteful. A proportion of rolls of 20 or even 10 would have been advisable.

Bulk consignments for stocking map depots in Sicily were put on slow maintenance convoys. The Movements Branch at G.H.Q. called them forward for loading ten days or more before the ships actually sailed. It was found essential for a survey officer to "live almost in the pocket" of the movements officer concerned so that the dates could be ascertained in plenty of time. The fact that the Survey Directorate was located some eight miles from G.H.Q. was a disadvantage.

The following are some of the lessons which were learnt regarding map distribution during the mounting stage:—

- (a) Survey representatives of the formation carrying out the operation should be included as an integral part of the planning staff at the earliest possible date.
- (b) Survey Directorates should be located close to the General Staff which they serve.
- (c) Security measures must be kept simple, and map distribution to ships should be handled centrally by the minimum number of officers. Formations can seldom be called on to provide either transport or escorts, and survey units will frequently have to assist. Map code lists should be made out as early as possible and copies given to all officers of the survey planning staff.
- (d) Adequate arrangements for mapping up all units in follow-up convoys must be made. There is a tendency to forget the late starters.
- (e) A table of "Scales of Issue" must be prepared well beforehand. Such tables are a great help when forecasting printing requirements in the production stage.
- (f) To save printing and freight, and to avoid waste, it is desirable that a certain number of rolls containing less than 50 maps should be made up, say a proportion of rolls of 20 and of 10.

(c) *In North West Africa.* Both 649 U.S. Engineer Topographical Battalion and 516 Field Survey Company R.E. were employed under A.F.H.Q. control on the revision of 1/25,000 maps of Sicily, and 649 Battalion completed a programme of 1/25,000 photo-maps of the island so far as photo-cover allowed, and also a 1/500,000 road map.

Bulk stocks of the standard series were sent out from the United Kingdom by convoy, but there was also a great amount of reproduction and printing done by units within the theatre, partly in the form of new original production, and partly to guard against, and make up for, late arrivals or losses by sea.

The forces which had to be mapped up in North West Africa under A.F.H.Q. control included:—

Force 141 (H.Q. 15 Army Group).

That portion of Force 545 (Eighth Army) which was mounted from North West Africa, including 1 Airborne Division.

Force 343 (U.S. Seventh Army) including elements of U.S. Navy.

North African Air Force.

Western Desert Air Force.

Initial issues, which were expected to serve until "D" + 30, amounted roughly to the following:—

Force 545	50 tons (Tunis).
Force 343	150 tons (Constantine).
„	30 tons (Algiers).

The organization available for the distribution of bulk stocks comprised the A.F.H.Q. Survey Directorate and 7 Field Survey Depot, the latter being augmented by pioneers and elements of two topographical sections of 516 Field Survey Company. Road, rail and air were used to transport consignments from the main depot in Algiers to the depots where unit bundling was to be done.

For that part of Force 545 which was mounted from North West Africa, bulk stocks were sent to 12 Field Survey Depot at Tunis. There they were broken down into unit bundles under the control of D.D. Survey First Army, who was also given technical direction of a detachment of 20 (Army) Field Survey Depot at Sousse.

For Force 343 (U.S. Seventh Army) the original plan envisaged sending all bulk stocks to a U.S. Map Depot Detachment established at Constantine. It was intended that Force 343 should arrange for unit bundling to be done there and to distribute from there to sub-formations. On 12th June, this plan was put into action and large consignments were sent by rail from Algiers to Constantine. On 18th June, however, representatives of Forces 141 and 343 sought the assistance of the Survey Directorate at A.F.H.Q. as their own arrangements under Engineer Section control had not been satisfactory.

A plan was therefore evolved whereby the Force 343 Depot at Constantine remained as a bulk stock depot, and breakdown depots were located at convenient sites for the various ports of embarkation. Force 343 was asked to supply detailed distribution tables and eventually distribution was effected up to schedule, but only just in time for the operation.

Map depots move to Sicily

The main body of 20 Field Survey Depot (Eighth Army) was in Tripoli when operations started with detachments in Malta and Sousse. A Sicily detachment opened up at Syracuse on 16th July which was reinforced by the Malta detachment. The remainder of the main depot arrived from Tripoli on July 23rd. The rear depot (Palestinian Wing) remained in Tripoli temporarily, but was under notice to move to Sicily to take over the Syracuse depot when the main depot moved further forward.

Control and ground survey in Sicily

Trig information was sparse, being limited mainly to primary points. The 1/25,000 maps, however, proved to be good and accurate, and it was found best to use map co-ordinates as the basis of the artillery grid, accurate bearings being observed and carried forward with frequent checks to guard against swing.

The field survey plan for the initial operations was to send forward a joint R.A.-R.E. survey reconnaissance party with the assault troops, followed by other elements of the composite batteries and by the rest of the topographical sections. On 13 Corps front, where 3 Survey Regiment R.A. and 13 Field Survey Company R.E. were operating, this plan worked well, but on 30 Corps front one topographical section of 517 Field Survey Company was, unfortunately, left behind owing to a last-minute change in shipping priorities. The R.E. reconnaissance party consisted in each case of one officer, one trig surveyor, a driver and a jeep.

After the initial landing the battle moved too fast for much survey to be required in view of the good quality of the maps, but to the north of Catania, sheets of the 1/25,000 series ceased to be available and, in preparation for a move into less well-mapped country, a chain of triangulation covering the whole of Eighth Army front was begun.

Early in August, the topographical sections of 517 Field Survey Company were withdrawn for service elsewhere, but the campaign was then drawing to a close, and as the army front was reduced to that of one corps, the topographical sections of 13 Field Survey Company had no difficulty in meeting all requirements.

Printing in the field

Printing resources in Sicily were limited to those of the field survey companies. Their chief task was the printing of the large scale maps and any other maps or overprints of a special nature which might be asked for not exceeding demy size.

Air photography

As far back as 1941, when D. Survey, Middle East, first began to consider mapping plans for Sicily, requests were made for systematic photography of the island. At that time the R.A.F. was preoccupied with the vital task of fighting and bombing, and was too ill-equipped to be able to spare suitable aircraft for the job. By early 1943 the situation had improved and the allied air forces were in the ascendant.

Early in March, 1943, D. Survey, realizing that the air-photo situation was unsatisfactory, represented the facts to No. 1 Planning Staff (Force 545) in Cairo. Force 141 (Algiers) were asked if they could arrange for suitable aircraft to photograph Sicily for survey purposes. At the end of March, it was stated that no aircraft suitable for survey photography were available in North West Africa, but that the Intelligence Branch had ordered reconnaissance photo-cover over the island. This task was undertaken by U.S. "Lightning" single-seater fighter aircraft equipped with 6-inch cameras. These were not suitable for air survey work as their view forward was poor, making navigation difficult, and they were easily "jumped" by enemy aircraft. This resulted in short random sorties with much variation in height and considerable tilts. They did, however, obtain a very useful amount of photography which was used for revision. It was estimated that the photography of the south-eastern corner of Sicily would be completed by 14th April, but there were delays, and the hold-up of

the mapping programme was so serious that a request was made for the two Mosquitoes which were operating with 60 Squadron (S.A.A.F.) in Tunisia. On 20th May, Mediterranean Air Command (M.A.C.) threatened to re-equip the two Mosquitoes for normal photo-reconnaissance work and this action was only prevented by the personal intervention of General Leese (Acting Army Commander) with General Alexander. The two Mosquitoes were returned on 10th June, and operational sorties began for air survey photography over Sicily on 13th June and were successfully completed.

SECTION 5. THE PACIFIC (*see* Sketch Map No. 17 facing p. 528)

Introduction

The conduct and control of operations against Japan in the Pacific was in American hands and, by agreement between the War Office and the War Department, Washington, responsibility for mapping policy, design, and initial production for the Pacific area was allocated to the United States.

Australian forces took a prominent share in the South West Pacific operations and an account of their survey and mapping activities is given in Chapter XIII, Section 2.

The following is a brief summary, compiled from the limited records and data available, of the U.S. topographical organization and its mapping and survey activities for supporting the operations in the Pacific resulting in the Japanese surrender on V.J.-day. It is added for general interest to complete the global picture and touches only the fringe of the extensive mapping problem that had to be solved.

Topographical control

Survey control in the Pacific was at first more complex than it ever was in Europe largely because of the splitting of the vast zone into multiple theatres of operations.

In the South West Pacific the Chief Engineer directed the work of the topographical units, but in the Mid-Pacific area, the Chief Engineer and the Navy shared control and the Joint Army and Navy Intelligence Staff exercised a general overall control by formulating a comprehensive mapping plan.

Towards the end of the war, the need for centralizing the control of all survey activities was realized when General Loper was assigned as Chief of the Intelligence Division of the Office of the Chief Engineer, Allied Forces in the Pacific Area (A.F.P.A.C.). All topographical responsibility throughout the Pacific was then placed under his direction.

Topographical units

So far as available records show, it would appear that, at the peak of their strength, the following American topographical units were available in the theatre:—

China-Burma-India Theatre

- 1 Topographical Battalion (Army).
- 1 Topographical Company (Aviation).

- 1 Map Depot Team.
- 1 Air Force H.Q. Company.
- Total strength about 800 all ranks.*

The Pacific Theatre

- 3 Topographical Battalions (Army).
- 8 Topographical Companies (Corps).
- 3 Topographical Battalions (Base).
- 1 Reproduction Company (Base).
- 1 Lithographic Reproduction Platoon.
- 1 Photo-mapping Platoon.
- 2 Survey Platoons.
- 8 Map Depot Teams.
- 4 Model-making Teams.
- 1 Reproduction Team.
- 3 Survey Liaison Teams.
- 5 Aviation Topographical Companies.
- 3 Air Force H.Q. Companies.
- 1 Aviation Reproduction Detachment.
- Total strength about 6,800 all ranks.*

Early mapping situation

The pressing need for the many and various types of maps essential for effective planning and operations will be apparent when consideration is given to the military situation in the Pacific at the time when U.S. forces were ready to take the offensive.

Pearl Harbour and after. The Japanese attack on Pearl Harbour took place in December, 1941, and was followed by campaigns against the Japanese in South East Asia and Melanesia. U.S. naval forces in the south-western and southern Pacific then turned the tide in Papua and the Solomon Islands. The Japanese penetration into Burma was held by British forces and, at the close of this period, an aggressive strategy by allied forces was under consideration.

The Planning Stage during 1942. While planning for an offensive, the planning staffs were handicapped by lack of adequate map coverage in critical strategic areas. In the Solomons, New Guinea and the numerous islands of the Pacific the available maps consisted principally of hydrographic charts which were out of date and unreliable.

For Java, Sumatra, Malaya and Indo-China there were good maps available and for these areas the U.S. Army Map Service and British map production organizations took action to print bulk stocks. The A.M.S. in Washington obtained mapping material at 1/50,000 scale covering most of Japan, from which maps were reproduced.

American Mapping Unit in Australia. In March, 1942, 648 Engineer Topographical Battalion took up permanent quarters at Melbourne, Australia. Only a limited amount of low-grade reconnaissance photography was available at that time, and this restricted their mapping output, but they quickly compiled and printed bulk stocks of hasty sketch maps and photo-maps for use during the campaign in Papua and the Australian operations in north-eastern New Guinea during 1943.

Mapping organization in Hawaii. For the Central Pacific Area 64 Engineer Topographical Company was established in Hawaii in June, 1942. This unit prepared maps and compiled topographical intelligence material for amphibious operations amongst the Pacific atolls and, in conjunction with an engineer unit operating in Portland, Oregon, they were engaged on map production for the U.S. forces in the northern Pacific, including operations in the Kurile Islands.

Air photography (1942-44)

When mapping units first began to operate in the Pacific, it was apparent that the procurement of suitable aerial photography for mapping purposes was going to be a difficult problem. Distances were enormous and, with only very limited quantities of suitable aircraft available, there was difficulty in obtaining sanction for long-distance missions to obtain only a few photographs when there was a critical need for air reconnaissance to meet immediate tactical demands.

In 1944, however, a directive was issued from Washington stressing the vital need for obtaining long-range photography, and this directive specified definite objectives and laid down priorities.

As a result, aircraft from the China Theatre procured valuable photo-coverage of Formosa from which the A.M.S. produced and distributed map stocks to support any operation that might be undertaken to capture the island.

Carrier-borne aircraft also procured photography of Saipan and Guam from which the 29th Engineer Battalion produced topographical maps by Multiplex methods.

Late in 1944, some rather poor photo-coverage was obtained of Okinawa and other parts of the Ryukyu Islands by the use of carrier-borne aircraft, and long-range aircraft based on Saipan.

Long-range photographic reconnaissance aircraft also began to amass considerable coverage of the southern shores of Japan itself when the strategic bombing of Honshu and Kyushu began at the end of 1944. Arrangements were made for 21 Bomber Command to procure mapping photography in conjunction with bomb assessment.

Mapping plans for 1945

A comprehensive mapping plan was drawn up for 1945 in which all areas of likely operations were considered, and provision made for long-range planning. 21 Bomber Command were to follow this plan as a basis for procuring mapping photography, and the Chief of Staff authorized the plan as representing official policy, and outlined specific operations for the mapping of Japan and its approaches.

In the Pacific Ocean Area (P.O.A.) good co-ordination was built up between the staff sections who dealt with aerial photography and mapping. Both the theatre photographic officer and the theatre mapping officer were responsible direct to the Assistant Chief of Staff. Photographic specifications and target dates, which were recommended to the theatre mapping officer by the Engineer, were immediately acted upon by the theatre photographic officer, who had authority to assign missions to the appropriate land-based or carrier-based air units.

Early in 1945, when the Pacific Commands were reorganized into the Naval Forces and the Army Forces, the need for establishing a closer relation-

ship between the mapping programmes laid down by the Headquarters of the Army Forces in Manila and the Pacific Area Command on Guam became an urgent one. A Pacific mapping conference took place therefore, at Oahu in the Hawaiian Islands on 25th May, attended by air, engineer, naval and marine representatives. The requirements and commitments of all the parties involved for the remainder of 1945 and into 1946 were considered and included in the report, and it became the governing plan until it automatically lapsed upon the cessation of hostilities.

The build-up of topographical resources in the Pacific

By the middle of 1942, U.S. topographical units were being established in overseas theatres. The A.M.S. had been organized to replace the former Engineer Reproduction Plant, and it concentrated on the production of small scale series of important areas on the assumption that local resources within the theatres could produce the large scale mapping required for tactical operations. There was little or no co-ordination of the various mapping procedures adopted in different areas each under separate control. Each individual mapping organization tended to develop its own particular methods and line of approach to a problem.

In the South West Pacific, the topographical units were working under a great handicap. Ground and height control for mapping was practically non-existent. Photographs were usually available only just before the target date of an operation, and even then were generally of poor quality. These delays in acquiring photographs were, of course, owing to the fact that, in almost every case, the next operation was at the extreme range of the aircraft. Headquarters and mapping groups were slow in moving forward owing to shortages of transport, men and material. The work produced by these topographic units consisted mostly of map substitutes (photo-maps) and hasty-type maps of somewhat doubtful accuracy. Long-range mapping, the theoretical ideal, was not possible at the time of these early operations.

Stereo compilation by Multiplex equipment was not practicable in the South West Pacific owing to a lack of the special type of photography needed.

In the Pacific Ocean Area, with certain exceptions, the situation was much about the same. The planning was more comprehensive, and conformed to the mobility of the fleet. It was possible to obtain better and more numerous photographs of it because the fleet was able to organize air-strikes over an objective considerably in advance of an operation over that particular area. There was also a limited amount of specially flown photography for Multiplex compilation. To meet the three-sided character of operations in the Pacific Ocean Area, mapping suitable for all three forces, land, sea and air, was provided. Multiplex compilation methods were employed whenever possible and, as a result of proper planning, maps for the whole of the Pacific forces were eventually provided.

Mapping projects and comments

During the first six months of the war the Engineer Reproduction Plant (the forerunner of the A.M.S.), assembled and packed all available maps that could be utilized by the various Task Forces which were being deployed

to the Pacific. Bulk consignments were assembled to stock the first map depot overseas, and these were shipped to Australia with the Task Force.

There were many mapping problems to be met and resolved before the A.M.S. was in a position to provide adequate quantities of suitable maps of critical Pacific areas. Some of the mapping projects undertaken are referred to briefly below:—

1/500,000 of Japan. This was a facsimile reproduction of shaded relief originals, and it offered many difficult technical problems in production. The methods used produced a bottleneck in the negative-cutting department, and required a high standard of press-work and press-room conditions to give a satisfactory result. The absence of a standard transliteration procedure adversely affected legibility. The finished production was useful only for emergency and planning use.

1/1,000,000 Netherlands East Indies. This involved a similar technique for facsimile reproduction to that referred to above, and produced a map which was available to the planning staffs and the air forces.

1/50,000 Java and Madura (Dutch series). The original Dutch maps were of excellent quality, printed in ten colours. It was decided to copy them by process colour-reproduction methods using the Bloom technique of continuous tone plate development, and process colour negatives. This method had, however, to be discontinued half-way through the series because the necessary materials for it were not available for equipping field units. Colour-separation by hand was then adopted.

Reproduction of British maps of the East Indies. By late 1941, some hastily reproduced black and white map coverage of the East Indies was available for distribution. In addition, a substantial quantity of large scale sheets of selected areas of the East Indies were reproduced from kodak negatives supplied from British sources. These gave a half-tone grey base of the detail, overprinted in colour to accentuate streams, roads and names.

Other new series produced early in the war. During the early months of the war, several new map series were initiated. Amongst them was a 1/500,000 compilation of Japan for the air forces, and a limited emergency edition covering part of Japan at 1/50,000 scale for planning purposes. There followed a 1/500,000 series of New Guinea, and 1/250,000 maps of the Netherlands East Indies.

Compared with later productions these early maps were not of a very high standard mainly owing to a shortage at that time of experienced cartographic personnel. There was also little efficient cartographic planning, specifications were not tight enough, there was very little policy regarding place-names, and there was some misinterpretation of original material.

Mapping projects for the Pacific in 1942-43. During the latter part of 1942 and early 1943, a number of medium and small scale series of various Pacific areas were being compiled at the A.M.S. to meet planning needs. Conditions were now rapidly improving, with better map design and specifications, a firm policy regarding place names, and a higher standard of cartographic personnel.

Compilation was started on maps of Korea (1/250,000), China (1/250,000), Sumatra (1/250,000), the Philippines (1/500,000), and Eastern Asia (1/1,000,000).

In order to speed up completion of mapping projects, and to prevent a growing tendency to continue work on a given task indefinitely by incorporating every piece of new material as it came along and continually changing procedure and technique, a more decisive policy was instituted. Stringent target dates were laid down, after which no new compilation data were to be included unless materially vital, and technical procedure, once approved and laid down, was strictly followed. By this means backlogs were eliminated.

Mapping projects for the Pacific during 1943-44. Mapping projects for the Pacific were assigned third priority throughout 1943 and well into 1944. By July, 1943, the A.M.S. had published approximately 15,000 different maps, of which half were of Pacific areas. By 1st July, 1944, the number had risen to nearly 28,000, and the 50 per cent quota for the Pacific area was maintained by producing emergency editions and reprints of British publications of South East Asia.

Cover plans, and the effect of leap-frogging tactics, involved numerous mapping projects which were never wanted or used. Amongst these were the large scale maps of Sumatra initiated late in 1943, the Formosa project started late in 1944, and the Chou Shan undertaking.

The Philippines. In 1944 representatives from the South West Pacific Area visited Washington to discuss plans for mapping requirements in the Philippines. These involved the preparation of maps at 1/25,000 and 1/50,000 scale for specified operations. These requirements were supplemented by the Chief of Engineers and the A.M.S. who added further publications on lower priority which proved invaluable during subsequent operations.

To meet the particular needs of beach-landing operations, offshore data were incorporated in the topographical maps. Most of the original source-material for the Philippines was of poor quality, suitable mapping photography was practically non-existent, and there was little ground or height control.

Formosa. Concurrently with the Philippines project there was a demand from Pacific Ocean Area for maps of Formosa at 1/25,000 and 1/50,000 scales. These were produced by Multiplex compilation. The project was much impeded by the transfer of 29th Engineer Topographical Battalion to the South West Pacific Area, and the work had to be allotted to other agencies.

Okinawa. Late in 1944, there was an urgent request for maps of Okinawa on 1/25,000 scale. Lack of suitable photographs was once more the chief factor which hindered the progress of the work.

The Chou Shan project. This requirement was sandwiched in between the Formosa and Okinawa projects and the many European mapping commitments on which the A.M.S. was so heavily engaged. Progress was much speeded up by the fact that a good deal of work had already been done in areas included within this task.

Build-up of "cushion-stocks." In accordance with the policy drawn up at the Oahu mapping conference in 1945, the A.M.S. built up "cushion stocks" of all critical areas. During the month of June, 1945, the A.M.S. produced and shipped 27,000,000 maps. These proved invaluable to meet occupational requirements subsequent to V.J.-day.

Map styles. Styles and scales did not differ materially from those used in Europe except that the air maps were of the fluorescent type as used by the U.S.A.A.F., and a target area designation grid was extensively used.

Size of editions (1/25,000 scale). In preparation for the final assault on Japan, requisitions for 1/25,000 maps reached a figure of approximately 90,000 copies of each sheet. In Europe there was, especially during the close fighting in Normandy, an increasing demand by all arms for large scale maps, which had originally been produced primarily for artillery use. The large demand for this type of map for the Japanese operations gives food for thought. There were, of course, a large number of troops involved, a number of different places from which the assault operations would be mounted, and an uncertainty of the exact assignment of missions until a date when it would be too late to effect an amended distribution. There was also a need for insurance against loss on a long sea-voyage where the use of air transport for bulk stocks was out of the question.

British share in the Japanese mapping programme. In accordance with the British-United States mapping agreement, the latter were primarily responsible for the production of maps of Japan and the Pacific in the same way as the British were primarily responsible for the European Theatre. As regards Japan, the War Office Survey Directorate undertook a portion of the mapping project at the request of Washington. This programme was not completed, nor were the results required owing to the sudden cessation of hostilities.

Beach-gradient determination

So far as is known, the determination of beach gradients was not a responsibility of topographic units in the Pacific, but was largely a naval task. A great deal of general information on beaches was provided by the Office of the Chief of Engineers, with the help of the Beach Erosion Board, and further detail studies were made in the field by intelligence agencies of the Army and Navy.

Personal reconnaissance by special naval teams was sometimes possible, and aerial photography in various forms was extensively used during the latter stages of the war. Special beach intelligence units, organized for the purpose of deriving the best possible information on beaches from available data and aerial photographs, were set up towards the end of the war, but never got into full play. It is understood that they would have operated under G-2 (Intelligence), and the topographical units would have participated only in drawing and reproducing the results.

Map distribution

For the early "island-hopping" operations, map distribution was effected by using improvised methods to fit in with the operational plan and the resources available. Re-supply was handled by using every available form of transportation, from aircraft to refuelling vessels.

For the final operations against Japan it was the intention to adopt a systematic map supply scheme on the European pattern, strengthened by an improved organization. It was recommended that at least one base map distribution company should be used, containing at least eight map distribution platoons and a transportation platoon with approximately 88 tons of truck-lift. There would have been extra facilities for map distribution at all levels.

CHAPTER XIII

DOMINION AND COLONIAL SURVEY UNITS

SECTION 1. CANADA (*see Sketch Maps Nos. 11 and 12*)

Formation

On 3rd September, the day on which war was declared in Europe, recruiting began in Ottawa for a Corps Field Survey Company R.C.E. When a strength of close on 90 all ranks had been reached recruiting ceased temporarily, and training began under the direction of the G.S.G.S. in Ottawa.

Recruiting restarted early in January, 1940, and ceased on 15th January, when the unit reached its full strength of seven officers and 137 other ranks.

Move to the United Kingdom and early training activities

The unit, under the command of Major W. J. Baird, R.C.E., sailed from Canada on 29th January, 1940, and after four weeks' military training at Aldershot, moved to Southampton where it underwent technical training in map reproduction and printing, and in field topographical surveying. Opportunity was taken to attach printing personnel to the Ordnance Survey for practical work. To allow of training in the use of mobile printing equipment, the War Office provided two double-demy hand-fed lithographic presses mounted in trailers, similar to those being used at that time by survey units with the B.E.F. in France.

Survey Directorate

In accordance with current British practice with regard to survey units and their control, during the winter of 1939-40 a Survey Directorate was formed at H.Q. Canadian Corps, with Lieut.-Colonel E. B. Elkington, R.E., as A.D. Survey. The Canadian Field Survey Company operated under his technical control as corps troops. In June, 1941, Lieut.-Colonel Elkington was succeeded by Lieut.-Colonel (later Colonel) H. L. Meuser, R.C.E.

Later on, when the build-up of Canadian Forces in the United Kingdom made it possible to form the First Canadian Army, this Corps Survey Directorate was reorganized as an Army Survey Directorate, with Colonel Meuser as D.D. Survey, an appointment which he filled with great distinction throughout the whole war. From then onwards, the survey control and operation of the survey units was on an army, instead of a corps, basis.

The compiler of this survey history who, as D. Survey successively with G.H.Q. Home Forces, 21 Army Group, and finally S.H.A.E.F., was privileged to work in close contact with Colonel Meuser and his Canadian survey units, is glad to take this opportunity of expressing his appreciation of their superlative achievements and co-operation during the period of training and preparation for the Normandy assault, and subsequent operations on the Continent.

Reorganization of the survey unit and training activities (1940-42)

After Southampton, and a short stay near Stratford-on-Avon, the company moved in August, 1940, to Cobham, Surrey, where it remained until August, 1942.

While at Cobham, the unit was reorganized and became the 1 Canadian Field Survey Company R.C.E., coming directly under Army control. It thus conformed to the change in War Office policy whereby Field Survey Companies R.E. ceased to work on a corps basis and became army troops units. Now under the command of Major W. K. McDonald, R.C.E., it numbered approximately 160 all ranks and consisted of:—

- H.Q. Section.
- 2 Topographical Sections.
- 1 Drawing Section.
- 2 Reproduction Sections.
- 1 Camera Section.

It had now been equipped with the new-type mobile printing and photo-mechanical lorries which replaced the trailer-borne presses. The equipment comprised two printing lorries (with demy-size, single-colour, full automatic feed Crabtree presses), and two photo-mechanical helio lorries for plate-making, proving, etc. Later on, these were replaced by stronger chassis to stand up to the strain of bad roads and active service conditions.

Training, both military and technical, continued in all branches of their work.

Further reorganization (1943)

Increase in strength. In the late summer of 1942, the company moved to Ripley, Surrey. Here it was increased in strength by the addition of special increment sections which were attached to the topographical, drawing, and reproduction sections of the unit for training. At this time, also, the camera section received its mobile lorry fitted with an auto-focussing camera. A static-process camera was also acquired and this at all times proved to be of great value.

Formation of Field Survey Depot. In April, 1943, the 1 Canadian (Army) Field Survey Depot was formed to cope with the problem of map storage and supply, and for holding and issuing to survey units stocks of expendable survey stores. The establishment of this unit was at first based on the British standard type of Field Survey Depot R.E. with one officer, 18 other ranks and one 3-ton lorry. The map stocks and survey stores held and issued by the depot were controlled directly from the Army Survey Directorate.

There was, however, a change in War Office policy as affecting the establishment of a field survey depot serving an army. Mainly as a result of experience gained with Eighth Army in North Africa, where it was found essential for Survey to assume responsibility for distribution down to divisions, a new and larger type of unit was approved. The Canadian Army conformed to this change, and in January, 1944, the depot was enlarged to three officers and 63 other ranks, with one car (light), three trucks (15-cwt.), and 16 3-ton vehicles.

This enlarged depot was organized so as to form a main depot and a depot section (advanced). Arrangements were also made to attach to the H.Q. of each corps and division under command a sub-section consisting of one

storeman, one driver and a racked 3-ton lorry for holding map stocks. Allowance was made for two corps and five divisions.

Formation of three separate companies. In June, 1943, the Canadian Army found it necessary to increase the strength of its survey troops, and it was decided to adopt a new type of organization. In the British Army, the survey strength considered necessary to support an army in the field was provided by allocating two or more standard-type Field Survey Companies R.E., each of which was technically and administratively self-contained, and capable of carrying out limited amounts of field survey, map compilation, drawing, and map reproduction and printing. In addition, a corresponding number of General Field Survey Sections were usually added, which were trained primarily for field survey and air-photo mapping work. With this organization there was always one self-contained survey unit (more if necessary) which could be detached at a moment's notice to support a special Task Force for a specific operation. On the other hand, the D.D. Survey could at any time, if he so wished, brigade together sections of similar type from two or more of the companies for mass production work, whether for field survey, mapping or printing.

The Canadian reorganization broke up the original all-purpose field survey company, and substituted three separate and independent units, one being for field surveys, one for map reproduction and printing, and the third for air survey and mapping. An Air Survey Liaison Section was also formed.

A few remarks on these types of units are given below:—

2 Canadian Field (Topographical) Survey Company R.C.E.

This was organized for carrying out all forms of field surveys, with special emphasis on the rapid supply of trig data to assist the artillery on the army front. It consisted of a headquarters and six topographical sections. The unit was very mobile, and the field parties were provided with jeeps instead of the 15-cwt. trucks used previously, thus enabling them to drive practically anywhere and quickly.

3 Canadian Field (Reproduction) Survey Company R.C.E.

This unit was organized for map reproduction and printing as under:—

H.Q.

4 Reproduction Sections	} With mobile equipment.
2 Map-Photo Sections	

(Note—At a later stage one of the Map-Photo Sections was transferred to No. 4 Canadian Field (Air Survey) Company.)

4 Canadian Field (Air Survey) Company R.C.E.

This unit was formed in June, 1943, to specialize in mapping work, more especially the production of new maps, and the revision of existing ones, from air photographs. Air survey methods had been used a great deal in Canada before the war, and it was therefore natural that the Canadian military survey organization should have a decided trend towards these methods for military mapping. Principally under the energetic leadership and control of Major L. G. Trorey, R.C.E., the 4 Canadian Field Survey Company produced remarkable results, both in connection with mapping preparations for the Normandy invasion, and during subsequent operations on the Continent through north-eastern France, Belgium, Holland and Germany.

Major Trorey built up a most efficient mapping organization, and trained the personnel to a high standard of rapid production methods. The unit had at its disposal a limited amount of Multiplex plotting equipment of which valuable use was made. Major Trorey also designed and had manufactured for unit use various items of photogrammetric apparatus, the most useful of which was, probably, his "anharmonic" rectifier which enabled map detail to be compiled quickly and accurately from the photographic prints.

The company was organized into sections dealing with control, interpretation and marking up the photos, detail compilation, contouring, fair-drawing, final edit, and photography.

To assist in its work a map-photo section was transferred from No. 3 Company.

30 Air Survey Liaison Section R.C.E.

This unit was formed under the control of D.D. Survey First Canadian Army, in June, 1943. Its war establishment and equipment tables were similar to those for R.E. survey units of the same type.

This small but highly technical unit was, throughout its existence, employed on special assignments connected with air survey including the following:—

- (a) The development, production supervision, and operational test of precise air survey cameras (Eagle V, with $3\frac{1}{4}$ -inch lens) embodying original and advanced optical features.
- (b) In co-operation with the National Research Council of Canada, and with the Royal Canadian Air Force, the development of a tri-camera installation in Mosquito aircraft.

(Note—Both the above were carried out under the direct personal instructions of General A. G. L. McNaughton, then G.O.C. in C. First Canadian Army.)

- (c) The determination of submerged beach gradients along the invasion coast of Normandy (Courseulles to St. Vaast la Hogue) by the wave-velocity method. This formed part of the project controlled by D. Survey (S.H.A.E.F.) between January and June, 1944.
- (d) The analysis and test of the wave-velocity method by actual tests on the Normandy coast, in co-operation with H.Q. Combined Operations and the Admiralty, between June and November, 1944.
- (e) The photogrammetric analysis of air-photos for the resection of air stations in connection with the experimental radar control of air-photographic aircraft. This work was done for G.S.G.S., War Office, between October, 1944, and January, 1945.
- (f) An analysis, from the photographs, of the internal and external orientation of tri-camera installations in aircraft, using Eagle V cameras, in co-operation with the Intelligence Division of the Chief Engineer (E.T.O.U.S.A.) and Special Wing 8th U.S. Army Air Force, between February and April, 1945.
- (g) Experimental research in connection with Multiplex plotting equipment and the slotted template, in co-operation with G.S.G.S., War Office, between May and October, 1945.

Training and productive work for operation "Overlord"

During 1943 and early 1944, intensive training was undertaken by all Canadian survey units. G.H.Q. Home Forces, followed by 21 Army Group, conducted large scale training exercises for all arms, in which the survey units took part. Sections of the topographical company carried out training in rapid triangulation, not only as individual exercises, but also in co-operation with the artillery, and the schemes were drawn up largely on the basis of triangulation conditions which were likely to be found in northern France.

Reproduction sections also worked under field conditions in co-operation with the artillery for producing such items as artillery fire plans, diagrams, task and barrage tables, and the overprinting of such information on large scale maps. Exercises were also undertaken which involved co-operation with Air-Photo Interpretation Sections for the production of defence overprints, and much valuable knowledge was gained which was to prove useful during operations following the invasion. Besides all this field-training 3 Field (Reproduction) Survey Company carried out enormous printing programmes in connection with the preparation of 1/25,000 and other large scale map stocks required for the operation.

To No. 4 Field (Air Survey) Company was allotted a share in the preparation from air-photos of 1/25,000 maps of various areas in northern France, including part of the Normandy bridgehead. During the early months of 1944, a revision programme was undertaken to check and bring the 1/25,000 maps covering the actual assault beaches up to date from the latest photos. A series of special large scale maps for the assault crossing of the R. Seine was also prepared. There was, in addition, the usual collection of special productions asked for by the various branches of army headquarters.

Apart from their technical mapping activities, all the units were trained in the waterproofing of vehicles, in the procedure of embarking and disembarking over beaches, and in all essential military subjects to fit them to take their part as fighting soldiers if the need should arise.

The invasion of the Continent

THE MOVE TO FRANCE

When the Canadian divisions first landed in Normandy they were under the command of Second (British) Army until 23rd July, when H.Q. Canadian Army arrived in the bridgehead, ready to assume command of its own troops. The Canadian Army Survey Directorate also started to function overseas. The moves of the survey units to France are referred to below.

No. 2 Company (Topographical). This unit was divided into two flights for the cross-over. The first flight reached Normandy on 9th July, and the second on 30th July.

No. 3 Company (Reproduction). This was also divided into two flights as a safety measure. The first flight went over on 28th July, and the second left the United Kingdom on 31st July, taking four days to get over.

No. 1 (Air Survey) Company. In September, 1944, No. 4 Company was reclassified as No. 1 Company, which title it held for the remainder of the war. Leaving the United Kingdom on 18th August, it took some days to cross and, on arrival, was first installed just outside Caen.

1 Canadian Army Field Survey Depot. The depot section (advanced) landed at Courseulles-sur-Mer on 30th July, convoyed to Fontaine-Henry,

and within two days was functioning as a map depot with stocks sorted and with sub-sections out with corps and divisions.

The main depot arrived overseas on 3rd August, and organized its lay-out of survey stores and bulk map stocks. The latter were obtained from No. 4 Field Survey Depot R.E. (which was the 21 Army Group base map depot) and from 3 Canadian (Reproduction) Survey Company which had begun the printing of 1/25,000 maps required by the fighting troops.

OPERATIONS FROM "D"-DAY TO V.E.-DAY

The First Canadian Army operated throughout on the left, or seaward, flank of the allied forces. The stubborn battles around Caen were followed by the break-out from the bridgehead, the crossing of the Seine, and the quick pursuit through the Pas de Calais into western Belgium and south-western Holland. In connection with all these operations, the survey units contributed their valuable support, especially concerning the production and supply of maps of all sorts without which the army could neither move nor fight.

Then came the vital operations for clearing the Lower Scheldt and the approaches to Antwerp, including the capture of Walcheren Island. There followed the fighting to clear southern and eastern Holland, and the approaches to the Rhine between Nijmegen and Wesel. Finally came the crossing of the Rhine itself and the pursuit into Germany leading up to the enemy surrender.

Some of the principal activities of the units concerned are touched on briefly below:—

2 Canadian Field (Topographical) Survey Company. Survey triangulation control was carried forward from the Normandy bridgehead to the Seine but, at this stage, the advance was so rapid that survey was not required for artillery purposes. It was during the operations round Caen leading up to the break-out that this unit suffered considerable casualties, including the severe wounding of Lieut.-Colonel W. K. McDonald who had by then become A.D. Survey at Army H.Q. and was up forward co-ordinating the survey control work. He had to be evacuated to Canada and was unfit for further service overseas. This was a great loss to the survey organization.

After the break-out the principal survey tasks undertaken included the following:—

- (a) Checking and amplifying the trig control around Boulogne, Cape Gris Nez, Calais and Dunkirk, where enemy pockets still held out.
- (b) Checking the triangulation from Bruges northwards towards Ghent, and from Eindhoven to Turnhout.
- (c) Survey support to the force which captured Walcheren and cleared the Lower Scheldt for opening up the port of Antwerp.
- (d) Survey of a network of microphone stations in connection with the defence of Antwerp against enemy V-weapons.
- (e) Revision of 1/25,000 maps from air-photos. After some special training the unit took over part of the programme being handled by the Air Survey Company.
- (f) Survey support to 2 Survey Regiment R.C.A. during operation "Veritable," which cleared up the area west of the Rhine between the Rivers Maas and Rhine.
- (g) Establishment of trig control in the Nijmegen and Arnhem area.

- (h) Surveys of bridge sites for the Rhine crossings at Emmerich in conjunction with Canadian Army Troops Engineers, and also for sites at Nijmegen, Zutphen, Arnhem and Deventer.
- (i) Survey support to divisions of 2 Corps during the advance into Germany until the final surrender.
- (j) Survey support to 1 Corps in western Holland.

Early in May, when hostilities were over, Company H.Q. moved back from Germany into Holland. On 1st July the unit was disbanded, and the personnel were absorbed into the other two survey units.

1 *Canadian Field (Air Survey) Company*. The history of this unit, from "D"-day onwards to V.E.-day, was a succession of urgent programmes of mapping for one operation or another. Many of these operations never got beyond the planning stage, but the special mapping required had usually reached an advanced state of preparation by the time that the cancellation order was issued. The rapid moves of the allied armies through north-eastern France and Belgium took them across obstacles such as the R. Somme and other potential defence positions with practically no opposition, where it had been anticipated that hotly disputed assault operations would have been necessary.

From Caen the unit moved to Abbeville in mid-September, and on again to Ghent at the end of the month. Here it remained until March when a further move was made to Tilburg in Holland. The stay here was only a short one, a further move being made to Almelo in mid-April, where it was located when the German surrender took place early in May.

A bare summary is given below of the output of this unit, taking into consideration only the principal large scale map series. Practically all the work was done from air-photos, and the amount of skill, energy and hard work expended by day and night, much of it under intense pressure of time, can only be properly appreciated by those who are acquainted with the technical procedure and difficulties involved. The figures given below include work done in the United Kingdom in preparation for operations on the Continent.

Revision	178 sheets
New Mapping	
1/25,000	99 sheets
1/5,000 and 1/4,000	45 sheets
1/10,000	19 sheets
1/12,500	87 sheets
Total	<hr/> 428 sheets <hr/>

3 *Canadian Field (Reproduction) Survey Company*. Within 24 hours of landing on the beaches near Arromanches, the first flight of this unit had two reproduction sections operational, and they started printing 1/25,000 maps. Apart from this more or less stock job one of the first major tasks was to produce "Going" maps, defence overprints, a fire-plan map, and engineer intelligence traces for an operation designed to break the enemy line in the Caen-Falaise area. On 4th August, half-way through the programme, the remainder of the company arrived. It is of interest to note

that the landing of this second flight involved the successful transfer by ship's crane from a Liberty ship to a landing craft of heavy technical printing vehicles weighing up to 20 tons.

There followed a quick series of moves for the unit. From Fontaine-Henry it went to Ouveille (near St. Pierre-sur-Dives), then to Brionne and, on 5th September, to Londinières whence another quick move took it to St. Omer. During these moves, demands for map printing were heavy owing to the rapid advance, which meant that the area covered by each map sheet was passed over at great speed. No attempt was made to print complete 1/25,000 cover for the whole area, but only where opposition was met or expected. The efficiency and mobility of the printing equipment was fully tested during this period.

The unit reached Ghent on 25th September, where it was able to house its printing vehicles under a roof for the first time since leaving the United Kingdom. Up till then, the work had been principally the printing of 1/25,000 maps, trying to keep ahead of the advance. Everyone worked at top speed, but it was clear that the establishment, both of personnel and printing equipment, was not sufficient to meet the requirements of the army, and plans were made to obtain reinforcements and to reorganize the unit.

On 10th October, the Company moved to Hoboken, near Antwerp, and the stay here was one of the busiest of the campaign. Maps were reproduced and printed for the crossing of the Leopold Canal, and for operations to clear the Scheldt estuary, including the assault and capture of Walcheren Island.

In mid-November, it moved on to Tilburg in Holland, and here two additional printing lorries were received, bringing the total up to six. The unit was then reorganized so as to consist of headquarters, two reproduction platoons (each of three printing lorries and two helio lorries), and a map-photo platoon.

For operation 'Veritable,' which was to clean up between the Rivers Maas and Rhine, a heavy programme was involved. This included the printing of 22 defence overprints, and a heavy output of 1/25,000 maps.

On 22nd February, one reproduction platoon was attached to 2 Canadian Corps to print fire plans for the fighting in the Reichswald Forest near Cleves. This was the first occasion on which printing equipment of any of the allied formations had crossed into Germany.

A further move from Tilburg to Oss took place in March and, during the last half of the month, a large printing programme was undertaken in preparation for the crossing of the Rhine. The final move, before the capitulation, was to Almelo on 18th April.

1 Canadian (Army) Field Survey Depot. The daily routine of a field survey depot is not very visible to the uninitiated, and is not perhaps as spectacular as that of the other types of survey units, but it is of the highest value and importance. The regular and unfailing supply of maps to the fighting troops is entirely dependent on field survey depots operating within the theatre, and the work requires most skilful and energetic handling by all those concerned. The Canadian Field Survey Depot maintained a very high standard of efficiency throughout the whole campaign, and its task was anything but an easy one.

The detailed control of map supply and issues was exercised from the

Survey Directorate, which had to maintain a constant and close contact with the depot, and translate the operational plans into rapid action for ensuring that no movement by any body of troops anywhere should be held up or impeded by a lack of maps.

As the depot was also responsible for holding and supplying expendable survey stores such as printing paper, chemicals, etc., the whole of the printing programmes were dependent on the efficient and timely handling of this side of its business by the depot.

The depot was organized into a main depot and a depot section (advanced), the idea being that the main depot would receive and break down bulk stocks and pass them to the depot section for distribution. Before crossing over to France six 3-ton lorries were loaded with maps and expendable stores which the depot would collect on their arrival overseas.

The depot section, with about 25 tons of maps, landed at Courseulles-sur-Mer on 30th July and by 2nd August it had seven sub-sections out with corps and divisions in the bridgehead. On 3rd August, the main depot arrived.

During August, when there was a rapid increase in the volume of 1/25,000 maps that had to be handled by the depot, it was found that the splitting of the unit into two parts was not giving smooth working. After supplying storemen for the divisional sub-sections, the depot section had not enough man-power left to handle the map orders. Early in September, therefore, the depot section and main depot joined up and opened in one location at St. Omer.

After a period of short supply of 1/50,000 and smaller scale maps during the rapid pursuit of the enemy from the Seine into Belgium, bulk stocks began to come in from the United Kingdom in ever-increasing quantity both by sea and air. The provision of sufficient transport and its maintenance was a constant difficulty, no adequate allowance having been made in war establishments for motor mechanics. Lines of communication were widely dispersed, and the depot was soon delivering maps to places as far apart as Le Havre, Calais and Antwerp.

On 23rd September, the unit moved from St. Omer to Ghent, four 10-ton lorries being borrowed to assist the move. The number of different map series, and the stock of each sheet that had to be held, demanded a large area of covered storage accommodation with good lorry access, and this was not easy to find, especially with the rival claims of other services. It was found by experience that, in order to facilitate quick moves, it was best to make up the maps in flat bundles of 50, and pack them away in clearly marked wood cases, which were easier to move than bales. Only sufficient stocks for immediate issues were kept out of cases. The maintenance of expendable survey stores was rendered difficult, as the 21 Army Group Base Depot was back at Bayeux in Normandy for a considerable time.

On 10th October, the depot moved to Antwerp, and the counting, marking and checking of map stocks was brought up to date, the first opportunity since the landing. Until then the depot staff had been working night as well as day-shifts to keep pace with the inflow and outflow of map stocks and stores.

The air-transport of maps from the United Kingdom was by now well organized. Consignments were accompanied by an officer from the War

Office, and at Brussels airfield he obtained R.A.S.C. lorries and delivered maps direct to the survey depot. The build-up of map stocks for operations in Germany was now taking place with increasing momentum.

During the winter of 1944-45, the large number of sub-sections that had to be maintained with field formations caused a heavy drain on manpower. The establishment provided only sufficient for two corps and five divisions. The need for finding one sub-section for an American division and another for the Polish Armoured Division brought the number up to nine in all.

Antwerp now became the target for attack by V-weapons, and the depot building was badly shaken by blast. It was, in fact, destroyed by a direct hit two days after the unit moved on to Tilburg.

The move to Tilburg took place on 15th November, ideal accommodation being obtained in a textile factory. To move the depot was quite a major operation. Four days were required, and the number of vehicle loads, ranging from 15-cwt. trucks to 3-ton lorries, was over 70.

Map orders for divisions and corps were now being delivered daily, the distances to divisions having been greatly reduced by the move forward to Tilburg.

When the German offensive in the Ardennes was launched in December there was an accompanying threat of a possible German offensive from the north across the Maas to recapture Antwerp. The personnel of the depot took their part in defence measures at Tilburg, and the precaution was taken of moving half the map stocks with a small detachment to Eindhoven. This involved the move of over 2,000,000 maps. It may be of interest to note the map stock situation in the depot at that date:—

<i>No. of Series</i>	<i>No. of different sheets</i>	<i>No. of copies</i>		<i>Total</i>
		<i>Tilburg</i>	<i>Eindhoven</i>	
54	1,212	1,720,000	2,371,000	4,091,000

In accordance with the development of the military situation, including the crossing of the Rhine and the operations northwards through Holland, further moves of the depot took place during March and April.

On 7th March, the main depot opened at Oss (Holland), and the Eindhoven detachment moved to Grave. Canadian divisions were now on the move again, and large map issues were being made daily. Over half a million new maps were taken into stock during one week in March, and the total stock was now over 4,500,000.

The last operational move was from Oss to Almelo, a shift of 120 miles. This involved the transport of about 500 tons of maps and survey stores, and brought the Grave detachment back into the main depot again. Though no doubt justified from the security aspect, the separation of stocks had not been satisfactory. For map storage alone 15,000 square feet of floor space was used in the Almelo factory.

SECTION 2. AUSTRALIA (see Sketch Maps Nos. 3 and 17)

The Australian war effort

To provide an operational background to their survey activities, the following notes give a brief summary of Australia's war effort during the 1939-45 war:—

Europe and the Middle East. The first Australian troops reached Palestine in January, 1940, and by the end of that year, Australian manpower equivalent to one corps was spread between Egypt and Palestine.

18th Australian Brigade, while *en route* from Australia to the Middle East, was diverted to the United Kingdom where it remained during the Battle of Britain.

In December, 1940, 6 Australian Division, consisting of 16th, 17th, and 19th Brigades, moved into the Desert and relieved 4 Indian Division. It then took part in the capture of Bardia, Tobruk and Derna and, on 7th February, 1941, accepted the surrender of Benghazi.

6 Australian Division was then relieved by 9 Australian Division and was sent to Greece in company with 2 New Zealand Division. Following the evacuation from Greece at the end of April, 1941, most of the division went to Crete, which fell at the end of May.

Meanwhile British forces had to retreat in Libya and 9 Australian Division fell back to Tobruk, where it was joined by 18th Australian Brigade from the United Kingdom. After beating off a major attack in April, the Australians in Tobruk were relieved by sea in the late summer of 1941, leaving one battalion which remained in Tobruk until the town was relieved.

7 Australian Division arrived in the Middle East in November, 1940, and was employed in Syria during June and July, 1941, taking part in the crossing of the Damour River line. A brigade group from 6 Australian Division, after its return from Greece, was also employed in Syria. The armistice with the Vichy French in Syria was signed in the Australian lines.

Following the entry of Japan into the war in December, 1941, 6 and 7 Australian Divisions were withdrawn from the Middle East to the Far East in February, 1942. 9 Australian Division, however, remained in the Middle East, and took part in the Eighth Army offensive in October, 1942. It was then withdrawn and sailed for the Far East in February, 1943.

The Far East. 8 Australian Division was sent to Malaya in late 1941. Contact was first made with the Japanese on 14th January, 1942, at Genas, 150 miles north-west of Singapore. When Singapore fell on 15th February, a great part of this division was taken prisoner. One brigade group took part in the fighting in the Dutch East Indies.

In the South West Pacific Area (S.W.P.A.), Australian forces played a major part in the defeat of the Japanese. They came under the supreme command of the American General MacArthur, with General Sir T. Blamey as Commander of the allied land forces. The main fighting, so far as the Australian forces were concerned, took place in New Guinea where the 3rd, 5th, 6th, 7th, 9th and 11th Australian Divisions were employed at various times, leading up to the final landings in Borneo by 7th and 9th Australian Divisions at Balikpapan and Labuan.

Early development of military survey in Australia

In 1907, a survey section of the Royal Australian Engineers was formed for survey duties under the control of the newly formed Australian Intelligence Corps. In 1915, an amendment to the Defence Act enabled a separate Survey Corps to be raised as a unit of the Permanent Military Forces, but its work in Australia was interrupted by the 1914-18 war during which most of the survey personnel volunteered for service overseas. After the war, the Survey Corps was not reformed, its members being transferred back to the old survey section which still existed on paper. This unit then undertook, between the two wars, a considerable programme of mapping, mainly in coastal districts around Brisbane, Sydney and Melbourne.

In 1932 there was a further reorganization, and the Survey Section R.A.E. assumed its previous title of the Australian Survey Corps. Impetus was then given to triangulation and base measurements to provide a proper control for national mapping.

In 1933, the Transverse Mercator Projection and the British Modified Grid system were introduced for Australia as a whole, with 5-degree belts and a standard meridian as origin. This superseded the previous individual state surveys each depending on its own origin, a situation which rendered a proper co-ordination between the individual surveys almost impossible.

Situation at the outbreak of war (1939)

In September, 1939, the military survey of Australia was being carried out by the Australian Survey Corps numbering nine officers and 41 other ranks. Since its inception the corps had produced approximately 70 1-inch maps of excellent standard.

As part of the defence programme in 1938-39, a three-year plan of expansion of the Australian Survey Corps was started by which it was proposed to increase the strength to 15 officers and 82 other ranks. By September, 1939, this plan had been completed for the first year with regard to personnel and equipment, and some of the second-year equipment was on order.

Early in 1940, the situation in the Pacific called for a rapid increase in the rate of production of maps of vital and strategic areas in Australia as under:—

Strategic mapping scheme. This had for its object the production of a series of maps at 4 miles to 1 inch covering:—

- (a) The coastal strip from Townsville to Port Augusta and extending 200 miles inland.
- (b) The coastal strip from Albany to Geraldton extending to 100 miles inland.
- (c) Certain strategic areas around Darwin and in Tasmania.

Emergency 1 inch to 1 mile mapping scheme. This was to provide 1-inch emergency maps of the more vital areas, using civilian surveyors in the employ of the State Lands Departments. This aimed at producing maps for emergency use while field survey units were being trained for the production of the 1-inch standard maps.

Australian Survey Unit in the Middle East

The 2/1 Australian (Corps) Field Survey Company was formed in April, 1940, for service abroad. On arrival in the Middle East during March, 1941, it was immediately warned for service in Greece, but the evacuation from there

caused a cancellation of the move and it was transferred from Egypt to Palestine where it was established at Sarafand. Plane-table mapping was undertaken along the Syria-Trans-Jordan border extending south to Amman.

During the Syrian campaign in June and July, 1941, this unit produced operational maps of the area to supplement those issued by G.H.Q. Middle East. Subsequently it undertook production of a series at 1/25,000 scale in the Lebanon extending over the coastal belt from the Palestine border to Tyre. Moving then to Souk el Gharb in the Lebanon it started on a further series of 1/25,000 mapping around Damascus, and at 1/50,000 scale along the Turkish frontier in the neighbourhood of Azaz and Aleppo.

In February, 1942, following the entry of Japan into the war, the 2/1 Field Survey Company returned to Australia, where it was converted into the 2/1 Australian Army Topographical Survey Company A.I.F. Thereafter it was employed on survey duties in the South West Pacific Area.

Reorganization of the Australian Survey Corps

In September, 1940, the Australian War Cabinet approved of a survey and mapping programme for the Home Forces which embraced:—

- (a) The completion of the balance of the three-year plan for the expansion of the Australian Survey Corps, and the merging of the permanent Survey Corps into a new organization.
- (b) The raising of the following units for field survey and map production:—

- Survey Directorate at Army H.Q.
- Army H.Q. Survey Company.
- Army H.Q. Cartographic Company.
- Four Command Field Survey Companies.
- One Survey Section for the Darwin Military District.
- One Corps Survey Mobile Reproduction Section.

The above units were later converted to:—

- Land H.Q. Cartographic Company.
- Four Field Survey Companies.
- Two Army Topographical Survey Companies.
- Three Field Survey Depots.
- One Mobile Lithographic Section.

Training

During the early part of the war, recruits into the Survey Corps were reasonably competent, having had some civil training and experience in field survey and drawing, but this supply was eventually exhausted, and in 1942 a Field Survey Training Depot was established in Victoria, where new recruits were given initial training before being posted to field units. This depot was closed down in April, 1944, owing to a deterioration in the man-power position.

Equipment

To start with, the provision of technical equipment presented many difficulties. Theodolites and other technical apparatus were provided mainly from Great Britain. Local manufacture produced a quota of minor optical instruments, and local purchase from the trade helped to ease a difficult situation. The remaining operational equipment was obtained through service channels.

The development of tri-metrogon air survey methods for mapping necessitated the local provision of angulators and sketchmasters, and these were developed from American design.

In addition to field survey equipment the following reproduction equipment was provided:—

- 15 Rotary offset printing presses.
- 7 Process cameras.
- 7 Printing trailers.
- 4 Camera trailers.
- 4 Dark-room trailers.

The provision of Multiplex equipment and stereo-comparagraphs for air-photo plotting remained a difficult problem.

Survey activities in the South West Pacific Area (S.W.P.A.)

SURVEY POLICY

As has already been stated, the Australian Forces operating in S.W.P.A. were under the supreme command of General MacArthur, with mapping and survey policy directed from G.H.Q. S.W.P.A., essentially an American headquarters. General Sir T. Blamey commanded the Allied Land Forces and there was a Survey Directorate at Advanced Land H.Q. maintaining a technical liaison with the Chief Engineer at G.H.Q.

The co-ordination of Australian and American mapping agencies was effective after the initial settling-in period, during which there was inevitably some duplication of effort, conflict of ideas, and other minor "teething" troubles. In general, the Australian Survey Corps undertook the mapping for operations in which Australian formations were engaged. When, however, urgent operational planning necessitated mapping beyond the capacity of either the American or Australian agencies, mutual help was always readily supplied.

Mapping of the Australian mainland was undertaken solely by the Australian Survey Corps, as the U.S. Base Mapping Plant (648 Engineer Topographical Battalion) did not function in S.W.P.A. until late in 1942, by which time New Guinea had become the focus of operation.

Theatre responsibilities for mapping had originally been established in accordance with agreements reached between G.S.G.S. (War Office), and the mapping authorities in Washington, and in Australia. Within the theatre, local survey policy was governed by directives issued from the Chief Engineer's Office at G.H.Q. S.W.P.A. It may be of interest to quote from one such directive, as it gives an indication of the manner in which responsibilities were allocated:—

GENERAL HEADQUARTERS SOUTH WEST PACIFIC AREA

AG 061 (21 Mar 44)E

APO 500

21 March 1944.

Subject: Mapping Responsibilities.

To: Commander, Allied Land Forces.
Commander, Allied Air Forces.
Commander, Allied Naval Forces.

Commanding General, Sixth Army.
Commanding Officer, 648th Engr. Topo. Bn.

1. All previous instructions and directives from this headquarters, in so far as they may pertain to the assignment of mapping responsibilities, are revoked, and the following substituted therefor:—
 - a. Supervision and technical co-ordination of the mapping and charting program of the theater will be exercised by this headquarters. Map and/or chart production of those areas not herein allocated to other headquarters will be executed through the GHQ Base Map Plant, as set forth and described in Technical Memorandum No. 11, Office of the Chief Engineer, GHQ.
 - b. The Commander, Allied Land Forces, is responsible for the production, reproduction and distribution of all maps, produced primarily for the use of ground forces, within continental Australia, Northeast New Guinea south of latitude 5° S, and Papua including the D'Entrecasteaux Group; the islands Arafura Ceram, and Banda Seas south of latitude 0° and east of longitude 125° E, excluding Halmahera and including Portuguese Timor, and revisions and reproductions of the NEI, as already agreed upon as a result of conferences between the Survey Directorate and Commanding Officer, 648th Engr. Topo. Bn. Mapping areas other than as listed herein will be undertaken only on receipt of further directives from GHQ.
 - c. The Commander, Allied Naval Forces, is responsible for the production, reproduction and distribution of all hydrographic charts in the SWPA.
 - d. The Commander, Allied Air Forces, is responsible for the production, reproduction, and distribution of all aeronautical charts, target maps, and other operational maps for the air forces in the SWPA.
 - e. The Commanding General, Sixth Army, will accomplish with the mapping forces under his direct control such portion of the mapping program in the zone of action of the Alamo Forces as may be determined in co-ordination with this headquarters.
2. All mapping agencies within the limits of their capabilities may request assistance from each other. Free interchange of data and direct communication between all mapping agencies are approved and encouraged. This headquarters will, however, be kept informed of any changes in map production brought about by mutual agreement between mapping agencies.
3. All agencies producing the same types of maps will co-ordinate their efforts to avoid duplication of map coverage both as to scale and area.
4. No agencies other than those indicated herein will produce maps in this theater except sketch maps for terrain studies and similar publications. Such sketch maps will not contain a military grid, and will not supersede any maps produced by regular mapping agencies.
5. An officer will be designated by each commander concerned to co-ordinate the mapping program within his command. Semi-monthly reports in both graphic and written form will be submitted by mapping agencies to this headquarters, attention Chief Engineer, and will be interchanged between mapping agencies to show mapping progress during the period of the report and mapping proposed for the future.

6. Except for reproduction or revisions of existing map series, and to minimize the number of different maps produced, new maps and charts will be limited to the following scales:—
 - a. Ground Force maps: Strategic Series—1 inch to 4 miles; 1 inch to 1 mile; 1/25,000 (where Australian Forces are to operate); 1/20,000 (where US Forces are to operate); photo-maps, 1/20,000 or larger, to be wherever possible printed on the reverse side of the equivalent scale battle map.
 - b. Air Force maps: Long-range air navigational charts 1/3,000,000; standard aeronautical series 1/1,000,000, 1/500,000 and 1/250,000; plotting series 1/1,000,000; special navigational map 1/2,315,000; target maps, to such scales as best fit the situation.
 - c. Naval Force charts: such scales as are best adapted to the situation.
 - d. In any case where scales different from those listed are desired, the mapping agency will refer the proposed map to this headquarters for decision. (Note: Construction survey maps made on the spot may be to any desired scale.)
7. A copy of Engineer Technical Memorandum No. 11 summarizing Mapping and Charting activities and procedures is furnished for your information and reference.

For the Commander-in-Chief:

(Sgd.) B. M. FITCH,

Colonel, A.G.D.

Adjutant General.

SURVEY ORGANIZATION IN THE FIELD

Australian survey units were normally army or corps troops but, in the latter stages of the war, a detachment of two officers and 22 other ranks was operating with each division. This detachment consisted of survey and drawing personnel, its primary function being to establish the divisional grid as early as possible, and to revise the maps as required.

There were many changes in the order of battle of Australian survey units consequent on various reorientations of Commands, but a satisfactory situation was eventually reached whereby all the major operational formations had sufficient survey units under command to meet their requirements. By August, 1945, the survey order of battle was as follows:—

Advanced Land H.Q.	Detachment 2/1 (Army) Topographical Survey Company.
	12 Field Survey Depot.
	1 Mobile Lithographic Section.
First Australian Army	6 (Army) Topographical Survey Company.
	Detachment 2 Field Survey Company.
1 Australian Corps	2/1 (Army) Topographical Survey Company (less Detachment).
	5 Field Survey Company (less Detachments).
7 Australian Division	Detachment 5 Field Survey Company.
9 Australian Division	Detachment 5 Field Survey Company.
2 Australian Corps	Detachment 2 Field Survey Company.

Total survey troops overseas: 862 all ranks.

TRIANGULATION AND FIELD SURVEYS

With the exception of Borneo, all territory in which operations took place may be regarded as having been previously unmapped, with no triangulation or other form of basic survey control whatever. After the initial campaign at Moresby, in New Guinea, all operations were of an offensive character. As the jungle terrain did not lend itself to ordinary field survey methods, it was usually impracticable to establish any form of survey control in enemy-held territory. Consequently, the first-edition maps had to be based on control taken from whatever hydrographic charts or administrative maps could be obtained. These were mostly inaccurate, and the adopted control could well be 5 per cent in positional error with a corresponding error in azimuth.

The survey troops with forward formations had the task of establishing a better control in whatever manner best fitted in with local conditions, and a second-, third- or fourth-edition map would be produced in an endeavour to stabilize the grid, and to improve the detail plot from air photographs and ground survey. Triangulation was carried out wherever conditions allowed, but in few instances was this of a standard better than third-order. Triangulation nets were based on a local origin fixed by astronomical determinations for latitude and longitude. Control was then mainly dependent on traverses along jungle tracks.

In Borneo there existed a local triangulation for which the relevant data were partly available. In addition, some reasonably good topographical maps had been produced by the Dutch. This material was used as a basis for new operational maps and, for the first time in the history of Australian operations in S.W.P.A., it was possible to produce maps with a stabilized grid and with detail and contours of adequate accuracy thus obviating, or at any rate reducing, the need for the subsequent production of later editions.

The Australian Survey Corps was not involved in survey work other than for normal topographical mapping requirements, except for the occasional detail survey of some base installation. There was some beach-gradient determination in the theatre, but this was done by the Engineer Intelligence Section at G.H.Q., and the technical work involved was not comparable with that used in the European Theatres.

Surveys for airfield sites were also carried out under G.H.Q. control, firstly from air-photos, and later by the construction unit in the field.

MAPPING IN THE SOUTH WEST PACIFIC AREA

There were no satisfactory maps of the New Guinea area existing before May, 1942, and, although strenuous efforts were made to improve this situation, the early campaigns in the Moresby, Milne Bay, Buna, Wau and Kumiatum areas were much handicapped through lack of reliable maps. In March, 1943, the 2/1 (Army) Topographical Company arrived at Port Moresby. This unit was complete with lithographic printing equipment and, from then on, the production and printing of maps could be undertaken locally. It then became the accepted procedure for urgent operational maps to be produced in New Guinea rather than on the mainland.

For the Lae operations, conditions showed a marked improvement as a result of the time-factor being more favourable, the greater availability of survey units, and the improved standard of air photography. Except for a few isolated cases this improved situation continued, and map production was generally considered effective.

On the mainland, long-range planning maps were produced by the G.H.Q. Cartographic Company located at Bendigo, Victoria. This unit was equipped with nine litho presses, and was able to cope with the many large demands made on it.

In addition to meeting the requirements of the Australian forces, the Survey Corps was called on to produce many maps for their American allies, amongst which those for Mindanao in the Philippines should be mentioned.

The peak of the mapping effort was reached in preparation for the final operations in Borneo. The movement of units and the time-factors were critical, but the standard of efficiency of the survey units involved, together with improved air photography, the existence of some survey control, and the high pressure maintained, resulted in the production of map series which were better than any produced for previous operations in the theatre.

AIR PHOTOGRAPHS

Every endeavour was made to procure air photographs, but until 1943, the supply was not effective. Mapping of the mainland was done by plane-table methods except for a few areas for which photography was available. On the mainland this photography was taken mainly by the R.A.A.F. Survey Flight supplemented by a contract covering 20,000 square miles with a civilian firm (Adastra Airways). The Survey Flight was not, however, equipped with aircraft suitable for operational work against enemy opposition.

In New Guinea and subsequent campaigns in the South West Pacific, the U.S. Air Force supplied the air photography under the direction of the Chief Engineer at G.H.Q. S.W.P.A. This was mainly of trimetrogon type on small and medium scales, supplemented by large scale intelligence photo-coverage. As a result of constant adverse weather conditions and enemy opposition, photography was rarely in the form of block coverage, and consisted usually of the "shoot and run" type with plenty of gaps due to cloud.

This situation improved for the Borneo operations owing to greater availability of photo aircraft, less enemy opposition, and more time available for planning. But the photo-coverage never reached the ideal at any stage of the operations.

The Australian Survey Units did not possess any Multiplex plotting equipment, and compilation depended on simple graphical methods using stereoscopes and parallex bars of local manufacture. Operational mapping photography was carried out mainly with K-17 and K-18 cameras.

A national air-photo library was eventually established by the Australian Survey Corps in Melbourne.

TERRAIN MODELS

These were produced by the Australian Survey Corps for planning purposes. Others were made by the Central Photo Interpretation Unit. Scales varied from 1/1,500 to 1/50,000. The technique usually involved the use of plywood or caneite layering, with water putty for filling in the layer steps, and suitable texturing and delineation. Jungle vegetation was shown by grated sponge rubber. During the last phase of the Borneo campaign the production of some rubber-mat casts was undertaken by survey units, but owing to the difficulty of procuring latex and processing troubles in the tropics, these models were not available in time.



PHOTO-MAPS

This type of map was introduced in 1942 and seems to have been subsequently regarded as an operational requirement. The scale was usually 1/25,000, with *ad hoc* sheet lines and an arbitrary grid. They were used to supplement the normal maps, and their main advantage lay in their capacity for depicting the various categories of jungle vegetation, a topographical feature which was so important in jungle warfare.

MAP DISTRIBUTION

Field survey depots were formed, and they functioned similarly to the British units employed in other theatres. In the operational areas, supply was frequently effected by air, a notable example of which was the movement by air of 30 transport planes loaded with maps which had been produced mainly by the Australian Survey Corps for U.S. forces.

MAP RECORDS

A complete set of records of all maps and material covering the S.W.P.A. was established at the Survey Directorate. This record section controlled the interchange of all material which might be required for the reproduction of maps within the theatre.

ARTILLERY SURVEY IN S.W.P.A. AND CO-OPERATION WITH THE SURVEY CORPS

Survey Batteries were allotted on the basis of one to each division, and consisted each of a battery H.Q., 3 troops and a meteorological section. Artillery survey in S.W.P.A. was influenced by the same basic factors as in other theatres, but an important consideration was the diversity of conditions which had to be encountered. Some of the factors affecting their work were:—

- (a) Topography and vegetation, which varied from bare desert to dense jungle-covered mountains.
- (b) Climate, which affected the health of the troops, their equipment and observations.
- (c) The sparseness of trig data.
- (d) The reliability of the available maps, which varied according to the ground control available.
- (e) The nature of operations—amphibious, airborne, etc.

The primary functions of artillery survey in S.W.P.A. were as elsewhere:—

- (a) The provision of survey information to enable guns, O.P.s, and targets to be correlated on the same grid. This was the main function, and other tasks were subordinated to it in order that data for artillery units might be provided by the time required.
- (b) General survey control in the area of operations if the true grid had not already been established by Survey Corps personnel.
- (c) Surveys for anti-aircraft and coast artillery installations.
- (d) Calibration of equipment.
- (e) Assistance to the Survey Corps for mapping when required.
- (f) The fixation of control for air-photos.
- (g) Supply of meteorological information.

Operations in New Guinea indicated the need for the early establishment of survey control. It was generally found necessary to establish the artillery grid in sympathy with the maps available, this grid being converted to the true grid when the latter had been established by the Survey Corps.

In thick jungle country, survey could only be carried forward by traverse and, as the traverse legs were usually short, extreme accuracy and care were essential, making use of frequent azimuth observations. Triangulation was freely used in open areas such as at Bulolo, Markham and Ramu Valleys, and Rai Coast. This did not always mean an increase in the speed of survey, as considerable time was spent in moving to and from observing stations, and the climatic conditions affected visibility, often only two hours each day being suitable for observations.

Motor transport was rarely available for survey parties in jungle operations, and equipment had to be reduced to a minimum to perform the task in hand.

In S.W.P.A., as elsewhere, an essential need existed for close survey co-operation in the field, particularly in New Guinea. A review of operations in New Guinea indicates that difficulties arose in connection with the work of the Survey Corps and that of artillery survey units as no common origin and orientation were determined at the beginning of each operation. This resulted in two different grids being in use, thus causing confusion when new map editions were published.

Steps were taken to remedy this, and a directive which was issued to formations embodied the following instructions which were framed with a view to smoothing out the major difficulties that had been experienced:—

“Survey personnel should move into an operational area as early as practicable and, where possible, representatives of the Survey Corps should move in prior to or with the first personnel of a Survey Battery. This should ensure:—

“(a) That survey information on the true grid is available for field artillery as soon as it is in the area.

“(b) The provision of early and adequate ground control to facilitate later editions of maps of the area.

“The operational staff should consult the artillery commander before fixing the time at which the new edition of an operational map is taken into use so as to ensure that, whenever practicable, artillery information can be concerted into sympathy before the map is used.”

CARE OF EQUIPMENT

The constant care of survey equipment under tropical conditions was essential. Metal, leather and glass were very susceptible to climatic conditions. After one day's use the metal parts of a theodolite were affected sufficiently by acid from perspiration and jungle vapours to start corrosion and had to be regularly oiled after use. All leather cases and straps were left in the sun to prevent growth of blue mould.

After a period of two or three months, the glass lenses and prisms in instruments tended to develop a fungus growth. Treatment with cotton-wool damped with methylated spirits or alcohol was found effective.

It was found desirable to set all instruments on their tripods and sun-bake them for two hours at least twice a week. When stored in rooms, a constant circulation of dry air had to be maintained. Alternate conditions of hot sun

and high humidity caused warping and cracking of tripod legs. The wood parts were kept well saturated with linseed oil or other preservative and, when not in use, the tripods were stored well off the ground to avoid destruction by termites.

SECTION 3. THE UNION OF SOUTH AFRICA

(see Sketch Maps Nos. 3, 5 and 10)

Early considerations

For a few years after the 1914-18 war, the Union Defence Force had a small Military Survey Service. This was, however, disbanded and the Trig-Survey Office, which was the Civil Geodetic and Topographical Service, thereafter maintained a close contact with the Union Defence Force (U.D.F.), and encouraged its professional assistants to take part in the activities of the Active Citizen Force. The Director of Trig-Survey was then appointed Director of Military Survey for the Defence Force, and, early in 1938, he was asked to draw up a survey organization for meeting its military survey needs.

By the South African Defence Act, all citizens were liable to military training in peace-time, and the Active Citizen Force was one of the components of the Union Defence Force, and consisted of officers, senior N.C.O.s and men trained in special duties, as well as citizens undergoing peace-time training. It was organized in units of the various arms.

At that time, it was decided that the Defence Force would base its military survey organization on part-time units of the Active Citizen Force, and have no full-time military unit. The intention was that the Trig-Survey Office would, in the first instance, furnish the nucleus of the first units formed, and that recruiting would be extended to include all surveyors, engineers and draughtsmen who were interested.

Before 1939, it was thought that South African Survey units would, in the event of any future war, serve firstly in Africa, and that their organization and equipment should primarily be designed for African conditions. Although the British establishment tables for survey units (Army and Corps Field Survey Companies), had been studied, it was considered that as they had been designed mainly for European warfare, they would not suit African conditions.

With regard to technical work, the Trig-Survey carried its map production to the fair-drawing stage only. It had no reproduction or printing resources under its own control. All map reproduction and printing were carried out by the Government Printer, with whom a close liaison was maintained. As a result of this arrangement it was decided that a similar system would be adopted for the military organization and, simultaneously with the preparations for a military survey service, the Government Printer was asked to prepare an organization for a Military Printing Service to include both letterpress printing and the lithographic printing of maps. This was arranged in the form of a Mobile Printing Company which included a lithographic section.

The formation of a Military Survey Service

Assumptions. The plan was based on the assumption that the service might have to conduct its work anywhere in Africa, involving the survey of large areas of unmapped territory with bad communications.

Basic principles. These were:—

- (a) An ability to throw off self-contained detachments, which could operate for indefinite periods away from unit headquarters.
- (b) Sufficient transport to make the unit completely mobile.
- (c) Ability to conduct all types of survey, from basic triangulation to the preparation of large scale topographical maps.
- (d) The proper maintenance of all survey records.
- (e) Provision for the supply of air photographs for mapping purposes by a special air force unit.
- (f) Provision for instrument repair within the survey unit.

Original organization. The original scheme provided for:—

- (a) A Field Survey Company for field surveys.
- (b) A G.H.Q. Company for fair-drawing, long-term computation of triangulation and traverses, and the filing and maintenance of survey records.
- (c) A few staff appointments (Survey) at the H.Q. of the Union Defence Force.
- (d) A Survey Photographic Flight with the South African Air Force.

The outbreak of war caused this original plan to be modified. Contact was established with the various branches of the survey profession, and it was known that many ready-trained surveyors, engineers and draughtsmen would be available on mobilization. Training would therefore be limited to military training plus the adaptation of their basic survey knowledge to military purposes.

Mobilization

FORMATION OF A FIELD SURVEY COMPANY S.A.E.C.

The survey service was mobilized on 3rd June, 1940. The previously proposed separate Field Survey Company and G.H.Q. Company were merged into one which was called a Field Survey Company S.A.E.C. It consisted of 33 officers, 242 European O.R.s, 132 non-European O.R.s, and 115 vehicles with a major in command.

The organization of the unit was as under:—

Company H.Q., which included:—

- A geodetic officer and 5 computers.
- A map-production officer and 31 draughtsmen.
- 3 instrument repairers.

Trig Group, for all types of field surveys:—

- Group H.Q.
- 5 Trig Sections each of 4 officers and 16 O.R.s.

Mapping Group, for the compilation of line maps from air photographs:—

- Group H.Q.
- 5 Mapping Sections each of 1 officer and 15 O.R.s.

MAP REPRODUCTION AND PRINTING

At no time during the war was there any establishment provision for map printing to be included as an integral part of the South African Survey Service.

As has been previously stated, the peace-time procedure in the Union was that the Government Printer undertook this work for the Trig-Survey Department.

On mobilization, the Government Printer mobilized a printing unit for both letterpress and lithographic work, and the intention was that the printing of maps would be done by this unit as in peace-time without the survey service having any direct control or responsibility for it.

In East Africa, however, as soon as a Survey Directorate had been set up to control and co-ordinate all the survey resources that were available for that campaign, it was found desirable, as was the practice in all other theatres, to place map production and printing under the direct control of the survey service. The lithographic section of the Mobile Printing Unit was therefore attached to the South African Survey Company for technical work, and this arrangement continued throughout the war.

FORMATION OF A SURVEY DEPOT

This was formed so as to ensure that the Field Survey Company could be maintained. Its functions were to give technical training to recruits, to carry out military surveys and mapping in the Union, and to provide a reserve. The Depot, which was a Major's command, consisted of 21 officers, 190 O.R.s, and 99 vehicles.

Operations in East Africa

The move to Nairobi. On 14th July, 1940, the 1 Field Survey Company S.A.E.C. (less the mapping group which joined the unit in December) left the Union for East Africa by rail (1,400 miles) and by road (1,500 miles) arriving in Nairobi on 3rd August.

The rapid mobilization and equipping of this unit was made possible only by the following factors:—

- (a) The loyal action of the surveyors, engineers and draughtsmen who had promised to join the Survey Company when it was mobilized, and who maintained interest before mobilization by attending meetings and lectures.
- (b) The fact that all the technical personnel had been technically trained in civil life.
- (c) The support of the Trig-Survey Office, which transferred a high proportion of its technical equipment to the unit.
- (d) The provision of a block appropriation of £10,000 to cover the acquisition of technical equipment not available from military or Trig-Survey stores, with authority delegated to officers of the unit to acquire the equipment by signing government order forms.

Amendment of unit establishment. In February, 1941, the establishment of the unit was altered. It was now called the South African Survey Company, and consisted of 35 officers, 209 European O.R.s, 241 non-European O.R.s and 142 vehicles, and became a Lieut.-Colonel's command. The new organization was:—

Company H.Q. including:—

Geodetic officer and 6 computers.

3 instrument repairers.

2 Drawing Sections (each of 1 officer and 15 O.R.s).

Two Field Groups, each consisting of:—

Group H.Q. (Captain in command).

3 Field Sections (each of 3 officers and 13 O.R.s).

Photo-topographic Group:—

Group H.Q. (Captain in command).

3 Sections (each of 1 officer and 16 O.R.s).

Activities during the East African Campaign. These are described in Chapter VI dealing with the East African operations. The Survey Company remained in East Africa from August, 1940, until the summer of 1941 when it proceeded to the Middle East. The H.Q. of the unit remained in Nairobi all this time where compilation from air-photos, the fair-drawing of maps, long-term computing of triangulation, and instrument repairs were carried out. The survey operations in the field were conducted by five field sections, two map depots, a divisional survey section, and a brigade survey section. The last two were not allowed for in the establishment, but were found to be very useful in certain types of operations. In bush and other difficult country these sections navigated the formations to which they were attached and assisted them in various survey matters.

The field sections were engaged on triangulation and small scale mapping in northern Kenya, their most difficult task probably being the triangulation of the Sugoca Valley area.

The vast areas involved, and the speed of the advance, precluded systematic mapping from air-photos so, in order to provide some sort of large scale map in time for day-to-day operations, uncontrolled strip maps were prepared from air-photos, covering the main communications.

Operations in the Middle East (see also Chapter V)

The move from East Africa to Egypt. The South African Survey Company received orders during April, 1941, to move to the Middle East. There was some delay, and the move did not actually take place till some weeks later, when the unit went round by sea. The H.Q. of the unit was established at Maadi, near Cairo.

Early activities in the Middle East. Air-photo compilation and fair-drawing were done at Company H.Q., and the field sections carried out valuable surveys, the most notable of which were, perhaps, the 1/50,000 mapping of the El Alamein area, which was to prove of such value later on, and the completion of the triangulation link between the Egyptian, Palestine, and Trans-Jordan triangulations. During this period of 1941-42 several divisional survey detachments operated in the desert.

Organization

The Japanese successes in the Far East made it necessary to make provision for the defence of the Union. At that time, the largest scale map completely covering the Union was on the 1/500,000 scale, which was not large enough for use as a tactical map. It was decided, therefore, to increase the survey strength in the Union, so as to improve the mapping situation, and major changes were made in the organization of the South African Survey Service.

It was found that the policy of combining training and production in one

unit was not sound. The Survey Depot, as it originally existed, was therefore disbanded, and in its place there were formed a Survey Depot (Training), and a Survey Depot (Technical). The former provided an establishment for giving all types of technical and military training to officers and O.R.s. The latter was a unit, consisting largely of female personnel, whose main functions were:—

- (a) The production of maps from air-photos.
- (b) The compilation and fair-drawing of maps of all sorts.
- (c) The production of photographic prints, enlargements and air-photo mosaics.

The South African Survey Company was found to be somewhat cumbersome. This led to the formation of the Type "A" and Type "B" Companies. The former was designed to work as a G.H.Q. unit, and the latter as an army unit. Their composition is given briefly below:—

Type "B" (Army Survey Company.)

Company H.Q.

Map Production Group.

Group H.Q.

Two Sections (each of 1 officer and 12 draughtsmen).

Checking and Records Group.

2 officers and 6 O.R.s.

Two Survey Groups (each having a Group H.Q., and 3 survey sections).

Type "A" (G.H.Q.) Survey Company.

This was double the size of a Type "B" Company, being of a more static nature, and having 4 Survey Groups, a Map Production Group of 4 Sections, and a Checking and Records Group.

It will be noted that both units included a Checking and Records Group. Experience had shown the need for a centralized section to control and check all the work produced by the unit. American topographical units had the same sort of thing, and called them "Operations Sections." The Checking and Records Group was responsible for co-ordinating all technical work between the various branches of the unit, and arranging for the flow of work evenly and smoothly, for checking the work, and for maintaining all the technical records. In the original South African Company such a group had been found essential, but as there was no provision for it on establishment, it had been formed by robbing personnel from other sections.

Reference has been made to the use of divisional and brigade survey sections during the East African operations. In 1942, provision was made in the establishment of the Survey Company for a number of divisional survey detachments, thus enabling one or more of them to be furnished without upsetting the normal strength of the parent unit. Each detachment consisted of three officers and nine other ranks with four vehicles, and was allotted to a division only when operations warranted such action. When not so allotted the detachments operated with the parent company.

Throughout the war, the South African Survey Service supplied staff officers for the various formations with which its units were operating. As the division was the highest South African formation in the field, there was no call for the provision of a Survey Directorate. There was always, however, a South

African administrative headquarters in the field at G.H.Q. level. Although this H.Q. had administrative powers only, with no operational control, provision was made on its establishment for four survey staff officers, and these appointments were filled as and when circumstances required. The officers were attached to formations where they were needed. For example, at one period they were more or less permanently attached to such widely separated formations as G.H.Q., Middle East, A.F.H.Q. at Algiers, and H.Q., Allied Armies in Italy.

Conversion to 46 Survey Company S.A.E.C., and assignment to Eighth Army

In the summer of 1942, the South African Survey Company was converted to the 46 Survey Company S.A.E.C. (a Type "B" Company), made fully mobile, and assigned to Eighth Army for operations in Egypt and Libya. Surplus personnel after this conversion were returned to the Union.

46 Survey Company was in survey support of Eighth Army from El Alamein to Tunis, together with 517 Field Survey Company R.E. which operated as a reserve company during most of this period. The achievements of 46 Survey Company, both technical and otherwise, were outstanding. The successful production and use of block-plots, first used at the battle of El Alamein as an aid to counter-battery shoots and the destruction of enemy targets by artillery concentrations, was perhaps the technical high-light. Map supply and distribution to fast-moving and widely separated formations was a difficult and never-ending task and, in addition, there was the day-to-day preparation of battle maps and the printing of map stocks in the field on the mobile printing equipment attached to the unit.

On the conclusion of the North African campaign in May, 1943, 46 Survey Company returned to Maadi for rest and refit in preparation for its next task.

Operations in Italy

ASSIGNMENT OF 46 SURVEY COMPANY TO FIFTH U.S. ARMY IN ITALY

In August, 1943, 46 Survey Company was assigned to Fifth U.S. Army and proceeded to Tripoli pending the move over to Italy. On 8th October, it landed at Salerno.

Group A was responsible for triangulation work covering the army front throughout the whole of the campaign in Italy. Mapping preparations for the landing at Anzio were carried out, and all the other many and various tasks that fall to the lot of any survey unit working in support of an army in the field.

After completing 19 months' unbroken service with Fifth Army, during which time it was twice awarded the army plaque for excellence in discipline, performance and merit, 46 Survey Company was released from this assignment on 16th May, 1945, on the conclusion of the war in Europe.

49 SURVEY COMPANY S.A.E.C.

This unit was formed in South Africa in October, 1943, arrived at Maadi Camp in December, and reached Taranto on 25th January, 1944. Shortly afterwards it came under command of Fifth U.S. Army.

In March, 1944, it was transferred to Eighth Army, and divisional survey detachments were supplied to 6 (British) Armoured Division, 6 (S.A.) Armoured

Division, and 1 Canadian Division, remaining with them till June when it became clear that the nature of the operations did not justify the continued use of these detachments.

49 Survey Company carried out trig work over Eighth Army front until 8th April, 1945, and a detachment was furnished to 3 South African Air Force Wing, remaining with it until the close of hostilities, being engaged on special computations connected with radar.

For the crossing of the R. Po, one section was assigned to the Task Force engaged on this operation. It began its special training in February and did the survey work for the bridging of the river and the final assault and follow-up.

General comments

The following general comments and criticisms are based on opinions and statements of officers who were closely connected with the work of the South African Survey units in the field. They are recorded, for what they are worth, as a matter of general interest, and for future reference and discussion:—

- (a) *Type "B" Company.* The war proved this type of unit to be a success. In all phases of warfare encountered from El Alamein to the Alps it fulfilled practically all the requirements for survey work of an army in the field, though it has been suggested that it might be improved by the addition of a third drawing section in the Map Production Group.
- (b) *Type "A" Company.* This was intended to be used at army group or G.H.Q. level, but it was too cumbersome. It has been suggested that it would be preferable to deploy two Type "B" Companies rather than one Type "A."
- (c) *Technical training considerations.* Experience showed that plane-tableing formed the soundest basic training for survey personnel. This should be an obvious fact to anyone who has had the responsibility of seeing or controlling the work of topographical surveyors under field conditions. The South African Survey Service recognized its importance from the start.

In the Type "B" Company the Field Group personnel (surveyors, topographical) were capable of carrying out triangulation, topographical surveys, and the production of line maps from air-photos. The personnel of the Map Production Group (draughtsmen, topographical) were qualified in all types of fair-drawing for reproduction.

It was considered that the efficiency of the Type "B" Company as a whole would be improved if all surveyors and draughtsmen were qualified in the compilation of line maps and the revision of maps from air-photos.

AIR PHOTOGRAPHS

It has frequently been suggested that, from the survey point of view, it is desirable to have an air force unit specializing in survey photography. In East Africa there was a South African Air Force Survey Flight which was virtually under the control of the Survey Directorate, and it certainly made a major contribution to the successful survey support which was given during that campaign.

The personnel of the Survey Flight moved to the Middle East when the South African Survey Company arrived there, and they were formed into

No. 60 Squadron S.A.A.F. Although the chain of command between Survey and the Squadron was not so direct in the Middle East as it had been in East Africa, nevertheless 60 Squadron did act in very close support of Survey and, during the El Alamein-Tunis period, 46 Survey Company sited its camps as near as possible to 60 Squadron.

The value to Eighth Army of the block-plots and maps which were produced from air-photos may be judged from the fact that the first Mosquito aircraft supplied to the Desert Air Force were, at the personal request of General Montgomery, used by 60 Squadron.

The demand for photo-mosaics and gridded photographs was a large and growing one. Experience indicated that Type "B" Survey Companies ought to be trained and equipped to deal with this requirement. It was suggested also that the equipment should include a portable enlarging and rectifying camera, fitted in a dark-room truck.

SECTION 4. SOUTHERN RHODESIA (*see* Sketch Maps Nos. 5, 7 and 8)

Formation

In February, 1939, the Chief Staff Officer, Southern Rhodesia Forces, initiated discussions with the Surveyor General (Major L. M. McBean) regarding the formation of a Field Survey Unit in Southern Rhodesia. The War Office had drawn up a suggested establishment for a Field Survey Company (African Colonial Forces) based on West African conditions, and in July, 1939, proposed that three such companies be formed, *viz.*:—

One from Nigeria and the Gold Coast.

One from Kenya, Uganda and Tanganyika Territory.

One from Northern and Southern Rhodesia.

All the above to be combined into a Survey Battalion on mobilization.

In view of the wide variation of conditions prevailing between East Africa, West Africa and Rhodesia, the Surveyor General was of the opinion that it would be a mistake to base the organization of all three units on the West African pattern, and suggested that the establishment of their respective units should conform to local conditions and resources.

Meanwhile the East African Command, with War Office approval, had taken action to produce its own establishment for a Field Survey Company, the first sections of which were mobilized by 3rd September, 1939. The formation and activities of the East and West African Survey Companies are referred to in Sections 5 and 6 of this Chapter. Thus, for service in the East African Theatre, three distinct types of survey units were formed, the establishment of each being drawn up to fit the personnel available, a course which seemed to be inevitable owing to the limited resources of trained survey personnel.

On 27th October the Southern Rhodesian Government, in response to an enquiry from the G.O.C., East Africa Force, agreed to provide a survey unit on the understanding that supplementary African personnel would be provided in East Africa. The original war establishment of the survey unit provided for 5 officers, 14 British warrant officers and N.C.O.s, 16 coloured M.T. drivers

and vehicles, and 67 African other ranks. The organization was such as to provide a headquarter section for administration, computing and drawing, and a field section of eight sub-sections for trig, topographical and phototopographical work.

The personnel consisted of land surveyors and topographers, and men from the geological, mining, engineering and architectural professions. There were practically no map printing personnel available, as it was considered essential to keep the existing base map reproduction plant operating in Salisbury.

Of the original N.C.O.s 66 per cent were eventually commissioned and, by the end of the war, the Southern Rhodesian contribution of military survey personnel had grown to a total of 20 officers and 45 British warrant officers, sergeants and corporals.

The unit was mobilized on 2nd March, 1940, and proceeded to a training camp at Salisbury under its commander, Major (later Colonel) J. E. S. Bradford. Nearly all the personnel had undergone recent military training in the Southern Rhodesia Territorial Forces, and ten intensive days were spent on drill, morse signalling and Swahili lectures. On 12th March, the unit left Salisbury for Broken Hill *en route* for Nairobi.

A Reserve Survey Section was organized in Salisbury during May, 1940, under the Surveyor General. Its main functions were, firstly to train and supply reinforcements to the Field Survey Company, and secondly to provide topographical maps required in the Colony for defence purposes. The Government Lithographic Press, though not mobilized, carried out printing and publication duties for map making throughout the war. In January, 1941, a military Survey Directorate was formed for Southern Rhodesia with Major McBean as Director of Military Survey.

Later on, in April, 1943, by agreement with the Union of South Africa, survey trainees from Southern Rhodesia, selected from suitable serving soldiers by the Director of Survey, were sent to the Survey Training Depot S.A.E.C. at Ladysmith to complete their military survey courses. They were then drafted to the East African Command to obtain final field experience before being drafted to the South East Asia Command as reinforcements to 155 (E.A. and S.R.) Field Survey Company about which details will be given later.

The campaign in Abyssinia (see Sketch Map No. 5)

ARRIVAL AND EARLY WORK IN EAST AFRICA

On 12th March, 1940, Major Bradford flew to Dar-es-Salaam *en route* for Nairobi. The Field Survey Company, moving by road after a rail journey to Broken Hill, completed the trip of 1,650 miles in 13 days. The unit was brought up to strength by the addition of African personnel from the East African Engineers, and moved, on 3rd April, to Ngomene in the Garissa area to carry out field surveys along the Tana River, which was regarded as the forward defended locality for British East Africa. There was an immediate requirement for the mapping of some 39,000 square miles in the northern frontier district of Kenya along the Abyssinian and Somaliland frontiers where no reliable topographical mapping existed.

Unfortunately there were no air photographic resources in the Command at that time, and the policy laid down by the General Staff was that methodical surveys at 1/100,000 scale should be undertaken by ordinary ground survey

methods. This continued until May when it was clear that Italy's entry into the war was imminent. By this time it was obvious to the officers commanding both the Southern Rhodesian and East African Survey Companies that the 1/100,000 mapping project would cover only a relatively small area in the time available before hostilities were likely to break out. They therefore recommended to the General Staff a change of policy whereby as large an area as possible should be surveyed by rapid reconnaissance methods so as to produce maps of the potential operational area at 1/500,000 scale as soon as possible. This was approved, and a new programme was started at once. In some localities which were difficult of access sketch topography was carried out from aircraft with successful results.

On 9th June, just before Italy's declaration of war, the reconnaissance parties were recalled and unit headquarters moved into the 1st East African Brigade area. The field sections were then employed on large scale mapping of selected defence areas, and the production of route reports from railhead at Thika to the advanced post at Garissa, 250 miles to the east.

RECONNAISSANCE INTO ITALIAN SOMALILAND (JUNE, 1940)

In preparation for forthcoming moves eastwards into Italian territory there was a need to fix the positions of salient points such as water-holes, and to establish ground control for air photography which would be undertaken by the recently arrived 60 (Photo) Squadron S.A.A.F. along the probable lines of advance. While doing this it was desired to prepare a route report. A survey section of the Southern Rhodesian Survey Company, with escort, left Garissa on 26th June, crossed the frontier and penetrated 23 miles inside enemy territory. Observations were taken *en route*, and in a little over 24 hours they had completed their mission, obtaining much information and data which were eventually used for the production of maps used by 12 (A.) Division when it advanced into Somaliland in the following February.

FORMATION OF SURVEY DIRECTORATE AND EAST AFRICAN SURVEY GROUP

In July, 1940, during a visit by D. Survey, Middle East, it was decided to form a Survey Directorate for the East African Force. It was decided also that 1st Survey Company (East African Engineers), the Southern Rhodesian Survey Company, and the West African Survey Company should be amalgamated to form an East African Survey Group with Lieut.-Colonel Bradford as its commander.

The Survey Group was organized into a H.Q. Group, a Map Production Group, and a Field Group. The personnel of the existing units were split up and used to the best advantage for making up sections in the new group, according to their qualifications and trades. The group had no authorized establishment of its own. Each unit retained on paper its own war establishment and, in spite of this somewhat unorthodox arrangement, the group functioned most efficiently for over two years of useful hard work.

Southern Rhodesian personnel were spread throughout the whole group but in particular No. 1 Field Section (photo-topo) was composed mostly of Rhodesians by virtue of their having been trained in such work in peace-time, and they were also represented strongly in the field sections employed on topographical duties. The photo-topographical section was withdrawn from

the field to Survey Group H.Q. in September, 1940, where, for seven months, it worked at high pressure preparing maps for the advance into enemy territory.

As the campaign in Abyssinia developed, it became necessary to alter the composition of the original field sections. Four of them were transformed into divisional and brigade survey sections to operate with formations in the field and to look after their immediate survey and mapping needs. No. 1 Field Section however, retained its original identity and functions.

MAPPING WORK BY NO. 1 (PHOTO-TOPO) FIELD SECTION

The advance of the East African Force into enemy country was, in general, along routes hitherto practically unmapped. On some occasions there was a complete absence of ground control, which affected the production of maps from air-photos in that it was impossible to show either an accurate true north or scale. These defects were partly overcome by the divisional and brigade sections, who were able to make the necessary observations in the field and impose a grid on the maps.

Movement was so rapid that the air photography was often only just able to keep ahead of the advancing troops, and the time available for the compilation and printing of the maps at Survey Group H.Q. was very limited. No. 1 Field Section was working for an average of 15 hours a day for weeks on end. During some emergency periods long non-stop sessions were necessary, with several of over 40 hours, including one peak stretch of 55 hours. Similar rush-periods were worked by other sections such as printing.

TRIG AND TOPOGRAPHY BY FIELD SECTIONS

The strategy up to August, 1940, had been of a defensive nature centred on such areas as Marsabit, Wajir, Isiolo, Garissa and Bura. During this phase Nos. 2 and 3 Field Sections, which included Rhodesian personnel, were employed on large scale mapping of defence areas. This included plane-table surveys, astronomical observations and triangulation for ground control, and rapid route reconnaissance traverses by prismatic compass. Shortage of water, and the need for keeping a constant look-out against attack by bands of enemy irregulars, hampered the work.

In August, the strategy became offensive in character, and preparations were put in hand for an advance eastwards towards Kismayu with a feint to the north. Between August and December, 1940, Nos. 2 and 3 Sections were engaged on trig and topographical survey in the northern frontier district of Kenya.

FORMATION OF DIVISIONAL AND BRIGADE SURVEY SECTIONS

In December, 1940, it was decided that survey sections should be attached to divisions and brigades during offensive operations. They operated with 11 and 12 (African) Divisions and with several of the independent brigades, and were present in all the major actions. On the fall of Addis Ababa in April, 1941, when the remaining 30,000 Italians retreated to Gondar, one survey section was assigned to the force which invested and finally overcame them there. The positions of enemy gun batteries were fixed by intersections from co-ordinated O.P.s and assistance was given to the artillery in other ways. The remaining sections were withdrawn and were employed in Addis Ababa investigating captured maps and equipment, and arranging for their evacuation to Nairobi.

OTHER WORK DURING 1941

Part of the remaining field sections was employed on the rapid establishment of mapping control in the areas of Abyssinia and Somaliland which were accessible under escort, but which, owing to the unruly tribes, would become inaccessible later when British troops withdrew.

Triangulation was carried out in the Lake Rudolf area and westwards along the south and east borders of the Sudan towards the White Nile. Training areas in Kenya also had to be mapped.

Defence preparations against a possible Japanese offensive

With the entry of Japan into the war in December, 1941, it was necessary to take defence measures against possible Japanese action. This involved the allied occupation of Madagascar and French Somaliland. Rhodesian survey personnel were actively engaged on mapping and other survey work in connection with these preparations.

No large scale maps existed for important coastal areas such as Malindi, Mombasa, Tanga, Dar-es-Salaam, and Lindi. Sections were deployed over wide areas to fix ground control for photography, and to survey coast defence batteries. At the end of July, 1942, following the initial landings in Madagascar, the field sections were withdrawn from their work in the coastal area to operate in Madagascar, in connection with the second allied landings and final conquest of the island.

At Survey Group H.Q. mapping work went on at high pressure through the whole of 1942-43. From July to November, 1942, there was an intensive mapping programme for Madagascar. At that time the East African Survey Directorate was responsible for a vast area embracing Eritrea, Abyssinia, the eastern part of the Sudan, French, British and Italian Somaliland, Aden, Kenya, Uganda, Tanganyika, Zanzibar, Madagascar, Indian Ocean Islands, Nyasaland, Northern Rhodesia, and the northern part of Portuguese East Africa.

The Madagascar operations

In March, 1942, Survey Group H.Q. were asked to produce under great secrecy a few copies of a large scale map of Diego Suarez from air-photos. On 4th May a force which had sailed direct from the United Kingdom landed at Courier Bay and captured Diego Suarez. This force was provided with maps prepared by the War Office. There was no survey representation for the initial operations and the R.E. Survey Section went in with the second flight some days after the first landing. In response to an urgent call from the force, a survey officer flew over from East Africa two days before the arrival of the survey section from the United Kingdom.

During the next few months, a strong survey section, including many Rhodesian officers and N.C.O.s, was based on Diego Suarez for fixing ground control, and for carrying out large scale coast defence surveys. Later on this section furnished personnel for attachment to the brigades which took part in the second landings at Majunga and Tamatave in September, and the final operations leading up to the capitulation in November. The last of the Rhodesian personnel left Madagascar in October, 1943, after completing a great amount of field survey in the island. Lack of air-photographs was a constant source of delay, as it had been in the coastal area of East Africa.

Reorganization of the survey organization in East Africa

By June, 1943, it was clear that very soon much of the survey resources in the East African Command could be transferred elsewhere. In response to an enquiry from the War Office, the Government of Southern Rhodesia agreed that their survey personnel should be employed wherever most required, and promised to provide reinforcements for the field sections.

Several alternative methods of utilizing them were considered, and finally it was proposed that a combined East African and Southern Rhodesian Field Survey Company should be formed for service outside Africa, with a Base Survey Company to be left behind for service with the East African Command. This proposal was agreed and adopted. On 20th October, 1943, the East African Survey Group was disbanded and the following came into being:—

155 (E.A. and S.R.) Field Survey Company for service overseas.

157 (E.A. and S.R.) Base Survey Company for service in East Africa.

The former, consisting of 19 officers, 2 warrant officers, 54 British N.C.O.s, 326 African ranks and 104 African non-combatants, was commanded by Lieut.-Colonel A. J. Seex (E.A. Engineers) and was organized as Headquarters, 3 topographical sections, 1 drawing section, and 1 reproduction section. Practically all the Southern Rhodesian personnel were posted to this unit.

For the last two years of the war, 157 Base Survey Company was kept very busy meeting extensive demands for mapping and survey which inevitably arose in such a large Command as that in East Africa. The work included not only the provision of maps for training, the preparation of large scale maps of specified areas such as the Island of Socotra and parts of Madagascar and Abyssinia, but also a special mapping programme for S.E.A.C., which included Army/Air maps of Java and Sumatra and navigational plotting charts.

With S.E.A.C.

155 Field Survey Company reached Colombo on 14th February, 1944, and Bombay a few days later. The first task in which Rhodesian personnel took part in the new Command was in connection with the combined hydrographic, topographic and engineering survey of the Cocos, or Keeling Islands, situated about midway between Colombo and Australia. This survey was part of a strategic plan for the development of the islands as an air-base in anticipation of future operations to recapture Malaya. A topographical party from 155 Field Survey Company was there for nearly three months.

Meanwhile the main unit moved on from Bombay to Fourteenth Army H.Q. which was then at Comilla in Eastern Bengal, and by mid-April one field section, including six Rhodesians, was operating with 33 Corps which was then fighting the battle for Kohima. The work of the section consisted largely of survey for, and in conjunction with, the Royal Artillery, and after two months in the Kohima area it was withdrawn to Comilla as soon as the road from Kohima to Imphal had been opened up.

In mid-April, another field section, including six Rhodesians, joined 15 Corps on the Arakan front and was engaged in extending the triangulation and the production of large scale maps from air-photos. When the monsoon broke in mid-May this section was withdrawn to Comilla.

H.Q. 155 Field Survey Company, with all sections other than the two temporarily detached to 15 and 33 Corps, remained at Comilla from April till mid-October, engaged on the production of maps for Fourteenth Army. There

were some delays in map printing owing to the non-arrival of certain equipment from the United Kingdom.

By June, 1944, it was apparent that some radical changes in the organization of the unit were necessary. Experience with Fourteenth Army and a consideration of future trends showed that 155 Company was too large for efficient employment as a single unit, and that a certain amount of splitting up and reduction in numbers would produce the flexibility that was necessary for utilizing the personnel to the best advantage.

On 18th September, therefore, 155 Company was converted into four smaller units, which effected a saving of about 200 African ranks. The new units were:—

155 (E.A. and S.R.) Field Survey Company consisting of H.Q., 1 trig, 1 topographical, and 1 air survey section.

17 Air Survey Section.

67 (Indian) Reproduction Section.

158 (E.A.) Map Supply Section.

Under the new arrangement, East African Command became responsible only for the maintenance of the first and last of the above, India assuming responsibility for the other two units. Practically all the Rhodesian personnel were posted to the new 155 Company and, with Major J. L. Reid in command, it moved to 15 Corps on the Arakan front on 19th October, 1944. Rhodesians now formed 86 per cent of the British personnel.

155 Company reached Cox's Bazar, where H.Q. 15 Corps was located, on the eve of the advance down the Arakan coast. The field sections were sent out to fix positions in the forward areas including Bawli Bazar, Maungdaw, Foul Foint, and Mayu River.

The remainder of the unit was employed at Cox's Bazar from November, 1944, till March, 1945, on air survey, block-plots, and the preparation of beach landing maps. The field sections accompanied the advancing troops of 15 Corps down the coast, carrying out triangulation on Akyab Island, at Myebon, on Ramree Island and on other islands in the vicinity, remaining with 15 Corps from February till April, 1945.

One field section was held in readiness to accompany the 15 Corps Task Force for the capture of Rangoon, but the assignment was cancelled at the last moment when the decision was reached to withdraw 155 Company from Burma to Bangalore for refit and training pending the projected invasion of Malaya. In July, however, shortly before the Japanese surrender, H.Q. Allied Land Forces decided to disband the unit and, leaving Bangalore on 7th October, it disembarked at Mombasa on the 25th.

During the period when 155 Field Survey Company was in S.E.A.C., Colonel J. E. S. Bradford held the appointment of D.D. Survey at H.Q. A.L.F.S.E.A. and later at H.Q. S.A.C.S.E.A., and had under his control the Survey Production Centre where so much of the mapping for the theatre was carried out. Major P. H. O'Brien, another Rhodesian, was D.A.D. Survey with the Survey Directorate at H.Q. Fourteenth Army. Several other Rhodesians held survey staff appointments or were in charge of technical survey activities, principally in connection with air survey mapping, both in India and with A.L.F.S.E.A.

With a limited number of experienced surveyors and map production personnel, which were not really sufficient for the formation of a properly balanced

unit, Southern Rhodesia had thus provided a most valuable contribution to allied survey resources in two major operational theatres.

SECTION 5. EAST AFRICA (*see* Sketch Map No. 5)

Kenya, Tanganyika, and Uganda

In March, 1939, a scheme was prepared for the formation of a field survey unit consisting of trained surveyors of the Survey Division of the Department of Lands and Mines in Tanganyika Territory. When war became imminent in the late summer the officer members of the unit, who had joined the King's African Rifles, Reserve of Officers, were in a position to take the field with little delay.

The Field Survey Unit, K.A.R., was mobilized on 1st September, 1939, and was located at Dar-es-Salaam. Early appointments included Major H. P. Rose in command, one Captain and Adjutant, five other officers, and three serjeants. 12 African ranks were enlisted at Survey H.Q. in Dar-es-Salaam, and 31 African ranks were enlisted from the K.A.R. In addition four European and some Asiatic civilians were posted to the Map Production Section at Headquarters. The unit was at first organized into a H.Q. Section, No. 1 Field Section and a Map Production Section. No. 1 Field Section was equipped with technical stores drawn from the Survey Division, and the Map Production Section began work on redrawing and publishing the Italian series of 1/M maps.

On 26th September, No. 1 Field Section left for Nairobi, where it immediately started on field surveys, including plane-table traverses on the lines of communication. One party went to the Isiolo-Archer's Post road, another to the Isiolo-Wajir road. The remainder began a series of astronomical observations to establish control for road traverses and for local trig schemes. Early in October, the adjutant reported to East African Force H.Q. at Nairobi to act as a liaison officer, and to undertake the formation of No. 2 Field Section, the European personnel for which was drawn from the Survey Departments of Kenya and Uganda. African ranks were recruited from the K.A.R. and, after some weeks of training, the section left for the North Frontier District. There they carried out plane-table road traverses, and a plane-table survey at 1/50,000 scale of an area round Wajir.

The formation of No. 3 Field Section was under consideration, the plan being to use Southern Rhodesian personnel, when it was learnt that Southern Rhodesia was forming its own survey unit, so the raising of the third section was temporarily postponed.

At the end of October, the designation of the unit was altered to 1st Field Survey Company, East African Engineers (E.A.E.), and it was assigned to Force Headquarters for operational control. The two field sections continued to carry out surveys in the forward areas, No. 1 being at Isiolo, and No. 2 at Garissa, and the Map Production Section at Dar-es-Salaam was busy with the reproduction of the Italian 1/M maps and of other maps as required by Force H.Q.

A large scale survey of Moyale was undertaken, combined with a topographical survey of the surrounding area of this frontier post. As war had not yet broken out with Italy, the work was conducted under conditions of secrecy.

No. 3 Field Section was formed in February and at the end of May all the field sections were concentrated at Isiolo in readiness for a rapid mapping reconnaissance of the whole of the North Frontier District so as to produce a 1/500,000 map of the potential operational area. Hitherto the policy had been to map methodically at the scale of 1/100,000, and it was clear that, on this basis, only small areas would have been completed by the time required. It was owing to the representations of the officers commanding the East African and Southern Rhodesian Survey Companies that this change of mapping policy was put into operation.

In July, the East African Survey Group was formed by grouping together the East African, Southern Rhodesian, and West African Survey Companies, the latter having now arrived in Kenya. The personnel of the three units were used to the best advantage to form trig, topographical, photo-topographical, drawing, and printing sections and, from now on, the independent operations of the 1st Field Survey Company E.A.E. came to an end. On incorporation into the Survey Group the unit retained on paper its separate war establishment although the personnel was split up, and it was redesignated 55 Survey Company E.A.E.

References to further activities of the East African survey personnel will be found in Section 4 of this chapter and also in Chapters VI (Italian East Africa) and VIII (South East Asia).

SECTION 6. WEST AFRICA (*see* Sketch Maps Nos. 5, 7 and 8)

Formation of Survey Company and activities in East Africa

When Nigeria and the Gold Coast sent military contingents to East Africa in the summer of 1940, they were accompanied by two survey contingents, one from each of the two Colonies. The European personnel were drawn from the civil survey organizations, and the trained survey draughtsmen and lithographers were recruited from the West African native staffs of the respective survey departments. These two contingents were formed into one West African Survey Unit, part of the Royal West African Frontier Force, the personnel belonging to the Nigerian and Gold Coast Regiments. The unit was under the command of Major E. W. Nesham (Nigeria).

The Nigerian contingent took with it some map reproduction plant including camera, hand litho-press and ancillary equipment. This proved to be of great value in East Africa during a critical period when map production facilities were very limited pending the arrival of equipment from elsewhere.

In August, 1940, the unit became part of the newly formed East African Survey Group together with the survey units from East Africa and Southern Rhodesia, and was redesignated 56 (W.A.) Survey Company. References to the activities of the unit as part of the Survey Group will be found in Section 4 of this Chapter and also in Chapter VI (Italian East Africa). It returned to West Africa in August, 1941, on the conclusion of operations in Abyssinia.

Formation of divisional survey sections for operations in S.E.A.C.

The West African Survey Unit was employed in West Africa during 1942-43 as a training unit. During that time divisional survey sections were formed for

duty with 81 and 82 (W.A.) Divisions who were to take part in the operations in S.E.A.C. These sections were composed of personnel drawn from the Survey Company plus a number of new recruits trained by that unit. The unit was eventually disbanded in 1945, all trained personnel being sent to India.

The Burma Campaign

10 (W.A.) Divisional Survey Section. When 81 Division first arrived in India in 1943, there were three brigade survey sections, attached respectively to 3rd, 5th and 6th (W.A.) Brigades. The sections with 5th and 6th Brigades were in the Kaladan Valley on the left flank of the Arakan front in Burma. They took part in a 200-mile outflanking march, and were employed mainly on surveys for the artillery, and on mapping a new 150-mile jeep road which was constructed by the division as a supply route. In July, 1944, the section with 5th Brigade was detached to H.Q. Fourteenth Army for 1/25,000 map production covering part of the Kaladan Valley.

3rd (W.A.) Brigade, with its survey section, was detached from 81 Division and joined one of the brigades of Wingate's 'Chindits' operating in northern Burma. This section was employed on the production of sketch maps of air-strips and camps, but otherwise did little survey work.

In August, 1944, the three brigade survey sections were amalgamated to form No. 10 (W.A.) Divisional Survey Section with 81 Division just behind the main Arakan front. Between September, 1944, and January, 1945, it produced a number of new 1/25,000 sheets of the Kaladan Valley for use by 81 Division on another outflanking march in that area.

In February, 1945, 81 Division was withdrawn from Burma to India to train for the invasion of Malaya. The survey section was to have been employed mainly on air-photo mapping for the operation, but in May, 1945, it was decided to withdraw the division from the Command, and its move back to West Africa was completed by early 1946.

11 (W.A.) Divisional Survey Section. This section operated with 82 (W.A.) Division on the left flank of the Arakan front in Burma. One of its field sections accompanied the advanced troops, the remainder being employed on 1/25,000 mapping.

In May, 1945, the section was withdrawn from the division and took over the Akyab map depot until it was closed in September, 1945. It then rejoined 82 Division at Taungup and moved with it to Rangoon in December. During the early part of 1946 it was working on the production of a new 1-inch sheet of part of the Shan States from air-photos, and in April of that year it returned to West Africa.

For further references see Chapter VIII (South-East Asia).

CHAPTER XIV

MISCELLANEOUS NOTES

The following diagrams are relative to this chapter:—

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SECTION 1. MAP PRODUCTION IN THE UNITED KINGDOM

Introduction

Considerations of time, and the limitations and risks of sea transportation, made it necessary for distant operational theatres to be very largely self-supporting in bulk map printing. In the Middle East, the extensive potential theatre of operations included Egypt and the Sudan, Libya and the Mediterranean, Palestine, Iraq, Persia, and Italian East Africa. The practical closing of the Mediterranean to convoys, resulting in the long sea-carry round the Cape, made it impossible to consider sending out bulk stocks of printed maps from the United Kingdom, and led to the installation of a large map reproduction unit at the base near Cairo. Similarly South East Asia Command depended almost entirely on its own resources and on the map production capacity of India.

For those theatres nearer home, where the shipping turn-round was quicker and the risk of sea transportation considerably less, the United Kingdom remained the principal source of bulk map printing. This applied more especially to the operations in western Europe and North West Africa.

During the 1944-45 campaign ("Overlord"), for example, although S.H.A.E.F., H.Q. 21 Army Group, Second Army, First Canadian Army, and the American forces had at their disposal large map production capacity overseas, the allied force was largely dependent for its main bulk stocks on consignments which were printed in the United Kingdom under War Office control, and in the United States through the War Department.

It may be well, therefore, to discuss briefly the resources which were available in the United Kingdom for dealing with this extensive requirement.

The Directorate of Military Survey (G.S.G.S. War Office)

The map production resources directly controlled by G.S.G.S. before the war consisted of a drawing staff of about 60 civilian draughtsmen and a small printing section equipped with three flat-bed lithographic machines and one camera. This section was installed in the main War Office building. At that time practically all the bulk printing of maps of Great Britain required for training purposes was contracted out to the Ordnance Survey at Southampton, a natural and convenient course to follow as most of the maps concerned were Ordnance Survey publications. The preparation and printing of bulk stocks of military map series for the B.E.F. operations in France and Belgium during

1939-40 were almost entirely carried out by the Ordnance Survey under instructions from the War Office.

MOVE OF G.S.G.S. (M.I. 4) FROM LONDON TO CHELTENHAM

On the outbreak of war in 1939, the drawing and printing sections with G.S.G.S. began to expand, and this expansion was accelerated when G.S.G.S. was evacuated to Cheltenham. While there, the number of draughtsmen increased by a small amount, and the printing staff grew from about 12 to 27 operators. A new photo-litho department was formed consisting of three camera operators and seven photo-writers, and the bromide printing section expanded from two to five.

RETURN OF G.S.G.S. TO THE LONDON AREA

The development of operations in all theatres, and the vital need for daily and close contact between Survey and the Planning and Operational staffs of the War Office who were still in London, put an end to the banishment of G.S.G.S. in Cheltenham and resulted in its return to the London area. Although hutted accommodation for most of G.S.G.S. was found at Eastcote, there was no room for the installation of printing machines, cameras and other plant. A suitable factory building was obtained in a western suburb, and a "Survey Production Centre" was installed there. There were increases of staff in every department, and the most up-to-date photographic and printing equipment was acquired. The responsibilities of G.S.G.S. regarding map production, especially where speed of output or high security were necessary, increased rapidly at this stage of the war, and made it essential that it should have under its immediate control adequate resources for map drawing and all stages of reproduction. The drawing staff lagged somewhat behind in this expansion, rising to about 100 personnel. The printing section, however, increased in strength to nearly 60 male operators and 65 females, the latter being employed on map examination and despatch duties. The bromide section increased from 5 to 12, and the photo-litho department grew to a staff of 84, many of whom were employed on the "Graber" auto-processing machines which were installed for the rapid duplication of kodak film negatives for use by field survey units abroad.

Thus the original printing section and drawing staff employing some 75 people in all, expanded to a final total of just over 320 during the period 1939-45. These numbers refer to productive personnel only, and do not include those employed on purely administrative duties.

The expansion in equipment was equally striking as is clearly shown in the following tables:—

Man-power.

<i>Section</i>	<i>G.S.G.S. Pre-war</i>	<i>Cheltenham</i>	<i>Survey Production Centre</i>
Drawing	60	70	100
Bromide	2	5	12
Photo-litho		10	84
Printing	12	27	123
Totals	74	112	319

Equipment.

Section	G.S.G.S. Pre-war	Cheltenham	Survey Production Centre
Drawing Bromide Printing	Normal drawing stores <i>pro rata</i> .		
	1 20" camera	1 20" camera 1 Photostat machine	1 20" camera 1 Photostat machine 1 Recordak machine
Photo-litho		2 Cameras (Size 24" × 36")	2 cameras (Size 24" × 36") 1 camera (Size 40" × 40")
Printing	3 Flat-bed presses	3 2-colour offsets 5 1-colour offsets	7 2-colour offsets 4 1-colour offsets

OUTPUT

Maps. During the period from September, 1939, to August, 1945, the printing section under direct G.S.G.S. control printed approximately 60,000,000 maps. This is independent of the numbers printed by outside agencies such as the Ordnance Survey and civilian printing firms. If these are taken into account the following figures of production in the United Kingdom during the latter part of the war show the extent of the map printing commitment involved.

January to June, 1943	Approximately	40 million
July to December, 1943	„	50 million
January to June, 1944	„	80 million
July to December, 1944	„	100 million
January to June, 1945	„	45 million

The peak week for production was at the end of August, 1944, when about 5½ million maps were printed during the seven days.

KODALINE FILM NEGATIVES

The mass production of kodaline film negatives from which the field survey units could make their own printing plates and undertake map production overseas was much facilitated by the installation of "Graber" auto-processing machines. These were operated both at the Survey Production Centre and by No. 18 Map Reproduction Section R.E. which was working directly under G.S.G.S. control. Between January, 1944, when this work started, and September, 1945, over half a million kodaline negatives were processed and distributed to Survey Directorates overseas.

The Ordnance Survey

The Ordnance Survey played such a valuable and important part in the production of maps for war purposes that it seems desirable to consider some of the factors which affected its potential output, to take note of some of its achievements, and to record some technical aspects regarding the work undertaken.

Pre-war. The functions and organization of the O.S. have been discussed in Chapter I, Section 2. In brief, the pre-war personnel employed at the O.S. consisted partly of civilians and partly of serving Royal Engineer officers and other ranks. Many of the civilians were ex-R.E. personnel who had completed their military engagement, and there were Territorials and Reservists with mobilization commitments. The total staff of the O.S. in September, 1939, was just over 3,000, many of whom were women.

The outbreak of war. When mobilization was ordered there was an immediate reduction in the strength of the Department. Many of the Royal Engineer personnel were posted to form the nucleus of the new survey units which were mobilized to accompany the B.E.F., and Territorials and Reservists went off to join their units. Altogether nearly 180 Reservists, Territorials and Militia who had been serving with the O.S. were called up on mobilization, between 1st July and 30th September, 1939. A large number of R.E. Survey officers, members of the O.S. executive staff, were among those who left to take up military duty.

To counter-balance this rapid reduction in strength, however, the normal civil work of the Department was set aside, and the remaining staff concentrated on War Office drawing and printing orders, and the execution of field surveys all over Great Britain required for war purposes.

Recruitment of junior temporary civil assistants. Early in the war, a system of special recruitment was organized whereby young men, aged 16-17 years, were engaged with a view to giving them a basic training in O.S. technical work until their subsequent enlistment into survey units. For this purpose their names were specially registered as "map constructors."

Between late 1939 and March, 1944, over 1,000 of these map constructors had been drafted into R.E. Survey units after passing through the Survey Training Centre, where they received their military and technical training.

Enlistment of O.S. civilian personnel into the Forces. After the June quarter in 1944, the regulations for drafting personnel into the Army were altered. During the remainder of 1944 and early 1945 nearly 150 young civilians were enlisted from the O.S. direct into the Primary Training Centres. It is probable that many of these found their way eventually into survey units.

Recruitment of civilian printing staff. During the early part of the war the O.S. was able to recruit skilled tradesmen from civilian printing firms, whose business had naturally been reduced under war conditions, but, later on, the problem became very difficult and, by arrangement with the Ministry of Labour and the War Office in 1942, a number of reproduction personnel were "directed" to the O.S. as an alternative to enlistment in the Forces, to enable the O.S. to meet its commitments.

The demands for map printing were so heavy in 1943-44 that it became necessary to recall some printing tradesmen from the Army by transfer to Class W Reserve. This arrangement was not, however, an unqualified success.

Formation of 522 Survey Company R.E. When, after the outbreak of war,

the old Survey Battalion was abolished, a new military unit was formed, consisting mainly of map reproduction tradesmen. This was 522 Survey Company R.E., and it worked directly under Ordnance Survey control, operating an important map printing installation on the outskirts of London.

DISLOCATION AT THE ORDNANCE SURVEY AS A RESULT OF ENEMY ACTION

The O.S. suffered severely through enemy action. The air bombing of Southampton late in 1940 resulted in considerable damage to the main buildings and necessitated a widespread dispersal of mapping activities all over Southampton in requisitioned accommodation which was, in many cases, quite unsuitable for the work. Amongst the buildings hit or damaged by fire was the main negative store, containing some thousands of glass negatives which formed the basic material for many of the map series which had been produced and revised during pre-war years. This loss was a very serious one, but the precaution had been taken at an earlier date to make duplicate sets of printing plates of those maps which were likely to be required for war purposes, and these had been stored in various dispersed centres for safety.

The damage at Southampton, and the threat of further damage at a later date from German secret weapons, brought about the decision to move the O.S. away from Southampton. The directing headquarters and one portion moved to hutments at Chessington in Surrey, another portion to hutments near Esher, and the balance remained in hutted accommodation which was erected at Crabwood on the outskirts of Southampton. 522 Company was installed at Waddon, in a London suburb. Each of these dispersed branches had its quota of draughtsmen and reproduction plant, and was more or less a self-contained entity.

In addition a branch office, which was employed mainly on war mapping, was opened at Nottingham, and the pre-war provincial branch offices in London, Bristol, and Edinburgh continued in operation.

It will be well understood, therefore, that the combination of an ever-changing staff owing to Army enlistments, the damage to important survey records by bombing and fire, and the wholesale move and dispersal of such a complicated and important organization, produced a host of difficulties and problems. In spite of all this, the quantity and quality of the O.S. production of war mapping was quite outstanding, and the high traditions of the Department were more than fully maintained.

EQUIPMENT

The following table shows the expansion in the principal items of printing and ancillary equipment at the O.S. during the war period:—

	1939		1944-45
<i>Litho printing machines</i>			
Rotary offset, Southampton	12	Chessington	7
		Esher	8
		Waddon	8
		Crabwood	6
			—
			29
			—

	1939		1944-45
<i>Litho printing machines</i>			
Flatbed, Southampton	10	Chessington	3
		Esher	2
		Waddon	3
			—
			8
			—
<i>Cameras</i>			
Monotype, Southampton	1	Chessington	1
		Esher	1
		Waddon	1
			3
Hole-in-the-wall	2	Crabwood	1
		Waddon	1
		Esher	1
			3
On rails	1	Nottingham	1
		Crabwood	1
			2
Enlargers	1	Chessington	1
		Esher	1
			2
Step-and-repeat	1	Waddon	1

In addition to the above, there was a corresponding increase in the number of proving presses, letterpress printing machines, photo-litho equipment, and other plant incidental to the big expansion in the map production programme.

EMPLOYMENT OF CIVILIAN PRINTING FIRMS

Early contacts. The employment of civilian printing firms to augment the resources available to the War Office and the Ordnance Survey for war mapping goes back to September, 1938, at the time of the Munich crisis, when a large programme of military mapping was in progress for the War Office. At that time five of the leading firms of high-class lithographic printers were approached in confidence and given trial orders, one of the firms already specializing in high-class map printing. The others had no previous experience of this class of work but their normal trade products were of such good quality that there appeared to be no doubts of their ability to take on the job. The O.S. supplied master plates, from which the firms made duplicates from which to print, and the O.S. also supplied the paper. The results were satisfactory, and the firms were earmarked in case their services should be needed in emergency.

On the outbreak of war, these five firms were entrusted with several printing orders and, in order to cope with rapidly growing commitments, further firms were approached and work was allotted to them.

Financial arrangements. Until the spring of 1940, the printing firms tendered for the work in the normal manner. It was realized, however, that the amount of printing would greatly increase, and it was essential that the O.S. should be able to place printing orders for immediate execution without the normal procedure of obtaining tenders. A cost-plus-profit scheme was therefore worked out with the British Federation of Master Printers. The O.S. was to supply the paper and the master plates from which the firms would make duplicate plates for the machines. Firms were allowed to charge the actual

time taken at a standard hourly rate which was ascertained by the cost accounting department of the Federation. A profit of $7\frac{1}{2}$ per cent was allowed, and a handling charge of 15s. 0d. for each 1,000 sheets of paper used on the job. The cost records and books of all the firms were open to periodical check by a member of the O.S. cost accounting staff.

There were altogether some 35 firms so employed during the war, and their work was of extreme value. Some idea of the scope of this contract printing may be gained from the following expenditure figures:—

1939–40	£31,973
1940–41	£83,039
1941–42	£44,859
1942–43	£91,483
1943–44	£122,313
1944–45	£272,700

The printing firms themselves had their own staff difficulties due to the calling up of many of their employees to the forces. In some cases arrangements were made for the reservation of certain key personnel to meet their commitments for the War Office and the O.S.

Output. The following figures give an indication of the magnitude of the task undertaken by the O.S. itself and the printing firms working under contract.

	<i>Approx. Number of maps printed</i>
<i>Ordnance Survey</i>	
Sept. 1939 to Mar. 1940	6,753,000
Apr. 1940 to Mar. 1941	13,813,000
Apr. 1941 to Mar. 1942	16,141,000
Apr. 1942 to Mar. 1943	31,411,000
Apr. 1943 to Mar. 1944	48,691,000
Apr. 1944 to Mar. 1945	66,266,000
Apr. 1945 to June 1945	10,700,000
Total	193,775,000
<i>Civilian Firms</i>	
Sept. 1939 to Mar. 1940	4,317,000
Apr. 1940 to Mar. 1941	10,503,000
Apr. 1941 to Mar. 1942	4,000,000
Apr. 1942 to Mar. 1943	13,914,000
Apr. 1943 to Mar. 1944	61,070,000
Apr. 1944 to Mar. 1945	52,307,000
Apr. 1945 to June 1945	2,529,000
Total	148,640,000

SECTION 2. RELIEF MODELS

Historical retrospect

During both the World Wars the demand for relief models was insistent. Although models are not maps, the survey service has always been approached by the General Staff when they were wanted, and has taken action, more or less on an agency basis, to obtain what was required.

In 1914-18, the static conditions of trench warfare produced a demand for relief models of enemy defence positions for planning offensive assault operations. The War Office undertook the preparation of a quantity of plaster models on 1/20,000 scale, the work being entrusted to an agent who organized a staff for their manufacture. The Ordnance Survey also constructed a large number of cardboard models made up by pasting together a series of cardboard layers of suitable thickness, each cut to the shape of the appropriate contour, and covered by a map sheet printed on special paper. These latter models were popular. They were light, did not break easily if dropped, and could be repaired easily. Each model had, however, to be made separately, and was therefore expensive and slow to make. In the report on Survey during 1914-18 it was stated that:—

“The value of these models has often been questioned. There is no doubt that they were of real use to some commanders, but it is certain that many were never used at all, or were mishandled, lost, or taken away as mementoes. On the whole, considering their cost, and the fact that they cannot be kept up to date, it is questionable whether they are worth making, and whether the money would not be better expended on layered maps.”

The nature of the recent war, with its many scientific developments, its commando raids, beach assaults, airborne operations, and the extensive use of air bombing has probably made much of the above adverse criticism untenable, though there is no doubt that many people, not realizing the amount of time and labour necessary to make the models, demanded them on occasions when a map would have served the purpose equally as well.

Looking ahead

It seems safe to assume that, in any future war, there will again be a demand for relief models for all sorts of purposes, and there seems no doubt that, so far as the Army is concerned, the General Staff will expect the survey service to procure what they require in this respect. The Americans did not hesitate about it. They recognized the fact that the demand would come, and they trained special Model-Making Detachments (under Engineer control according to their normal survey policy), and equipped them thoroughly for the job.

There appears to be no doubt therefore that, to meet future war requirements, clear-cut arrangements should be made regarding manufacture and the responsibility for controlling and organizing production and distribution. If it is decided that the survey service is to act as advisers and/or suppliers then it should prepare itself for this task accordingly. Recent experience has shown that it is quite useless for anyone to maintain an ostrich-like opinion that models are useless and unnecessary, and that a map is equally as good and should be used in lieu. The relief model has come to stay, for certain purposes, and research into methods of manufacture and organization for their efficient and quick construction should be extended.

With the B.E.F. (1940)

When the "Dyle" plan for the move forward of the B.E.F. and French forces into Belgium in 1940 was being planned, there arose a demand from British G.H.Q. and from corps commanders for relief models of the R. Dyle defensive zone between Louvain and Wavre to which the B.E.F. was destined to move to meet the expected German onslaught. Survey was asked for these models, but no arrangements for procuring them had been made or even thought of either in the B.E.F. itself or in the United Kingdom. Fortunately, however, it was known that the French Army, through their Service Géographique, had installed a model-making department in Paris and they willingly accepted the demand and supplied what was needed. The subsequent retreat put a temporary end to any further model activities and, for the moment, they retired from public view.

Relief models for use by the R.A.F.

The R.A.F. early realized their importance for briefing pilots, more especially for bombing raids, as an aid to the identification of targets. They therefore set up a model-making installation at Henley (subsequently moved to Medmenham), as a part of the Central Interpretation Unit. This unit specialized in furnishing all kinds of intelligence information to the Navy, Army and Air Force, mainly from a study of air photographs. For this model-making the R.A.F. personnel were classified as Pattern-Makers (Architectural).

Early "Models" policy for the French coast

In June, 1942, the Chiefs of Staff were considering plans for operation "Round-up," an assault landing on the French coast in the Pas de Calais area. The Chief of Combined Operations, when addressing the Chiefs of Staff on this subject, stated that "it will be necessary to have large scale models of the whole assault area for use during the later planning stages." Priority areas were selected for which 1/25,000 scale models were to be made covering up to a depth of 15 to 20 miles inland from the coast, and 1/5,000 scale models to a depth of 4½ miles. At a later date, interest was shifted further to the west, and models made of this latter area in connection with "Round-up" served as a preliminary instalment of those required for "Overlord," covering as they did part of the Cherbourg peninsula and the Normandy beaches running east from there.

U.S. Model-Making Detachment

When the U.S. Eighth Air Force came over to the United Kingdom to take part in the bombing of Germany, the Air Ministry looked to the U.S. Army to provide additional model-making capacity. They were not disappointed, and an Engineer Model-Making Detachment of one officer and 20 men (subsequently increased to three officers and 85 men) was sent over from the United States in the latter part of 1942 and, after a short training course at Henley, they joined up with the R.A.F. model-making team to form a powerful allied group which, during the course of the war, turned out a remarkably fine series of models in wide variety. This American contingent joined up just at a time when the "Round-up" programme had been temporarily suspended, and models were being made for operation "Torch," the landings in North West Africa. The British and U.S. personnel worked together as one team on the same jobs, operating on a shift basis. In those early days the tools, equipment

and materials used on the work were simple and few. Stereoscopes were used for interpreting the intelligence photographs, buildings were cut out of linoleum, sawdust made the trees, coloured pumice represented scrub and brushwood and roads were painted in colour. The finished models were accurate and good to look at. In addition to showing natural and artificial detail, they represented ground-form in greater or less degree by adjusting the vertical scale in comparison to the horizontal.

Expansion of the model-making programme

The increasing volume of work entailed a move from Henley to Medmenham. After "Torch", demands came in for models in connection with the assaults on Sicily, Italy, and the Normandy coast. A model of the island of Pantellaria, near Sicily, was made in the United States and sent over in October, 1942. There followed models for the air attacks on the dams at Eder, Sorpe, Moehne, and Bisorte, the ball-bearing works at Schweinfurt, the viaducts at Bielefeld and Neuenbecke, the oil refineries at Ploesti, the ship lift at Magdeburg, and many others, including a programme for South East Asia Command. Later came models of the experimental V-weapon installations at Peenemunde and launching sites at Bois Carré, Watten, Siracourt, and Wizernes.

U.S. Model-Making Detachments under the control of the Director of Survey at A.F.H.Q. did a lot of very useful work both in North Africa and in Italy. The main effort was in preparation for the assault on the south coast of France. There was also a part of a Model-Making Detachment with Fifth U.S. Army in Italy. There were, however, never enough model-makers and the British neglect of this service was a handicap.

Equipment models, made in large numbers, were extensively used for working out the best way of loading different types of vehicles on to various sorts of assault landing craft. For this purpose scale models were made of L.S.T.s, L.C.T.s, tanks, lorries, jeeps, DUKWS, etc., and, by arranging and rearranging the models, the best loading plan was arrived at.

The "Overlord" programme

During the winter of 1943-44, 369 originals and copies of models of various parts of the Normandy invasion coast were turned out in all sizes, shapes and scales. The general control of this programme was handled by the Survey Directorate at S.H.A.E.F., who dealt direct with the Air Ministry branch under whom the model-makers were operating.

The original programme for Normandy had included a number on 1/25,000 scale, with beach areas covered on 1/500 scale. Later on, opinion hardened against the 1/25,000 scale, and resources were concentrated on beach area models on 1/5,000 scale extending from Cherbourg eastwards as far as Houlgate, and on very large scale models of specially selected beaches.

During the last few months leading up to the invasion, formations of 21 Army Group were asking for models on still larger scales, 1/1,000 and 1/500. Arrangements were therefore made for personnel from these formations to be trained in the construction of briefing models of a type known as the "egg-crate," so called because they were made up of intersecting strips of cardboard, cut to the shape of parallel ground sections, over which cloth was stretched which made the actual surface of the model. This type was developed primarily for speed and, when the destruction of the German battleship *Tirpitz* was being

planned, egg-crate models of the Norwegian fiords of Bogen, Alten, and Trondheim were hastily constructed, and played a useful part in the ship's final destruction. Representatives from British, Canadian and American corps and divisions serving under 21 Army Group Command completed over 700 egg-crate models during the planning period, and many more were made in the field during actual operations. The Canadian Army made a large number for their operations leading up to the liberation of Holland. Officers of the Royal Navy were also trained in their construction.

U.S. model-making team goes overseas

In August, 1944, the allied team at Medmenham broke up. The Americans felt that they would have so many model requirements in connection with land operations overseas that it was necessary for the modelling personnel to be within easy reach and in close touch with operations. The Model-Making Detachment moved therefore from Medmenham to Paris, where it was set up as an independent unit under the control of the Engineer Intelligence Division. Work began at once on models for assisting in the assault on the Siegfried Line, the crossing of the Rhine and the thrust into Central Germany. The models of the forts at Metz, which held out for some time after the town had been occupied, assisted greatly in planning for their capture.

Some notes on the use of relief models

It might be of interest to quote from a report coming from the Third U.S. Army indicating the manner in which they made use of two different types of models:—

“Specific Installations Models (e.g. the Metz forts).

“They were examined hastily by Army and Corps staffs and then passed on to division commanders. At division level they were used to familiarize the staff with the nature of the fortifications, and the principal problems of the assault.

“Divisions passed them on to regimental commanders for study of tactics and techniques, points of attack, assignment of phased objectives, and planning supporting fire.

“They were then passed on to battalion and company commanders for detailed phasing of individual assault teams' objectives, planning of employment of special weapons and normal close support weapons, etc.

“Platoon leaders then received the models and briefed their men on the nature of the problem, plan, and all pertinent detail.

“Area Models, 1/10,000 and 1/25,000.

“Initially these models were used by the Army and Corps staff for overall planning.

“Divisions received them and utilized them for more detailed planning, i.e. planning direction of attack, determination of defiladed areas, and supplementing the map in appreciation of terrain.

“Regimental commanders received the models and used them to brief battalion and company commanders in the nature of the terrain to be traversed, plan of approach, deployment and attack, indication of area objectives, and determination of defiladed areas for supporting weapons.

"The users feel very strongly that the models are of tremendous value in specific objective attacks, and permit an accurate and understanding way of presenting terrain information to the men who will have to take the ground."

The uses to which models were put during the war may be classified briefly as under:—

Strategic planning. Scale was usually from 1/100,000 to 1/500,000. This small scale eliminated any great emphasis on detail and, to accentuate the character of the terrain, an exaggeration of the vertical scale was required. The general character of the topography was shown, with main roads, railways, towns, wooded areas and waterways. Such models were used by the General Staffs at Force or Army Group level for general planning.

Tactical planning. On this type of model, the information, though not always realistically indicated, was classified by graphical means. Major topographical features, land forms, built-up areas, woods, roads, rivers and canals, quarries and other such features were shown. The surface covering of the model was usually a map which had been revised from air photographs. Sufficient copies were required to supply headquarters of corps and divisions. The initiation for these normally came from Army H.Q. The usual scales for this type were 1/25,000, 1/12,500 and 1/10,000. Vertical exaggeration did not exceed 3 to 1. An exaggeration of 2 to 1 on rugged terrain was normal. Models for a river crossing or the attack on some special feature would come within this category.

Assault landing. Scale usually 1/5,000. Models for this purpose had to be completely detailed and show all features in three dimensions and realistic colouring. They were used by all echelons and branches for planning an operation, and included information valuable to all users. The Navy required shore lines, details of beaches and off-shore obstacles. Infantry required details of the beach terrain, woods, buildings, and hostile defence works. Salient features for controlling artillery fire and engineer obstacles were included. By emphasizing prominent features the Air Force was helped to identify targets. This type was used largely for the landings in North West Africa, Sicily, Italy, and Normandy.

Commando raids. These raids usually took the form of an assault on a definite objective such as a gun battery, tidal lock or radar station, and often entailed the destruction of a specified installation and the taking of prisoners, possibly from some definite building. All information from air photographs, available maps, and intelligence reports was carefully indicated on the models at a scale of 1/500 or 1/1,000. They were required by the directing H.Q. of the operation and the lower echelons to brief the troops making the assault. Examples of this type were those for the raids on Bruneval, St. Nazaire, and Dieppe.

Airborne landings. For this purpose it was usually desirable to have two scales. The smaller scale (1/10,000 or 1/12,500) covered the entire area over which the landing was to take place, and showed sufficient detail to allow pilots to be briefed for recognition of dropping zones and the terrain leading to them. Airborne unit commanders found these useful to acquaint themselves with the detail of these zones and the assembly points. The larger scale (1/1,000 or 1/2,500) covered the vital target area.

Air-bombing targets. Models for this purpose, at a scale of 1/2,500 or 1/5,000, gave the pilots an accurate three-dimensional picture of the target area and the character of the terrain surrounding it. Special emphasis was laid on distinguishing features and points of recognition which served as guiding marks leading to the target. The models of such places as Schweinfurt, Magdeburg, the Eder and Moehne dams, V-weapon sites and the Ploesti oil-fields were examples of this type.

Egg-crate or hasty-construction type. This was the truly tactical type, capable of quick construction and going direct from the maker to the user. As stated previously, teams from formations of 21 Army Group were trained to construct this type so that they could meet tactical requirements in the field.

SECTION 3. ARMY/AIR MAPS

Many references will be found in this history to Army/Air maps. It may be well, therefore, to consider briefly the origin and purpose of this style of map.

Although at one time there was a school of thought which considered that the air forces must have special maps of their own, it was soon realized that, for those operations which involved co-operation between the ground and air forces it was essential that both should use the same map. This facilitated briefing and inter-communication, and ensured a common basis of co-ordinate references to map detail. It was necessary, therefore, that the maps should be of a style suitable to, and acceptable by, both parties. It requires little consideration to realize that the use of maps common to both ground and air forces leads to much economy both in production and maintenance.

As soon as this policy was realized and accepted, experiments were carried out to produce maps on scales of 1/250,000 and thereabouts which would:—

- (a) give to the ground forces all the information which they would normally expect to find on maps of such scales; and
- (b) give to the air forces a clear map, easily legible under conditions of air operations by day and night, and containing all the data required for such operations.

Though later found not to be essential, the R.A.F. at first insisted on using an amber cockpit light at night. The colours on the maps had therefore to be selected so as to be legible under these special lighting conditions. During operations air crews use their maps in cramped and unstable conditions subject to intense vibration, so legibility and clarity are of great importance.

For ground operations it was obvious that the open skeleton type of air maps on 1/250,000 scale which had been specially produced for the R.A.F. was not suitable. It did not contain sufficient topographical detail of tactical importance and, where air co-operation during battle was concerned, the R.A.F. were interested in the same ground features as the troops whom they were supporting.

Heavy mapping commitments for many theatres precluded the possibility of drawing special maps for meeting this Army/Air requirement, nor was there any justification for such a drastic step. The problem was to take the existing standard maps and adapt them for common use.

The following were the principal items which received attention and suitable action:—

Detail and grid.

Railways were emphasized.

Grid lines were slightly thickened up in some cases where they were very fine.

Water features.

Coastlines were picked out by a blue verge.

Inland water, such as lakes, was shown in a solid blue tint of a rich colour. Rivers were slightly emphasized where necessary, and printed also in a rich blue. Water systems are always of primary importance to airmen.

Woods.

These are of great importance as aids to navigation.

The existence and shapes of woods were checked from air-photos or other modern source of information and printed in a brilliant green.

Magnetic information.

Isogonals were printed across the face of the map.

Layers and spot-heights.

Layers were printed in graduated shades of violet.

Selected critical spot-heights were shown on ridges and other summits which constituted a danger to flying in fog or darkness. Where necessary these heights were printed in a "box" cleared of all other colour printing so as to show up clearly.

The range of altitudes which had to be covered over western Europe was so great that, for high altitudes, the layers reached a very dark purple, with consequent difficulty in reading the map detail. In the case of the 1/250,000 series, which was much used as a wall map, a homogeneous colour scheme for the layers had to be maintained but, in the case of the 1/100,000, which had greater use as a tactical map, an overall homogeneous system of layer colours was not insisted on. The layer sequences were modified and the colours toned down so as to ensure legibility of the basic detail.

Roads.

The colour was selected so that, under the amber light, it would neither fade out, nor become so dark that it would be confused with railways. The object was to cause the main roads to appear as an apparent sepia colour.

In this manner the Army/Air edition was produced, which embraced most of the 1/250,000 series in practically all theatres, many of the 1/100,000 series, and also the sheets of the 1/M series which was extensively used everywhere.

As might be expected, there was some divergence of opinion regarding the merits of this Army/Air style. Some considered that it was not an unqualified success. A good many users, both in the Army and in the R.A.F., preferred the original standard ground style of 1/250,000 map for Army/Air co-operation. In the case of the 1/100,000 scale, which in some theatres was not used by the air forces, the Army/Air style was considered to reduce its value to the Army as

the purple tints gave little, if any, relief effect in low-lying country and, in high altitudes, the dark layers tended to obscure the detail. These criticisms will no doubt be taken into consideration when considering the style of map which will best serve the needs of ground and air forces in the event of another war.

SECTION 4. MAPS FOR THE AIR FORCES

Policy

Included in the pre-war organization of the Geographical Section, General Staff (M.I. 4) at the War Office, was one officer who concerned himself with survey and mapping matters for the R.A.F. He worked partly at the War Office and partly at the Air Ministry, where he had an office and a small staff including a few draughtsmen. Map stocks for the use of the R.A.F. were stored in the Air Ministry building.

The period 1934-38 coincided with the expansion of the R.A.F. and the preparations for possible war in Europe, and special air maps were produced. The design of these special small scale maps, which were mainly for use with visual navigation, was evolved between G.S.G.S. and the Air Ministry.

At one time there appeared to be some tendency on the part of the Air Ministry to break away from the War Office so far as mapping was concerned, and to try and run their own mapping branch, but this never took place and, before the outbreak of war, it was definitely established that the War Office was responsible for R.A.F. mapping and map supply. As a result of experience gained during the war there does not seem to be any doubt that this is the correct policy. Co-operation between air and ground forces during tactical operations is of such vital importance that it is essential for both to use the same maps. The War Office has necessarily to maintain a large and complete mapping organization and, by making it responsible also for R.A.F. mapping, economy is assured by the avoidance of duplication in the collection of mapping material, and the production and printing of the maps, and by obviating the need for cartographic experts to be held by the R.A.F.

The section of G.S.G.S. which worked at the Air Ministry was known formerly as the Air Ministry Map Branch, and later as the Assistant Directorate of Maps, Air Ministry. It was found that this title led to confusion, and it was abolished in May, 1943, when the duties of G.S.G.S. were reaffirmed as follows:—

“The Geographical Section, General Staff, is administered by the War Office. All its services are equally available to the Army Council and to the Air Council, and it has a joint and equal responsibility to each of these bodies for:—

“(a) The production of maps and the execution of topographical or similar field surveys for the Army and the Royal Air Force, either direct or through representatives of the Survey Service in field armies.

“(b) The supply, in conjunction with the Military Survey Service, to the Army and the Royal Air Force, at home and overseas, of all ground, air, or army/air maps.

“(c) The holding and distribution of maps down to, and including, army formations and R.A.F. headquarters, on which the Survey Service is represented. Distribution to and within lower formations will remain the responsibility of the respective services.

“(d) Operational security and movement arrangements for map supplies to both the Army and the Royal Air Force.

“The Geographical Section, General Staff, will continue to be responsible for the supply of maps for the use of the Civil Aviation Department.

“The Geographical Section, General Staff, will have direct access to the General Staff and to the Air Staff in connection with its duties; liaison between the Geographical Section and the Air Ministry will be maintained at all necessary levels.”

Maps for general use by the air forces

Apart from Admiralty Charts, there were four main categories of maps which were provided for general use by the air forces:—

PLANNING AND GENERAL PURPOSE MAPS

These were required primarily for intelligence and strategical planning, and also for use in the air for navigation when larger scale maps were not available. The 1/M map (based on the International series) was available for all areas of operational interest and it was, during the course of the war, converted to Army/Air style.

OPERATIONAL MAPS

These included:—

Plotting maps on Mercator's projection for navigational use:—

- (a) The standard “Plotting” series was on 1/M scale (at 56° N). Sheets were published covering the whole of the Atlantic, the western seaboard of North and South America, all western Europe and Africa, southern Asia including Turkey, Arabia, Persia, India and Burma, the Far East and the East Indies, Australia and New Zealand and the oceans connecting all the above.

It was a skeleton outline series, originally printed in black but later changed to red, and was used for navigational plotting both on the chart table and in combination with the Astrograph. Selected spot heights were shown, and high ground was indicated in generalized form.

- (b) The small scale “Plotting” series on 1/2M scale was similar in design to the above but did not extend so far south or east as the 1/M series.
- (c) A still larger scale “Plotting” series on 1/500,000 scale was published covering limited areas of the North Sea for use in connection with Air/Sea rescue.

Special “flying” maps. The following were the two principal series prepared especially for “Air” use:—

- (i) 1/500,000 *Air Map* (GSGS 4072). The 1/500,000 map was designed solely to meet R.A.F. requirements, especially those of Bomber Command. Certain features such as railways and water were emphasized as they provided valuable navigational aids. Outline generally was shown in its simplest form, and all unessential detail was omitted. The series was compiled from the best available maps on the same or larger scales. The generalized style limited its value for military use, but sheets of the series were largely used as wall maps on which to mark up situations of strategic interest.

The military grid was shown by means of ticks and crosses so that the grid itself could be drawn in by hand if so desired. One of the chief merits of this map was that it provided the only homogeneous series at a scale between 1/250,000 and 1/M which covered the whole, or nearly the whole, of Europe.

- (ii) 1/250,000 *Air Map* (GSGS 3982). This 1/250,000 series was compiled between 1938 and the latter stages of the war. It showed in generalized form the railways, main and secondary roads, towns and large villages, contours, and water features. It was clear and readable and, for some time, was the only series available at 1/250,000 scale over certain areas of Europe. Like the 1/500,000 map the military grid was indicated on the face of the map by grid ticks and crosses.

The sheets were mostly layered in purple, with spot height boxes on all critical ridges and hills. Coastal sheets were published showing marine depths in layer tints.

Maps for use with Radar aids to navigation. These included special versions of both "Plotting" and "Flying" maps covering large areas of Europe, the North Atlantic and other selected areas. They comprised various types of "Lattice" charts for use with 'Gee' navigational aids, radar plotting charts, and gnomonic fixing charts. (See also Chapter XI, Section 7.)

Army/Air editions of standard topographic maps were published at scales ranging from 1/2M to 1/100,000. These are referred to in many places elsewhere in this history and were an adaptation of the standard military maps designed to suit the needs of both ground and air forces. Those on 1/250,000 scale and larger were required for tactical co-operation with the ground forces. (See Section 3 of this Chapter.)

MEDIUM AND LARGE SCALE MAPS

Normally these were the standard military tactical maps at 1/50,000 scale and larger and were required for depicting target areas, for air-photo plotting, for other intelligence purposes, and on occasions for use as Tactical maps during operations.

TARGET MAPS

These were produced in large numbers mainly for Bomber Command operations and were of specialized design.

MISCELLANEOUS MAPS

There were a large number of miscellaneous maps produced for special use by the air forces. Amongst them were the following:—

Lighthouse recognition charts. These charts, on scales varying from about 1/600,000 to 1/M, indicated lighthouse structures which provided valuable day landmarks.

High-altitude "Fighter" maps. These were provided to meet the requirements of fighter aircraft flying at high altitudes. At a scale of 1/M they gave a bird's-eye view of the principal built-up areas, woods, rivers and railways. No roads or other minor features were shown, and very few place-names were included.

Oblique perspective target maps for U.S. Bomber Command. This type of target map was evolved by U.S. Bomber Command. It consisted of a central map, circular in shape, generally on 1/50,000 scale, in which the selected target was at the centre. Five or six "run-in" lines were chosen, and perspective oblique maps were plotted with their central axes corresponding to the "run-in" lines. These perspective obliques were printed around the central map and radial to it, so that the approach line was in continuation of the corresponding line on the central circular map.

U.S. Bomber Command prepared the models, and the work of production was at first done at the Ordnance Survey. Later the Americans took on the drawing of some of these maps and developed a rapid technique for producing the perspective maps by photographing the centre map with a tilted camera. Altogether, nearly 200 such maps were produced.

SECTION 5. SOME COMMENTS ON SURVEY ORGANIZATION

General considerations

Nearly six years of war in all parts of the world proved that the military survey organization was an essential link in the chain of land and air operations.

There seems little doubt, however, that the facilities and opportunities available before September, 1939, for the training of officers and other ranks in the duties appertaining to survey directorates and field survey units in war were not adequate. There was not sufficient opportunity for the more senior survey officers to study and appreciate the needs, methods and procedure of the General Staff with whom they would be working in close contact during planning and operations. Conversely, it would have been of advantage if the potential staffs of formations had learnt by peace-time experience the extent and type of service which Survey could provide for them during a war, and what assistance Survey would require from them in carrying out their tasks.

There were no active Royal Engineer survey units available before the war for peace-time duty and training with the potential Expeditionary Force. The Geographical Section at the War Office, though handicapped at first through lack of adequate staff to meet the many demands thrown upon it, was in due course built up into a smooth running and efficient organization now known as the Directorate of Military Survey.

The survey officers and other ranks from the Ordnance Survey of Great Britain, the Survey of India, and the Colonial Survey Departments, who formed the nucleus for the earliest formed units and directorates were, generally speaking, of high technical efficiency in their own fields of activity. But peace-time survey duties did not, by themselves, form a complete training for war, and few of the senior N.C.O.s had much opportunity of learning the important duties of unit administration.

The above comments will serve to indicate the desirability of maintaining in peace-time the nucleus of a military survey service to serve the needs of and train with the rest of the Defence Forces.

Survey training

The Survey Training Centre,* which was established in the early days of the war, more than justified its creation, and would seem to be a necessary part of the peace-time survey organization. It formed a centre of military survey thought and doctrine, and ensured the adequate initial training of personnel in technical, military and administrative duties. (See Chapter I.)

War establishments

There were many changes of war establishment during the course of the war concerning both survey directorates and units. This was inevitable, as conditions were constantly changing and requirements in the various theatres were difficult to foresee. Frequent changes in establishment are clearly undesirable, and the experiences gained during the war in all parts of the world, combined with subsequent developments in survey technique, will no doubt facilitate the drawing up of survey establishments for any future war. The importance of adequate resources in personnel and transport for map supply and distribution cannot be over-emphasized.

Survey representation with field formations

During the B.E.F. operations in France and Belgium in 1939-40, survey staff representation went down to corps, where there was a small survey directorate (Lieut.-Colonel, Captain, and small staff). As the whole force up to the time of the evacuation did not exceed three corps, this was probably a sound arrangement, especially in view of the lack of previous co-operation and training between Survey and the rest of the Army. Later, however, it was decided that survey directorates and units would not normally be allocated lower than army level. Though this decision was partly owing to a shortage of trained survey officers at a time when the number of corps was increasing, there is no doubt that it was correct policy. In some overseas theatres, however, where corps and even divisions were operating independently, it was found desirable to provide survey staff representation and units down to corps, and in some cases even to divisions and brigades.

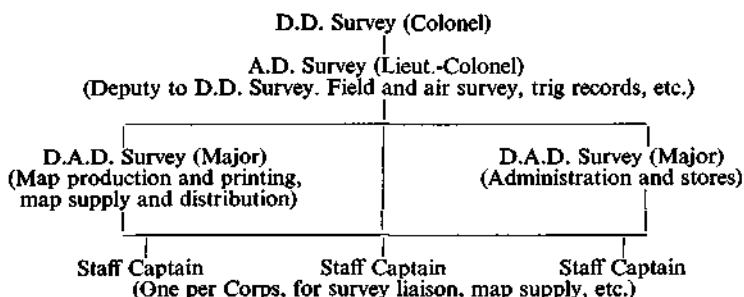
The organization of the Survey Directorate with British Second Army as shown in Diagram 14 was typical of normal standard practice. It should be understood, however, that there will often be variations in the allocation of work between the officers, dependent on their characteristics and qualifications,

* Now known as the School of Military Survey.

and the particular wishes of the D. (or D.D.) Survey concerned. The provision of staff captains (one to each corps), held on the Army Directorate establishment, for close liaison with corps under command, especially on map supply and distribution matters, was found to be most valuable.

Diagram 14

Organization of Survey Directorate with British Second Army during "Overlord," 1944-45



The above organization worked well though both D.A.D.s Survey were consistently overworked, especially the one responsible for maps. The addition of one staff captain to control the records of air-photos and mapping work, to check proofs, and to assist the D.A.D. Survey employed on map production, supply and distribution, would have been a great advantage. Normally the work of the survey units was controlled from the Army Directorate. This involved frequent reminders to the staff that there were survey units working in the army area, and that accommodation and other administrative arrangements were required.

The following notes dealing with the organization and working of the Survey Branch of H.Q. Eighth Army during the campaign following the battle of El Alamein are recorded because the conditions under which fast-moving operations were conducted in the desert may well be met with on future occasions, and past experiences are always worthy of study. This should be read in conjunction with Chapter V, which gives the operational background.

The work was divided amongst the officers of the Branch* as follows:—

D.D. Survey	Planning and policy.
A.D. Survey	Trig and air-photo work. Understudy to D.D. Survey.
D.A.D. Survey	Map records and production.
Captain	Map distribution.
Captain	Stores. Administrative officer.
Captain	{ Assistant to any of the above as required. Liaison officer and general messenger.

(Note. The division of work between the A.D. and the D.A.D. Survey depended on the particular qualifications of the officers holding these two posts.)

During the battle of El Alamein, the experiment was tried of putting survey troops under command of corps and/or divisions, and of attaching an officer

* In Eighth Army the title "Branch" was preferred to that of "Directorate."

to Corps H.Q. as survey adviser, and to maintain survey liaison with Army H.Q. This was not found satisfactory. The officers attached to Corps H.Q. were less able to maintain contact between the survey units and Army H.Q. than when they were based on Army H.Q. from which they could pay frequent visits to the forward units, while work at Army H.Q. suffered for lack of sufficient officers. The survey units were, it was found, used to greater advantage when under the direct control of Army H.Q., and attached to formations or units for administrative purposes only. The only exception to this was the case of a topographical section attached to a composite battery of a Survey Regiment R.A., when the two units worked under the orders of the C.C.R.A.

During an advance the survey staff moved as a whole with Main Army H.Q. but occasionally dropped a small party for a few days to see a job through to completion, afterwards catching up with the main body. Examples of this were:—

The map distribution officer or stores officer, with possibly a clerk, supervised the installation of the Map Depot in a new site on a change of base, to ensure that the maps and stores did, in fact, arrive satisfactorily by the new routes.

The map production officer remained behind to check proofs, and to supervise completion of an urgent printing job. This entailed the holding back of the mobile reproduction sections so that sheets could be published by a given date.

These detachments were considered bad in principle, but were sometimes inevitable. They were kept to an absolute minimum.

With regard to the other ranks, the serjeant clerk was required to carry out the functions of senior N.C.O. rather than those of a clerk. The corporal and sapper clerks were employed at their legitimate trade, but the serjeant and sapper storemen were not required. The corporal and sapper computers were employed mainly at their trade, but during slack periods of computing they were used to assist in any other work. The corporal draughtsman kept the map production records and carried out any drawing jobs required, assisted by the sapper draughtsman. Record keeping was not work which could be done satisfactorily by men of the trade of storeman (survey) as was sometimes suggested.

During the advance from El Alamein to El Agheila, the Survey Branch was divided in two. One party consisting of D.D. Survey, D.A.D. Survey, the map distribution officer, an officer charged with triangulation duties, and six other ranks went with Main Army H.Q. The other party consisting of A.D. Survey, one captain, the corporal clerk, the sapper computer and the sapper storeman, were given control of survey work in the rear areas on a territorial basis, with a field survey company under command. This rear party first of all took over the Western Desert area of Egypt, and subsequently eastern Cyrenaica. The experiment was, apparently, not an entire success. Though it was undoubtedly useful to have representatives in rear areas when communications were long and strained, it was found that they had by no means a full-time job, and that it was really better to keep the survey staff concentrated, exercising what supervision was required in rear areas by periodical visits.

The advance from El Alamein to Tripoli covered a distance of some 1,700 miles. Over that distance there was but a single road serving as a line of

communication, and this was very bad in places. Eighth Army was obliged on several occasions to leave behind anything that was not absolutely essential. Detachments of the Survey Branch had therefore to be "thrown off" in order firstly to reduce to the bare minimum the numbers going forward, and secondly to cater for the needs of the L. of C. and troops which were left behind. The need to reduce numbers going forward to a minimum resulted in the rear detachments being stronger than was strictly necessary for their work.

It was for the same reason of bad and overloaded communications between Army H.Q. and troops leading the pursuit that detachments of the Survey Branch were sent to corps, in the expectation that these detachments would be better placed to control surveyors with the forward troops. This expectation was not fulfilled as Corps H.Q. appeared even less able than Army H.Q. to keep touch with such army troops as were operating in the corps area.

It was the difficulty of communications also which led to the placing of a topographical section under the orders of a C.C.R.A. The case was analogous to that of a corps with an independent role needing R.E. field surveyors but having no R.E. survey troops under command nor any survey representation at Corps H.Q. It is not an example to be followed except in unusual circumstances.

Representation with the higher formations (army groups and above) was, of course, an essential part of the survey organization. While the survey staff at Army H.Q. was committed with the day-to-day problems of map supply and distribution, large scale and special map printing, and field surveys, the directorates at army groups and above were responsible for mapping and survey policy, bulk map supply, long-term map production and printing, the preparation and maintenance of trig and map records, and the provision of maps specially required by the planning and operational staffs. Adequate establishment provision to meet all these commitments had to be built up, as the initial provision was, in most cases insufficient.

In the case of S.H.A.E.F. and A.F.H.Q., establishment provision was complicated by the fact that they were both composed of British and American personnel working as an integrated staff. In spite of many differences in basic organizational systems and technical outlook, these integrated survey staffs worked together with great success.

The importance of allocating survey directorates to the headquarters of formations at the earliest possible moment cannot be too strongly stressed. The advantages of Survey being represented at early planning stages are too obvious to need further emphasis. Several cases did occur during the war when survey representation was not made available until planning was well advanced, thus adding greatly to their difficulties and prejudicing the successful completion of the map supply arrangements.

Before leaving the subject of survey directorates, it might be well to consider the question of nomenclature. At any level other than at the War Office, should the survey organization at the headquarters of a formation be called a "Directorate" or a "Branch"? In Eighth Army it was always known as the "Survey Branch" as it was considered, and possibly rightly, that this was of real value in establishing close relations with the General Staff. It was held that a "Directorate" tended to be looked on as something separate from the rest of the headquarters, a technical detachment instead of part of the family. Psychologically there is probably some weight to be attached to this view.

Relations with the General Staff

Many lessons on this important aspect were learnt during the course of the war. Close, friendly and constant relations and co-operation between the officers of a survey directorate and the rest of the staff at any headquarters are indispensable. A Director (or D.D.) of Survey *must* possess the complete confidence of the Chief of Staff (or Brigadier, General Staff) to whom he is responsible, and of his subordinate staff officers, more especially those concerned with planning, operations and intelligence. The practical non-existence of a military survey service before the war made it necessary for Directors of Survey to build up these close working arrangements and, with a due mixture of tact and firmness, to persuade the General Staff that Survey could fulfil their functions properly only if taken fully into the confidence of the General Staff and given early information about impending operations and future plans, and invited to relevant staff conferences. This, of course, will never absolve the survey officer from keeping on the alert, and making quite certain that he is keeping a full length ahead in all his preparations. Not the least of the essentials for a survey staff officer is that he should be a good mixer, trustworthy of confidence, an intelligent forecaster, and genuinely one of the staff team and not simply a technical expert.

Survey Units

GENERAL NOTES

There were differing views regarding the organization of field survey units. Firstly there was the British type of general purpose unit consisting of topographical, drawing, photographic and printing sections in a given proportion. Secondly there were units organized on a functional basis (air survey, mapping, printing, etc.) such as those employed by the Canadian Army. Thirdly there was the battalion organization as adopted by the American Army. It is possible that the functional type has certain advantages leading to greater efficiency of production and output, and this would be satisfactory so long as the units can always be employed on their own particular function but they may suffer from a lack of flexibility, and are not so suitable for meeting the needs of an operation where limited survey action and high mobility are required, and transport facilities are limited. It is probable, also, that they place a greater burden on survey directorates than do units designed to manage a variety of tasks on their own. With regard to the American battalion organization, there are probably some advantages to be gained in having all the survey troops within the Army under one command, and staff direction is possibly made easier thereby. In the American Army it seems that the officer commanding a topographical battalion is expected to have a staff function as well as a command function, but this may not suit the British organization where there is survey staff representation at a headquarters responsible to the General Staff. Again it would seem to British eyes that the American type of survey battalion is rather an unwieldy unit, not easily broken down into small sub-units for minor tasks or independent missions.

As a result of war experience in many divergent theatres it seems to be generally considered that the British field survey company system is the most suitable for British needs. The company is a compact, comprehensive major's command, and can undertake most of the survey tasks likely to be required.

It is suitable for an independent mission, and three such companies will be sufficient to serve an army of three corps. In this connection, some consideration will be given later to the question of enlarging the company organization slightly from what it was at the end of the war in order to make it possible to meet the requirements of an army with two companies only, thus saving considerably in "overheads." The handling of field survey companies by a Survey Directorate is generally simple and, when an army is on the move, the units can be conveniently "leapfrogged" forward so that while one is moving the other(s) can be maintaining output. When considered necessary, sections of similar type of the three companies can be brigaded together for mass production and centrally controlled output. There is a further factor which perhaps concerns peace-time training. The general purpose unit seems likely to provide better all round training than the functional type, both for junior officers and for those likely to be selected for command and, being so much smaller than the battalion type, a greater number of separate units can be maintained for the man-power involved.

(CORPS) FIELD SURVEY COMPANY R.E.

As originally organized, one of these companies was allocated to each of the three corps with the British Expeditionary Force in France and Belgium in 1939-40. According to the war establishment there were topographical, drawing and printing sections but no photographic section. This latter was not provided until the companies were reorganized after Dunkirk. The printing machines were of double-demy size, hand-fed, slow running, and mounted in trailers towed by independent tractors, which was a great disadvantage from the point of view of mobility and ease of handling. There were some advantages in the large size of the machines, but they were too heavy and cumbersome to mount in self-propelling lorries, and their output was too low for field requirements. The tractors did not belong to the survey units and the risk of not being able to move the trailers quickly in emergency was a serious one.

FIELD SURVEY COMPANY R.E.

This was the successor to the above unit. As a result of experience with the B.E.F., it was decided to make certain changes in the organization of field survey units. The decision to concentrate the units at army level instead of decentralizing them to corps rendered the title "Corps Company" superfluous. No material change was made in the organization of the topographical sections or the drawing section, but photographic sections equipped with lorry-mounted cameras were formed, and one such section was incorporated with each company. The equipment of the reproduction sections was greatly improved. Fast-running printing machines of demy size, with full automatic feed, were substituted for the larger but slower and heavier machines previously issued. They were mounted in specially designed lorries whose sides opened out to give working room around the machine, and were found to be most efficient wherever employed, giving good quality work at high speed. Newly designed photo-mechanical lorries were issued to work in conjunction with the printing lorries and the ancillary reproduction equipment was also of greatly improved type.

The standard sectional organization of a field survey company was:—

Headquarters.

2 Topographical sections.

1 Drawing section.

2 Reproduction sections (each with 1 printing lorry and 1 photo-mechanical lorry).

1 Photo section (with 1 lorry-mounted camera and 1 processing lorry).

During the Normandy campaign, it quickly became apparent that the printing capacity of the three field survey companies with Second Army was insufficient to meet requirements. This was primarily a result of the unexpectedly large demands for 1/25,000 maps by all arms especially in the enclosed "bocage" country, where fields were small and there were many hedges, involving a lot of close-quarter fighting. An extensive demand for "Going" maps and defence overprints also added considerably to the heavy printing programme. Two additional printing machines and one graining machine were therefore allocated to each of the three companies, together with an extra printing officer. Each reproduction section then consisted of two printing lorries, one photo-mechanical lorry and one grainer. This addition of printing power continued with Second Army for the remainder of the campaign and the following comments may be of interest:—

- (a) One photo-mechanical lorry was found capable of feeding two printing lorries.
- (b) The additional printing capacity was never too much under the conditions met with by Second Army in western Europe.
- (c) There were some disadvantages owing to the increased size of the companies (especially when a General Field Survey Section was under command as was usual with Second Army), in that accommodation troubles increased.
- (d) It was frequently found necessary to detach one printing and one photo-mechanical lorry on urgent missions for the preparation and printing of fire-plan and other special maps for the corps artillery.

There were some who were of the opinion that the organization of a field survey company, as it existed at the end of the war, could be modified with advantage; firstly, so that two such units would normally be sufficient to serve an army, and secondly to improve the internal organization. Three general principles are offered in this latter connection:—

- (a) The unit should be so organized and provided with officers as to ensure effective decentralization of work, and the proper control of all the unit's activities.
- (b) The "field survey" portion should be fully capable of temporary independent existence, and be organized and of suitable size to undertake a comprehensive survey task. It is desirable moreover that, in conditions of semi-mobile operations, and with a reasonable density of trig control, it shall be capable of executing field surveys over a whole army front. It is also desirable that this part of the unit shall be capable of undertaking both ground and air survey work up to the compilation stage of map making or revision.

- (c) Experience has proved the desirability of each company having a records and checking section, whose main functions would be to look after and control record material such as kodak negatives, original mapping material and air photographs which a unit has to hold for its map production and printing tasks; to amplify the technical details of a production job after broad formulation by the company commander; to carry out the routine checking of all completed work; and to maintain a set of trig records for use by field observers and computers.

Considering now the different portions of the unit, it was felt by many who had experience in the handling of field survey companies that the topographical sections might be organized as a "survey group" rather than as a number of independent sections. They frequently operated at a considerable distance from the parent unit and, being small individual sub-units, they often had to be attached to other units for administration, usually an unsatisfactory arrangement. Moreover the topographical strength of a field survey company was not sufficient during mobile operations for due rest periods to be arranged. The suggested organization therefore aims at having a topographical group headquarters, preferably commanded by a captain, with three sections each commanded by a subaltern. Group headquarters would have both technical and administrative functions. Such a group would be capable of executing a comprehensive task working as a whole, or alternatively the sections would each be capable of independent action. Four officers would preferably be needed for the best results, but if this is considered too extravagant in officers the alternative would be to have a captain and one subaltern at Group H.Q. leaving the sections under the command of the section serjeants. This latter arrangement might be appropriate in peace-time, with the extra subalterns added on mobilization. All the personnel in these sections would be trained in air survey as well as ground survey tasks.

The drawing section, as it was at the end of the war, was too small to be fully effective. It was always a bottleneck, and the section should either be duplicated or doubled in size. Such action, incidentally, should not be at the expense of lithographic draughtsmen with the reproduction sections, who are required for their own class of work. An officer to command the enlarged drawing section is considered essential.

The proposed records section might possibly be placed under the control of the drawing officer, and its composition might be, say, two surveyors with knowledge of trig lists, two draughtsmen, and two printing tradesmen, with a serjeant in charge of the section.

It has also been suggested that the reproduction and photo sections might, with advantage, be organized as a group, commanded by a captain, with one subaltern as his assistant, the sections each being under their own serjeant. A small headquarters would be desirable for dealing with the centralized control of jobs passing through the various sections of the reproduction group, for controlling supplies of paper and reproduction stores, and for packing up and despatching the finished work. The litho draughtsmen might well be grouped together to work directly under the group commander.

With the above arrangement company headquarters should have purely administrative and no technical functions. The O.C. would, of course, be responsible for the technical work of his unit as a whole, but the detailed technical control would be in the hands of the two group officers and the drawing

officer. It is thought that there are many advantages in having the second-in-command in charge of administration at company headquarters, where he is readily available to take charge of the unit in emergency, and to know the intentions of the O.C. at all times. Indenting for and obtaining stores, though worked out in detail by the group officers should, of course, all go through the channel of the company quartermaster.

Survey units were at times handicapped by the lack of non-survey tradesmen for carrying out first-line repairs to electrical equipment and M.T. The major repair of survey instruments and printing machines is probably best undertaken on a theatre basis, but each unit should have its proper quota of well trained tradesmen for first-line repairs and adjustments.

The provision of guards and fatigue duties was always a serious drain on technical output. A larger quota of pioneers might serve to reduce this loss of technical efficiency.

With regard to transport, the survey group should be completely mobile, and equipped with nothing but four- or six-wheel drive vehicles, the larger proportion of which should be of the jeep variety, possibly with trailers. At least one bigger vehicle (3-ton) would be necessary for group headquarters, and a few 15-cwt. trucks for use by headquarters and the field sections. The rest of the company probably need not be fully mobile, but it is important that as much as possible of the unit equipment should be arranged for easy and rapid loading into vehicles specially prepared to receive it.

Working accommodation is always an important point for consideration. There are many occasions when buildings will not be available, even for those parts of the unit which must have some sort of covered shelter to enable them to work efficiently. It does not appear reasonable, however, that a full complement of tentage should be carried permanently around. Possibly the war establishment table might carry a note which would serve as authority to draw sufficient tentage and heating equipment for use when the occasion justified it.

Reference has been made to the need for flexibility. It is suggested that one field survey company of the above type would normally be sufficient for an independent corps, and two for an army. It is clear, however, that there will be occasions requiring a variation from the standard survey potential. It is suggested that this elasticity might be provided by varying the number of sections of each type (*i.e.* topographical, printing, etc.). The provision of extra sections of a standard type, in the form of a reinforcement to a unit, is probably preferable to the attachment of a different unit such as a general field survey section, which was common practice during the war. In any future mobilization, therefore, it would seem desirable to form a number of spare sections of each type, in addition to the requisite number of complete units. The war establishment of a field survey company could then, by varying the number of sections, provide that particular size of unit which was considered appropriate for the pending operations. Further adjustments could be made later as required.

ARMY FIELD SURVEY COMPANY R.E. (1939 TYPE)

Two only of this type of unit were formed. No. 19 was mobilized to accompany the B.E.F. to France in September, 1939, and No. 512 was raised later and went out to the Middle East early in 1940. The name of the unit implies that it was designed to operate with an army in the field. If, by the word

"Army," it referred to a field army of two or more corps engaged on mobile operations, the design of the unit was wholly unsuitable for the purpose. It consisted of a headquarters, a mobile echelon of four topographical sections for field surveys, and an immobile echelon of drawing, photographic and reproduction sections. The latter were equipped with six double-demy static printing machines which had to be erected from their individual component parts in suitable accommodation possessing a solid flooring. It was an unwieldy unit and, in view of its size and the assortment of mobile and immobile echelons, it was extremely difficult for any one commanding officer to control it properly. In France, the headquarters of the unit together with the drawing sections and the mobile echelon were located about ten miles or so from the G.H.Q. Survey Directorate. Intensive search failed to find any suitable accommodation for the six printing machines all together in the B.E.F. area. Two machines and a camera were erected in a converted derelict sawmill near company headquarters, and they produced much valuable work for G.H.Q. and the three corps. Eventually a factory building was requisitioned in Paris where the remaining machines were erected, and they had just reached production stage when the German offensive took place in May, 1940. All the equipment in Paris was lost, so also were the machines near G.H.Q. There was no time to dismantle them before the enemy arrived.

After Dunkirk 19 Field Survey Company was reorganized on a much reduced establishment, with a smaller type of machine, and went to Iceland, where it remained for some months carrying out local surveys and map production. It returned to the United Kingdom for a short period before going to the Middle East, still on a reduced establishment, and served for a time with Paiforce.

512 Field Survey Company, after expansion and alteration, became the principal base map production unit for the Middle East. The topographical sections were detached for field duty in the Western Desert, in Iraq, and elsewhere. The commanding officer was unable to retain much effective control over them while they were away, and they might just as well have been a separate unit. Quite unfitted for operating with a mobile formation, it was also, in its original form, organized wrongly for duty as a base unit. When reorganized, it carried out an immense amount of valuable map production and printing for operations in the Middle East and for A.F.H.Q.

MAP REPRODUCTION SECTION R.E.

This type of unit was designed and raised subsequent to the return of the B.E.F. from France in 1940. The object was to provide a source of semi-mobile reproduction power at the disposal of Directors of Survey with an army group or higher formation. The machines were of double-demy size so as to take on jobs bigger than could be printed on the mobile equipment with field survey companies. Though easier to move than a permanent base installation, they were not mobile enough to operate with a field army during fast moving operations. They were used with conspicuous success with S.H.A.E.F., 21 Army Group, A.F.H.Q. (in the Mediterranean Theatre), and elsewhere. As standard equipment, they each carried one double-colour and one single-colour fast-running machine capable of large and rapid output. The machines were assembled in convenient-sized blocks or sections which could be easily

bolted together, thus facilitating erection and dismantling. The blocks were crated and were carried on 10-ton lorries during moves from one location to another, these lorries being part of the unit transport. Each section also carried one "Baby" printing machine for dealing with the many small-size jobs that are so often required at any large headquarters, a camera, and all the necessary ancillary equipment that go to make up a self-contained and efficient reproduction unit. Although a quota of lithographic draughtsmen were held on establishment, there were no cartographic draughtsmen. These latter are always necessary to work in conjunction with a reproduction unit at a higher formation headquarters. To get over this difficulty S.H.A.E.F. attached a general field survey section to the map reproduction section, and they were at all times fully employed on a variety of work, much of it entailing air-photo compilation. While there was during the war, and may well be in the future, a requirement for a small reproduction unit of this type, it seems probable that, for a base or even an army group map reproduction organization, a more comprehensive unit containing its own draughtsmen, printing and photographic personnel and equipment, records section and packing section would be more appropriate. Overall control would be simplified and "overheads" saved.

GENERAL FIELD SURVEY SECTION R.E.

Though used for a variety of purposes in western Europe and elsewhere, this was not a well designed unit. It aimed at being a limited general purpose unit, with personnel belonging principally to the surveyor and draughtsmen trades. In theory they were all supposed to be trained in air survey mapping methods. The section had no cook and no clerical staff. It was not administratively able to exist by itself. The intention was that it should always be attached to another unit, usually a field survey company, and so augment the survey potential of the unit to which it was attached. The first few sections were formed at a time when D. Survey, G.H.Q. Home Forces, was about to undertake a big programme of 1/25,000 mapping from air-photos for "Overlord." They were assembled together to form an 'air survey group,' each section having its own subaltern, the group being under the control of a captain who was at the same time second in command of No. 1 Air Survey Liaison Section. Lack of administrative staff presented many difficulties, and cooks and clerks had to be borrowed from an infantry depot unit. On completion of this special mapping programme, shortly before "D"-day, the sections were allotted to their operational assignments. S.H.A.E.F. employed one to work alongside No. 13 Map Reproduction Section. H.Q. 21 Army Group had two, and three were assigned to Second Army. These latter were normally attached, one to each of the three field survey companies. On occasions they were lent to D. Survey 21 Army Group for employment on 1/25,000 map revision and other special tasks of that nature. During the fast-moving operations subsequent to the Rhine crossing they were used by Second Army as mobile map depots for ensuring efficient map distribution. This latter use might seem at first sight to be a waste of good technical tradesmen but, at the period in question, there was no field survey work for them and map distribution was of such vital importance that all means were justified to ensure its success. On the whole it does not appear that a perpetuation of this type of unit would be justified. To carry out the tasks on which they were employed during the war, it is suggested that a modification of other units would be preferable.

AIR SURVEY LIAISON SECTION R.E.

With the certainty that big programmes of air photography for mapping purposes would be undertaken in all operational theatres, it was considered necessary to design and raise a type of unit which would work in close liaison with the R.A.F. and ensure, as far as possible, that the photographic programmes would be undertaken in such a manner as to meet survey requirements. This involved, first of all, the technical briefing of the pilots before each sortie on matters affecting the actual taking of the photographs. Of great importance also was the maintenance of the plots, or cover diagrams, of the sorties so as to keep a running record of what photo-cover had been completed to date. To carry out this work effectively, it was essential that the section should live and work with the R.A.F. squadron which was undertaking the photography. It was also most important that the officer appointed to command the section should be of the right personality to mix well with his R.A.F. associates both in his work and in everyday social life.

With the introduction of studies for the determination of beach gradients in areas of possible assault operations, the responsibilities of the section were extended. When Survey was first asked to assist in these beach studies, extending from Holland to the Brest peninsula, research work was started by No. 1 Air Survey Liaison Section to develop practical methods of determining the gradients. The personnel of the section were employed on a study of the photographs which had been taken in accordance with a carefully timed programme prepared by the section officer. The results of their work were sent to the Hydrographic Branch of the Admiralty who, from these data, prepared beach-mosaics and gradient sections. No. 1 Section went over to France with 21 Army Group, and similar units were sent out to the Mediterranean and South East Asia Theatres, where they were successfully employed on similar valuable work. From the point of view of command it seemed a curious organization, as the commanding officer was graded as a staff officer. There is no doubt that this type of unit was an essential and useful part of the survey organization, and something of its kind will probably be required for any future operations.

FIELD SURVEY DEPOTS R.E.

Original standard type. As first designed, this unit consisted of one lieutenant, one warrant officer Class I, one warrant officer Class II, and 16 other ranks with one 3-ton lorry. One such unit accompanied the B.E.F. to France in September, 1939, and had to be split in two portions. One warrant officer and a small party remained back at Rennes to look after the base map depot, to receive bulk stocks from the United Kingdom, and to send forward consignments to G.H.Q. as required. The O.C. and the remainder moved forward to open and control an advanced depot near G.H.Q. for detail issues to the corps and to G.H.Q. troops. At that time, the map supply and distribution policy was based on the assumption that the corps, as advised by their A.D.s Survey, indented for their requirements on the G.H.Q. depot, and sent their own transport to collect the maps. Thereafter, the corps were responsible for further distribution to corps troops and to divisions. From September, 1939, to early May, 1940, conditions were more or less static and provided no proper test for map supply or distribution arrangements. When active operations started on 10th May and the B.E.F. moved forward into Belgium, it became necessary to form a third echelon of the depot in order to open up an advanced

depot near Brussels. There was not enough depot personnel to meet this extra commitment, and transport had to be obtained from a G.H.Q. pool, which at that time was heavily committed in other ways. Then came the retreat with all its confusion, and the cutting off of the B.E.F. from its main lines of communication including its principal map stocks. The depot, as such, ceased to carry out its normal map supply functions with the result that, when the B.E.F. was evacuated to the United Kingdom, there were little firm data, as a result of battle experience, on which to base future map depot and map distribution policy for mobile operations.

The first real test came in the Middle East, where the fast-moving Eighth Army had to be supplied over long distances. There it was found that, unless Survey took a hand in actual distribution down to divisions, there was always a risk of breakdown in map supply. As a result there was developed the prototype of the "Army" type of field survey depot which thereafter worked so successfully, with certain amendments, right through to Tunis, all through Italy, and with the British and Canadian Armies in western Europe. In bare essentials, this new unit was able to furnish a main depot and an advanced depot, and map lorries, accompanied by map storemen, were allotted to the headquarters of each corps and division. There is no doubt that, during the fluid operations in the desert, where distances were great, and formations were often separated by long distances from their higher headquarters, there would have been grave danger of their maps not reaching them at all under the old system.

The lorries with the headquarters of corps and divisions held replacement stocks, and maps of areas immediately ahead of current operations. A forward map dump near Army H.Q. acted as a link between the advanced map depot, and the formation vehicles. Maps covering areas ahead of those carried in the formation vehicles were held at this dump, and its two lorries were used to replenish the formation vehicles.

(Army) Field Survey Depot. This, then, was the forerunner of the (Army) Field Survey Depot which functioned in Italy and during "Overlord." The basic establishment consisted of three officers, 49 other ranks and 13 vehicles, with an additional sub-section of one vehicle, one driver and one storeman to each corps and division. Even so, it was not strong enough to deal with the situations met with during "Overlord." With difficulty, map stocks were kept down to about 3,500,000 in the army depot. They rose to 5,000,000 during a somewhat static period in Holland in the winter of 1944-45. With stores and paper, the weight of the depot was never less than 200 tons, and in the final phase 300 tons. Throughout the whole campaign from Normandy to the R. Elbe, except during the short static period in Holland, it was found necessary to attach one, and often two, platoons of pioneers, also 20 extra R.A.S.C. vehicles. During the advance into Germany Army H.Q. moved, on the average, every five days. Hence the depot had to move at an equal speed, but it took seven to ten days to move it, so a system of "leapfrogging" had to be adopted. Distribution, during the most rapid period of the advance, was maintained only by employing three general field survey sections with the depot, an irregular but quite necessary use of skilled survey tradesmen.

FIELD SURVEY DEPOTS FOR EMPLOYMENT WITH AN ARMY GROUP OR AT THE BASE

Except for the "Army" type of depot referred to above, the original establishment of one officer, 18 other ranks and one lorry remained standard for

other purposes up to the launching of "Overlord" in June, 1944. The map depots which were organized in the Home Commands in 1940 for defence and training were manned by this standard type of unit. When H.Q. 21 Army Group went over to Normandy it had at its disposal two such depots. No. 4 was to act as the base map depot, and No. 5 was to handle the base survey stores. At the end of August, 1944, No. 25 Field Survey Depot was assigned to 21 Army Group to function as a L. of C. map depot handling both maps and stores which it would receive from the two base depots. It was soon found necessary to increase the establishment of No. 4 to deal with its administrative responsibilities as well as its big volume of maps. This situation was aggravated by the fact that it was left a long way behind when H.Q. 21 Army Group moved forward so quickly. The amended establishment for No. 4 brought it up to three officers (including a captain as O.C.), one warrant officer I, and 83 other ranks including two attached cooks, the latter being essential for the general welfare of the unit which was often somewhat isolated. Included in the establishment were 54 storemen (survey), but it was stipulated that if these were not available, civilians or personnel of low medical category from any arm of the service might be employed instead. The transport was also greatly increased. The need for a small vehicle for domestic use had always been felt, and there were other essential transport requirements. The new establishment provided two motor cycles, one 2-seater car, three 15-cwt. trucks, three 3-ton lorries and five 10-ton lorries.

Nos. 5 and 25 Depots, though remaining on the old establishment, always had to employ extra personnel. This was largely met by employing local civilians, a fairly satisfactory expedient when operating in a friendly country.

Any future plans for the organization of field survey depots will have to take into account the purpose which the depot is destined to fulfil, such as whether it will be operating with an army in the field, at an army group H.Q., or at the base; whether in a friendly or hostile country, and what quantities of maps and stores it will have to handle. The type of country within the probable area of operations, and the nature of communications, will also affect the situation.

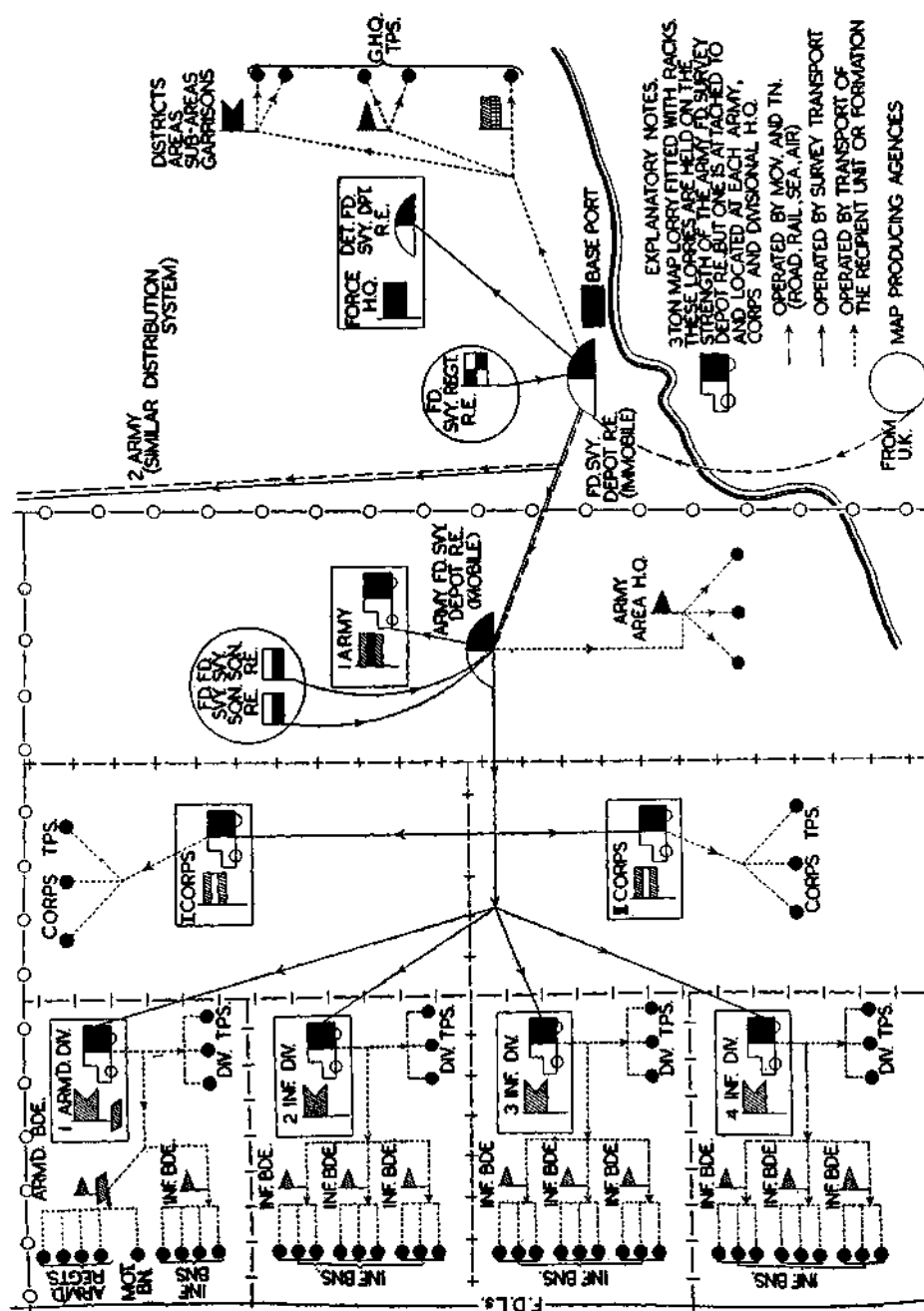
The problem will be inseparably linked up with the policy for map distribution which will be adopted. It may be considered necessary to arrange for mobile map depots of reasonable size to operate at corps and even at divisional level. During the rapid-moving operations of Second Army east of the R. Rhine, it was found essential to have mobile map depots on wheels.

Diagram 15 illustrates the organization for map distribution in the field that was ultimately developed. (In this Diagram the titles of R.E. survey units conform to those adopted since the war ended.)

SECTION 6. RADAR CONTROL FOR AIR SURVEY PHOTOGRAPHY

In the foregoing chapters, a considerable amount of space has been devoted to the subject of air photography, with special reference to its use for new mapping and revision. As will have been noted, the ideal requirement for air survey photography, as distinct from reconnaissance photography carried out for intelligence purposes, is that the photographs shall be taken vertically, at constant altitude and in the form of parallel strips, with fore and aft stereo-

DIAGRAM 15



Map Supply and Distribution in the Field

scopic overlaps just sufficient to carry forward the survey control along the strip, and with a lateral overlap sufficient to connect the strips together and ensure complete coverage. This surveyors' ideal requires scientific precision of navigation with regard to both line and level. Where there are existing maps available for laying down the strips, visual and compass navigation can often be used, but it requires a well trained and experienced pilot to ensure accurate navigation along a given line by such methods, and in jungle-covered or desert country there may be few points of detail. Under war conditions, especially in the face of air opposition, it will be appreciated that the task of flying these straight and level strips, with proper overlaps and without any gaps, presents considerable difficulties. It often happens that owing to cloud, enemy interference, or other cause, there are gaps in the coverage which prevent a proper and complete compilation of the map. It is then necessary to send aircraft out again with orders to cover the gaps. This is a most difficult task, even when reliable small or medium scale maps are available to the pilot.

So far we have considered only the case where maps of one sort or another already exist over the area where photography is required. It may happen that the operational area is virtually unmapped, and that there is a complete lack of ground control. In such a case the pilot would have no visual navigational aids for his strip flying, and there would be no ground control from which to establish the scale of the photographs and on which to hang the topographical detail compiled from them.

Early in 1943, the problem of map production for the Far East was considered by the Director of Survey at the War Office (Brigadier M. Hotine). Under his general control pioneer research into the application of radar to this problem was carried out. The need had arisen for the production of medium and large scale maps of parts of enemy-occupied Burma where there was a complete lack of ground control, and no suitable maps to act as navigational aids to the pilots who would be carrying out the photography. It was necessary to evolve some method of determining the position of the photographic aircraft at the moment when each photograph was taken.

As a result of experiments, a suitable technique was developed for the production of reasonably accurate tactical maps on a scale of 1/25,000, using air photographs whose vertical ground positions were fixed by remote radar control from stations 200 to 250 miles away, and with no direct access to the ground in the area to be mapped.

As events turned out this technique was not actually used during the campaign, but it has been developed and used with success for post-war surveys in the Colonies.

The method chiefly employed so far has depended on the simultaneous determination by radar of the distances between the aircraft and two accurately located ground stations at the instant of exposure of each photograph. By knowing the exact location of the two radar control stations, the two slant-range measurements, and the approximate altitude of the aircraft, the position of the latter may be determined at any instant.

Alternatively, where it is desired to begin photography over a pre-selected ground location, the ranges to that position can be computed, and the aircraft can be navigated thereto and the camera put into operation at precisely the right instant.

The method so far used for radar-controlled strip flying is that the aircraft is navigated to the selected starting point for the photography, and is then flown

along a circular track of long radius at a constant distance from one of the control stations. Range measurements from the second station fix the aircraft positions along this track. The limiting range for carrying this out under existing conditions has been about 200 miles.

One great advantage of this radar-controlled navigation for strip photography over that depending on visual aids is that it enables the lateral overlap to be cut to about 15 per cent, with certainty of complete coverage, as against 25-30 per cent under ordinary visual navigational conditions where there was always the probability of gaps being left in the coverage. This clearly results in a considerable economy in photography and time.

No particular difficulty has been experienced in dealing with strip flying on a circular track of wide radius, but straight-line tracks would clearly be an advantage. It is reasonable to suppose that this, as well as many other improvements in technique, are being achieved by further research.

SECTION 7. GRIDS AND MAP CO-ORDINATES (see Diagrams Nos. 2 and 8)

The use of a grid on British military maps dates back to the closing stages of the 1914-18 war when the Nord de Guerre (Foch) grid was introduced for use by the Allies on their maps. The purpose of the grid was twofold. Firstly it afforded a simple method of quoting map references. Secondly it offered a means whereby the artillery could measure and compute bearings and distances between one point and another and so, having surveyed the position of the gun, lay on to any selected target whose position had been located on a gridded map.

It would be inappropriate to discuss here the technical aspects of map projections and grids. It is sufficient to say that it is not possible to portray on a flat sheet of paper, such as a map, all the topographical features of a curved earth's surface without introducing some form of distortion. This distortion will affect both distances and bearings in greater or less degree.

Depending therefore on the general shape and size of an operational theatre, the grid for any map series is computed on a mathematical basis so as to give, within a limited area, the best possible conditions of range and bearing when these are determined from a combination of surveyed positions on the ground and co-ordinates measured on the map.

Owing to the spherical shape of the earth, any selected grid system, which is mathematically based on its own local origin, cannot be extended indefinitely in all directions without introducing distortion. Grid systems based on one type of projection system can be extended in an east-west direction without such distortion, and those based on another projection can be extended to north and south. Other projections possess other properties. Therefore the projection and grid system for any theatre, or part of a theatre, will be selected to suit the shape and size of the area concerned.

The above will serve to explain why it was necessary to employ different grid systems in the various theatres and even, in some cases, to have a change of grid within the operational area itself.

In some cases the existing grid systems of the country concerned, where they were appropriate, were accepted and used for the British military map

series. For example, in north-eastern France there was the 1918 Nord de Guerre grid which the French General Staff had retained for use. Over the rest of France there were the three National Grid Zones I, II, and III (North, Central, and South) based on the Lambert Conical Orthomorphic Projection. All these were adopted by the War Office for use in their military map series. There was an unfortunate change of grid between the Nord de Guerre and Lambert I Zones, and this occurred in a vital part of the battle area just to the east of Caen in Normandy.

To the normal map user, the grid is principally a means of quoting map references, and the instructions for doing this are generally included in the marginal information on the map sheet. To the military surveyor and to the artillery, however, the use of a grid, and a sudden change of grid system within a battle area, are matters of considerable technical significance.

The inconvenience caused by a change of grid will be realized when it is considered that the guns may be located on one side of a grid junction, and the targets may be on the other. Obviously, when range and bearing are to be computed between one point and another, the co-ordinates of both points must be in terms of the same grid.

Shortly before the launching of "Overlord" in June, 1944, S.H.A.E.F. published a series of "Operation Memoranda" on various subjects. Among these were two dealing with survey subjects:—

- | | |
|--|-----------------------|
| No. 28. Artillery and Engineer Survey. | } See Appendices Nos. |
| No. 9. Map Co-ordinates. | |

In both these Memoranda there were references to the grid systems in Europe and instructions for their use. Warning notes were included regarding the action to be taken where changes in grid systems were met with. The two Appendices should be read in conjunction with these notes. Although they were issued primarily for "Overlord" in the main essentials they might well have applied to any other theatre.

One advantage of the Nord de Guerre grid in north-eastern France was that, being based on the Lambert Conical Orthomorphic Projection, it could be extended eastwards into Germany without introducing accumulative distortion. Thus there was no further change of grid system once the Allies had passed out of Normandy and were pursuing the German armies through France, Belgium, Holland and Germany.

With regard to some of the other principal grid systems, Italy was divided into two grid zones (North and South). The Iberian Peninsula had its own grid, and further east there were the Danubian and Mediterranean Zones. In North Africa, Egypt was covered by two belts (Red and Purple), based on the Transverse Mercator Projection, which could be extended southwards without detriment but which were limited as to their east-west extension. Then came the Libya grid extending to the Tunisian frontier where it effected junction with the North West African Zone which covered the whole of the operational theatre in Tunisia, Algeria, and Morocco.

It is not necessary to describe the remaining systems which were in use during the war over all actual and potential operational theatres. Each presented its own particular problems to the surveyor, and are referred to in the chapter dealing with those theatres.

SECTION 8. SURVEY EQUIPMENT

Introduction

In the case of a global war, with its diversities of climate and topography, and differing standards of survey requirements and working conditions, it would be impossible to design and draw up an equipment scale for technical equipment which would be ideal for all possible theatres to which a survey unit might be sent. Considering all the difficulties that had to be faced, the equipment which was provided for British survey units was generally satisfactory, and enabled them to fulfil their functions with marked efficiency and success. It is to be expected that, as a result of experience gained during the war, and development of research and design, the standard of equipment in future will be at a much higher level than before. Flexibility of ideas and powers of improvisation will, however, always be essential characteristics for survey personnel.

It is not intended here to cover a wide field of discussion regarding survey equipment. There were changing requirements and developments in design during the course of the war, some of these being a result of the infiltration of American methods, and others because of the imperative need for speeding up map compilation and production to meet an ever-increasing world-wide commitment. Only one or two of the principal items of survey equipment will be briefly mentioned below.

First of all, however, attention should be drawn to the existence and work of a special technical research section operating as part of the War Office Survey Directorate. To this section much credit is due for the initiation and development of instrumental design, research and production in connection with certain items of survey equipment, especially those of an optical nature and those concerned with photogrammetry (the plotting of map detail from air photographs).

Air survey cameras and film

The camera for taking photographs required for mapping purposes was an item of R.A.F. equipment, but as the survey service was so vitally interested in the quality of the photographs, it may be well to consider briefly the question of design. This always appeared to lag behind the technique for actual map compilation from the photographs, and it was often necessary to rely largely on photos taken by cameras primarily designed for reconnaissance photographic work. This situation became very apparent during the early part of the war, when considerable scientific effort was being directed to the development of photogrammetric equipment to satisfy a growing demand for maps from armies in the field. As a result of representations made by the survey service, first moves were initiated towards the provision of a camera for air survey purposes, special attention being given to the lens, shutter, and focal plane register. The requirement was that the camera should be designed as a survey instrument, with the lens, non-distorting shutter, cone, and register glass assembled and calibrated as one unit. It was essential, also, that the characteristics of the camera lens should be considered in conjunction with the optical system forming part of the photogrammetric apparatus which would be used for the compilation of map detail and the determination of heights.

The use of ordinary film was found to introduce intolerable errors during

photogrammetric operations, owing to its distortion during processing. It became necessary therefore to specify that "topographic base" film should be used exclusively for air survey photography. This special film was manufactured so as to be sensibly free of residual stresses, but it was essential that certain rigid precautions were taken during the processing of the film so as to minimize the risk of stretch and distortion.

To minimize distortion errors, when it was desired to undertake precise stereoscopic measurements in stereocomparators, a sensitized aluminium foil was manufactured giving very good definition and accuracy.

It has been frequently suggested that precise survey cameras should be constructed for use with glass plates instead of film, in order to avoid distortion due to the film base. Under war conditions the weight of the glass plates would appear to be prohibitive and, if a modern film base is used, there is little to support the view. Nevertheless there is a big field of research open in connection with the minimization of errors due to distortion of the photographic film.

Photogrammetric mapping methods

Between 1918 and 1939 much research was undertaken under the guidance of the Air Survey Research Committee to evolve photogrammetric methods best suited to meet Empire survey requirements and future war mapping. In 1930, a new type of stereocomparator was designed by Captain (later Lieut.-Colonel) E. H. Thompson, R.E., several of which were manufactured before and during the war. These were used in many operational theatres, more especially for fixation of control and height determination. A few years before the outbreak of war in 1939, Messrs. Barr & Stroud were asked to undertake the design and manufacture of a new photogrammetric plotting machine based largely on the Fourcade method of correspondence setting. Two of these instruments were made, and were under trial at the Ordnance Survey, Southampton. Unfortunately both of them were destroyed during enemy air raids, but it had been established that the design was sound, and the setting and operation of the apparatus appeared to be superior to any hitherto produced either in Great Britain or on the Continent.

Until about 1942, the standard technique of plotting from air-photos for British military mapping purposes was that known as the "Arundel" method. This was based on the radial line principle, and assumed that the photographs were vertical and free of tilt. The personnel of British survey units were trained in this method, which required the simplest of equipment, and involved the drawing of a minor control plot for each photographic sortie. The accuracy of these plots was largely dependent on the personal skill of the draughtsmen and, in order to relate them to the fixed ground control, a lengthy process of graphical adjustment between the plots had to be undertaken.

The American topographical units which came to Europe in 1942 were equipped with the 'slotted template' method for fixing minor control. Using semi-mechanical means this enabled assembly to be made directly to a common scale in relation to a triangulation control. The use of the slotted template, especially when a transparent medium was used, increased the accuracy of the result, reduced the amount of ground control necessary, and practically halved the time required for the compilation of detail. A British model of the slot punching machine was designed and manufactured so that British survey units could be equipped with this apparatus for use in the field.

In conjunction with the Multiplex plotting apparatus referred to below, the slotted template method of establishing minor control was used very extensively for the production of much of the new mapping undertaken during the latter stages of the war, more especially by American units.

For the interpretation of detail from air-photos, the British survey units were equipped with hand stereoscopes (Universal pattern) which were used extensively to assist the compilation of maps, especially those on 1/25,000 and larger scales. There was always a need for some simple form of rectifier which would enable a photo to be adjusted into the ground control, and so quicken up the compilation of detail. Several experimental designs were tried out, but the one which appeared to give the most practical assistance was the hand-operated anharmonic rectifier designed by Major L. G. Trorey, R.C.E., and manufactured for use by air-photo personnel of the Canadian Survey Company. It was a small table model, quick in setting and easy to use.

Both the Canadian and American survey units were equipped with the Multiplex plotter, though of slightly different types. This equipment attracted considerable attention owing to its obvious merits for speeding up war mapping, and carrying out various items of photogrammetry which were difficult to achieve by other methods. Designed for plotting on the basal plane principle, the Multiplex anaglyphic projectors marked yet another stage in the development of photogrammetric plotting apparatus in England. For some considerable time the equipment with the American and Canadian units was the only Multiplex apparatus available, and every projector was kept working overtime. Quite apart from its use for large scale mapping of regular series, such as the 1/25,000 maps of northern France, mention should be made of its use for the preparation of close-contoured plans of a large number of potential airfield sites in the Normandy area which were photographed and mapped before "D"-day as a reconnaissance aid to the airfield constructors.

The original programme of 1/25,000 mapping from air-photos of northern France was begun by British survey units, using the normal "Arundel" method. With the arrival of the American topographical units the slotted template was brought into use for establishing the minor control, and the Multiplex plotter was used largely for heighting and contouring, and for extending control over gaps in the existing ground network.

Multiplex equipment which was used by U.S. topographical battalions in all the major theatres had been made by Bausch & Lomb in the United States, and its optical characteristics were complementary to the lens in the K-17 6-inch camera. Only photos taken with that particular camera could be used for making diapositives for Multiplex operation. In early 1945, arrangements were made for the manufacture of projectors and ancillary equipment by a British firm.

Reproduction equipment for use in the field

PRINTING EQUIPMENT

With the B.E.F. 1939-40. The field survey companies who went to France with the B.E.F. in 1939 on a corps basis were equipped with double-demy hand-feed printing presses mounted in trailers which were towed by Scammell tractors. The ancillary plant for plate making, proving, etc., was carried in lorries, and had to be unloaded and erected for use.

The printing machines were heavy and slow-running and, though there

were undoubtedly many advantages at times in being able to print maps of double-demy size, the great weight and size of the trailers was a disadvantage. The Scammel tractors were not part of the unit's establishment and had to be borrowed when required. When the retirement from Brussels started, one of the field survey companies had to stop all helio work for plate making and keep the equipment packed up so as to retain sufficient mobility to move at a moment's notice. During the retreat, the survey units set up their equipment and printed maps on every suitable occasion, but their work was hampered by the lack of mobility which they would have had with the later designed lorry-mounted plant described below.

New lorry-mounted equipment (demy size). Early in 1940 new specifications were prepared by G.S.G.S. (War Office) for the production of lorry-mounted reproduction equipment. This consisted of demy-size printing presses with full automatic feed, mounted in specially designed lorries (3-ton 6-wheeled Leyland) whose sides could be opened up to enlarge the floor space. Each printing lorry was paired with another similar lorry in which were mounted the various items of photo-mechanical equipment necessary for preparing, exposing and processing the zinc plates, proving, etc. These two made an excellent combination, and formed part of the standard equipment for all field survey companies operating with a mobile field force. Later in the war, when it was found that the lorry chassis were not strong enough, the printing presses and ancillary plant were remounted in improved-type lorries carried on 10-ton chassis, many alterations and additions in design being incorporated.

There was one problem which never seemed to be satisfactorily solved. Moisture condensation inside the lorries caused a lot of bother, rusting up the metal parts of the plant, and dripping on to the work. The heating of the lorries, a complementary problem, was difficult. Oil stoves caused eye-trouble amongst the operators. There is room for further research and consideration on this point.

CAMERAS

The Corps Field Survey Companies R.E. with the 1939-40 B.E.F. did not carry a camera. After Dunkirk, however, it was realized that cameras were essential and, though for some time they were not incorporated as part of the units' establishment, photo sections were formed and were attached to the units. These sections were equipped with one lorry carrying the camera, and another fitted up with the necessary plant for processing. The two lorries were so designed that they could be coupled together when standing side by side.

One of the early problems to be solved was the form in which the map reproduction material should be carried, so that units in the field could make their own printing plates. Although the printing of the 1/25,000 maps was no doubt the most important task for the printing sections, it was realized that they might require to print sheets of, or overprints on, other map series. This meant that each unit would have to carry reproduction material for a large number of sheets, and it was necessary to reduce weight and volume to a minimum.

It was planned, therefore, that units should carry reduced-size positives measuring about $6\frac{1}{2}$ inches \times $8\frac{1}{2}$ inches. From these small positives the litho plates would be made by projecting the image through a camera on to a "Silvalith" plate, enlarging up to the correct size in the process. The camera was designed accordingly, and was known as the mobile auto-focus camera.

The theory was probably all right, but in practice the plan was unsuccessful. The difficulty of producing the reduced positives, of maintaining the camera in perfect adjustment for its auto-focussing duties, and of making satisfactory plates, led to an abandonment of the design. The Canadian Survey Company successfully produced its own lorry-mounted process camera of standard design, and eventually the photo sections were re-equipped with standard Hunter-Penrose 20 inch \times 25 inch cameras mounted in lorries. Illumination by both 500-watt lamps and mercury vapour tubes was, after trial and error, designed on a satisfactory basis, and the cameras, in their improved form, were much used and with great success. The dark-room processing lorry contained constant-temperature tanks, tables with transparent light tops, and thermostatically controlled heating and refrigeration units.

With the abandonment of the miniature positive idea, full-size kodak film negatives of each demy-size map sheet were mass-produced, and distributed to the field survey units. Special boxes were provided for storing them flat.

The photo sections were eventually absorbed into the establishment of the field survey companies.

POWER GENERATORS

Mobile power was supplied by portable Lister Diesel generators delivering 24 kw. at 110 volts d.c. They were found to be very satisfactory.

SECTION 9. THE SUPPLY OF SURVEY STORES

Introduction

There are certain stores of a general nature which are required by all military units for their maintenance in the field, and these are normally obtained through Ordnance channels. In the case of survey units there are, in addition, a multitude of technical stores, many of them of an expendable nature, which are required to enable them to carry out their tasks of survey and map production. These stores cover a very wide range, and include such items as theodolites, drawing instruments, printing presses, cameras, zinc printing plates, coloured inks, paper in very large quantities, photographic film, and all sorts of chemicals connected with the photographic and lithographic printing processes.

Situation during the B.E.F. operations 1939-40

The arrangements current in 1939 for the supply of survey technical stores was that some were to be supplied through Ordnance channels and others through H.M. Stationery Office. On mobilization the survey units drew their entitlement and proceeded overseas, on the assumption that they would be able to replenish stocks in the field through the normal Ordnance and H.M.S.O. channels. Through the entire period from September, 1939, till the evacuation from Dunkirk in May-June, 1940, the supply of stores was a source of extreme difficulty and anxiety. Immediately after arrival in France in September, the Director of Survey made out a forecast showing the stocks which it was considered necessary to build up and maintain in the theatre. At the time of the evacuation the items concerned were only just beginning to trickle in through the official channels, and during that period it had been necessary to depend almost entirely on the resources of the country by local purchase.

Soon after their arrival overseas, survey units naturally found that their small mobilization stocks of chemicals, paper and other essential stores were consumed. They submitted indents for replenishment in the normal way, but nothing was available and work threatened to come to a standstill. Authority was therefore obtained for the units to obtain what they could by local purchase, and it was not long before all the existing stocks of printing chemicals, paper and other necessary items were exhausted in the large towns such as Lille, Arras and Amiens in the British zone. As the weeks went by, and supplies were still not forthcoming through official channels, units were told to send an officer to Paris in order to make purchases there. The G.H.Q. Survey Directorate purchased bulk stocks of printing paper from Paris, with the assistance of the Service Géographique.

These individual visits to Paris were unsatisfactory. The procedure was disliked by the Financial Adviser on currency exchange grounds, but there was no alternative to local purchase of some sort or other. Early in 1940, the Director of Survey at G.H.Q. once again drew the attention of the Ordnance and Stationery Services to the unsatisfactory and dangerous state of affairs, and suggested that he (D. Survey) should have authority to purchase a two months' supply of survey stores in Paris, if still available, and place these with the Advanced Ordnance Depot and the Advanced Stationery Depot, both of which were then at Arras. This was agreed, and the purchases were made. At the same time it was represented to both services that:—

- (a) Stocks from the United Kingdom must be hastened.
- (b) Survey units should indent direct to the Advanced Depots instead of to the Base as was normal.
- (c) Five months' estimated consumption of expendable survey stores should be built up in the theatre, of which two months' supply should be at the Advanced Depots and three months' supply at the Base Depots.

The German offensive in May, and the subsequent withdrawal of the B.E.F. from France, automatically resolved all these difficulties and anxieties, but the experience gained was valuable for framing future stores policy.

G.S.G.S. (War Office) takes charge

G.S.G.S. wisely appreciated that new arrangements must be made to meet future operational requirements. It was agreed that G.S.G.S. should now accumulate bulk stocks of all survey stores which were likely to be needed by survey units both in the United Kingdom and overseas. These stocks, which included both expendable and non-expendable items, from a complete printing lorry to a pound of gum arabic, were assembled in a central survey stores depot under G.S.G.S. control. By arrangement with survey directorates at home and in overseas theatres consignments were shipped as required on an agreed basis.

In some theatres, for example the Middle East, at a time when sea communications were long and precarious, the stores situation, even under the improved system of supply, was often uncertain. In such cases the Director of Survey concerned had to make the best arrangements possible to ensure maintenance of map production.

Supply of survey stores in the Middle East

At the outset of the Middle East campaign, and for some months thereafter, the source of supply of technical survey stores and paper was through Ordnance and Army Printing and Stationery Services (A.P. and S.S.). By May and June, 1941, supply was still being sought through the same channels, but the situation was unsatisfactory and caused much anxiety.

11 Field Survey Depot R.E. had been installed as a survey stores depot at Abbasia, Cairo, and drastic steps were being taken by the Survey Directorate to secure supply from alternative sources. In July, 1941, authority was obtained to order map printing paper without reference to the A.P. and S.S. and attempts were made to secure provision of reproduction stores from organizations such as the Central Provision Office in Simla and through the British Military Mission in Washington. Other sources of supply included local purchase, and captured enemy material from Italian East Africa. One request for stores was sent to Washington but it was ruled that further orders would have to be placed through the War Office and the Ministry of Supply. Lists of monthly requirements were submitted also through Ordnance and A.P. and S.S. to the Middle East Provision Office.

In August, 1941, provision seemed to be on a slightly firmer basis, though it was still critical. Both Ordnance and A.P. and S.S. agreed that certain specific items should be obtained direct by the Survey Directorate, who were authorized to approach the Eastern Group Services of Supply and, through the War Office, the Western Group also.

The situation in September was still disquieting, and there was as yet no indication of any authority from the Ministry of Supply (United Kingdom) for D. Survey to communicate direct with Washington regarding a monthly supply. By October, local purchase in Egypt was practically exhausted, and it seemed that the United States was now the only satisfactory potential source of supply for reproduction stores. Small paper stocks had been received from India, but labour troubles in the mills there placed further consignments in danger. There was at this moment a prospect that both paper and reproduction stores would be exhausted by the end of the year. Stocks of photographic film were ordered from Kodak (Australia) through the Middle East Provision Office, but for some time there was no news of shipment.

As a precaution against enemy air action, arrangements were made for the move of 11 Field Survey Depot from Abbasia to Tura Caves where the reproduction unit was installed, and after some difficulties in connection with careless unloading at the docks it was decided to locate some depot personnel at the ports to supervise the handling of survey stores coming off the ships.

By December, 1941, the survey stores situation was more satisfactory though it was still acute with regard to some items. The improvement was largely due to the Survey Directorate (War Office) whose action in connection with long- and short-term supply was much appreciated, and also to the American authorities for agreeing to help with the supply of stores and paper. A complete scheme of long-term maintenance from the United States was arranged by the War Office through the British Mission in Washington and, to cover the period till regular monthly consignments should arrive, D. Survey Middle East was given authority to order direct from the United States those stores which were essential for maintaining production. A demand was therefore placed by signal, and a shipment was arranged for January, 1942, with delivery in Egypt during March. As a second line, War Office arranged for a monthly supply

from England and also signalled to the Middle East information regarding the shipments of stores which had been sent out during the last seven months. This enabled Survey to locate and collect survey stores from various Ordnance Depots and docks where they had been lying. The port detachments from 11 Field Survey Depot and other units did excellent work in finding and clearing these stores.

Difficulties now arose in connection with consignments of survey stores which had been railed to Ninth Army in Palestine and to Eighth Army in the Western Desert. These were taking some weeks to get through and in some cases had been lost in transit, so arrangements were made for units to collect their own stores from 11 Field Survey Depot using their own transport.

In February, 1942, responsibility for the provision of survey stores to Tenth Army in Iraq was accepted by D. Survey Middle East, and also for supply to the force in East Africa. The route to the latter was *via* the Nile Valley. For supply to Tenth Army the sea lines of communication were unsatisfactory, so an overland route was chosen through Palestine, Damascus, and Baghdad.

By March, supplies from the United States and from England were arriving, and the situation seemed more hopeful. During March and April, 11 Field Survey Depot completed its move to Tura Caves and all issues now took place from there. By the end of April the position regarding the various survey stores items was that the depot had ample stocks of 20 per cent, two to three months' stock of 70 per cent, and no stock at all of the remaining 10 per cent.

The situation with Tenth Army improved during April, May and June as the overland route was found practicable, and consignments were received also in Iraq from India. Stores convoys continued to be sent to East Africa.

Paper stocks began to run low in August owing to extensive mapping programmes for operations in the Western Desert, so War Office asked Washington to help. The latter undertook to ship three months' supply of paper to Middle East at once. Pending its arrival the situation during the autumn months of 1942 caused serious anxiety. A map salvage campaign was instituted so as to print on the backs of old maps.

The stores situation was, however, much more healthy as consignments from America were arriving and demands for future monthly needs continued to be sent to Washington. As a precautionary measure, when Eighth Army retreated back into Egypt it was decided to disperse some of the stocks, and 25 per cent were sent to Paiforce. Then came the victory at El Alamein, and with the need to keep quick-moving units supplied with paper and stores over lengthening lines of communication a limited amount was sent forward by air, and freight by sea to Benghazi proved satisfactory. In January this sea freight was switched to Tripoli.

The paper situation improved considerably in December when supplies were received from America, from East Africa on loan, and from India, and by January, 1943, there was about two and a half months' supply of double-demy and four months' supply of demy size in 11 Field Survey Depot, in spite of the fact that one shipment from America containing about six weeks' supply was lost by enemy action.

Planning for operations in Sicily and Italy started in February, 1943, and a three months' map production programme was put in hand involving a big expenditure of stores. Fortunately a supply of photographic film had arrived from Australia during March.

With the occupation of Sicily in August, 1943, Middle East Survey Direc-

torate ceased to be directly responsible for the supply of survey stores to Eighth Army, who now looked to A.F.H.Q. for their requirements. The opening up of sea communications through the Mediterranean speeded up delivery from both England and America, and big increases in stock necessitated an enlargement of accommodation at Tura.

Some idea of the monthly quantities handled by 11 Field Survey Depot may be gathered from the fact that, during September, 1943, nearly 350 tons of paper were received into store from America and nearly 400 tons from India. During the same period, over 330 tons of stores were received, the greater part being from America. Issues from the depot for unit consumption were correspondingly high. Big consignments of Indian map paper were now being shipped from 11 Field Survey Depot to A.F.H.Q.

By January, 1944, the stores which had accumulated in 11 Field Survey Depot were used as a pool from which supplies were sent to other parts of the Mediterranean Theatre, and it was arranged that Middle East would supply all survey units in Eighth Army as well as the Survey Directorate at A.F.H.Q. with survey stores as and when available. The amount of stores traffic being handled by 11 Field Survey Depot was so great during the spring of 1944 that a rail siding was allocated for the exclusive use of the depot.

In the summer of 1944, operations in Burma were demanding extensive mapping programmes in India. Surplus paper stocks with Paiforce were offered to India, and considerable quantities of expendable reproduction stores were offered by Middle East to relieve a temporary shortage in India.

By September, 1944, Middle East was holding a large accumulation of stores and survey equipment which was no longer needed in the theatre. These were offered to War Office, to A.F.H.Q. and to India, and consignments were prepared for shipment.

For over two years a small party of U.S. Engineers had been working with 11 Field Survey Depot and had given most welcome and efficient service. This section, on transfer to the United Kingdom, left in October when the volume of work had fallen. From now on receipts of stores fell to an almost insignificant trickle though issues continued to India, A.F.H.Q., and East Africa, until the end of hostilities.

During the years since its first arrival in the theatre 11 Field Survey Depot had consistently given most efficient and valuable service. There had been periods of great anxiety when urgently needed stores and paper had been almost non-existent, and units were having to exist from "hand to mouth." There had also been periods of extreme high pressure when receipts and issues were being handled day and night.

This brief account of the survey stores activities in the Middle East cannot be closed without reference to the debt that was owed to our American friends in the United States, without whose ready help in supplying paper and stores at very critical periods, the work of map production in the Middle East would have been gravely jeopardized.

Stores supply during "Overlord"

It may be of interest to consider a few of the salient points regarding survey stores supply during "Overlord." Here was a theatre within easy reach of the United Kingdom, where command of the sea enabled shipments to be arranged more or less at will.

In the United Kingdom there was, as has already been stated, a Survey

Stores Depot under G.S.G.S. control where bulk stocks of all the required commodities were assembled. Although S.H.A.E.F. was in supreme command of all the allied forces, it had been wisely decided that the Survey Directorate (S.H.A.E.F.) would not be concerned with the actual handling of bulk stocks of either maps or stores for the allied survey units. This meant that D. Survey 21 Army Group dealt direct with G.S.G.S. for bulk supplies required by British and Canadian survey units, while the Chief Engineer, Communications Zone (through Colonel H. Milwit) arranged stores supply for the American topographical units. There was one Map Reproduction Section working at S.H.A.E.F. for which survey stores were drawn direct from the 21 Army Group Stores Depot.

D. Survey 21 Army Group had at his disposal No. 5 Field Survey Depot in the Rear Maintenance Area which was concerned solely with the holding and issue of survey stores. Located first of all near Bayeux under canvas, it moved subsequently to Antwerp when that port was liberated.

The Second British and First Canadian Armies each had their own field survey depot which held both maps and stores. When the field survey companies went over to France soon after "D"-day they each took with them enough stores and paper to last them for one month of anticipated working. At about the same time one month's supply of stores and paper for each of the three field survey companies in Second Army was shipped over by early convoy to 3 (Army) Field Survey Depot. This constituted two months' supply actually with Second Army. The policy was that each unit would draw a monthly issue from the depot, the latter replenishing its stocks from No. 5 Depot in the rear. To facilitate issues and holding it was arranged where possible for units to draw on staggered dates during each month.

In the case of No. 5 Depot two months' supply for each of the two armies was shipped over during June and July, each consignment being accompanied by a conductor to ensure prompt handling and safe arrival. During September, No. 25 Field Survey Depot arrived in France and was assigned for duty under D. Survey 21 Army Group as an advanced L. of C. depot for both maps and stores. The rapid advance through north-eastern France and Belgium was then in progress and, though a two months' supply of stores and paper was prepared for No. 25 Depot to take forward when the time was ripe, the advance continued so rapidly that there was no opportunity to effect the change over, and No. 5 Depot continued to supply direct to the two army depots. Owing to the rapidly increasing distance between consumers and suppliers, the armies found it difficult to send back for their requirements and, with transport limited, forward delivery was effected only with great difficulty. Although during this critical time there were many anxious moments, there was, in fact, no failure to distribute paper and stores in time for the units to meet their map printing obligations.

By late September, the demands for paper and reproduction stores were increasing about four times the estimated monthly consumption, and this raised many problems of supply from the United Kingdom. The matter was fully discussed at a conference held in Brussels as a result of which a revised "company month expenditure list" was drawn up, and it was agreed that 21 Army Group would send to G.S.G.S. a monthly statement of stocks held in their stores depots. Based on these figures G.S.G.S. would then forward, without indent, sufficient stores to keep the depot holdings up to an agreed level.

In October, No. 5 Depot was packing up so as to be ready to move to

Antwerp from the rear maintenance area in Normandy. Meanwhile, to ease the transport situation, a small survey detachment was sent to Ostend to work in close liaison with the port authorities so as to expedite the passage of stores being shipped to that port. By the end of November, No. 5 Depot was installed in Antwerp; all stores had been transferred from Normandy, and they were divided between two buildings so as to reduce the risk of total loss from flying bombs and rockets which were causing much damage.

Local resources were used wherever possible. Gevaert's photographic factory still had stocks of certain classes of film which were taken over, and arrangements were made with a local firm of printing machine engineers to overhaul the printing presses and photo-mechanical equipment held by units, which had seen several months of heavy service and were showing signs of wear and tear. The shortage of machine spare parts was a serious problem.

The revised system of stores supply from the United Kingdom was successful and, at the end of February, just before the Rhineland battle, the situation was satisfactory. Second Army drew an extra month's issue of stores during March to ensure against possible shortage during the anticipated quick advance into Germany. The routine procedure for the First Canadian Army was on similar lines. These arrangements dealt very adequately with situations that arose during the final two months of fast-moving operations, and map production output from the survey units remained at a high level.

To meet urgent requirements there were occasions when it was necessary to have certain critical stores flown over from England, but the normal system of supply, as finally evolved, seemed to be quite satisfactory. Paper and photographic film were the items which offered the greatest difficulties in supply, owing to the ever-increasing shortage of raw materials in the United Kingdom. As a result of close co-operation between British and American survey organizations, much assistance was obtained from American sources.

SECTION 10. BEACH INFORMATION FOR ASSAULT OPERATIONS

Historical foreword

The development of amphibious operations, based on the large scale use of landing craft, made it necessary that accurate information regarding tides, currents, water depths, beach configurations and obstacles should be obtained for the use of the planning staffs and for the actual operations themselves. The British and American Navies were well equipped with charts covering sea areas around their own and other coasts, but there had never before been a requirement for accurate maps showing the configuration of the actual beaches.

Apart from "Overlord" amphibious assault operations took place in North West Africa, Sicily, Italy, southern France, in South East Asia, and in the Pacific. In preparation for the projected landings on the Malayan coast in 1945 there were plans for large scale amphibious operations which, owing to the Japanese surrender, did not take place against enemy opposition. In home waters there was the assault landing by Canadian forces on the occasion of the Dieppe raid.

The largest scale amphibious operation of the war was that which took place on the Normandy beaches in June, 1944, and as the tidal and other conditions met with in the English Channel are probably as complex and difficult as are

likely to be found anywhere, the survey activities in connection with the determination of beach gradients there are given below in fair detail. Some notes are also given about a similar task undertaken in S.E.A.C. It should be noted that only those aspects of the problem which concern survey are dealt with. A great deal of precise and more specialized detail about the beaches selected for the assault was obtained before "D"-day by means of night raids by naval and commando personnel.

Beach information for the invasion of Normandy ("Overlord")

The problem. Early in 1942, when planning was started, one of the first problems to be solved was the selection of the coastal area along which the assault would take place. There were certain overriding factors which affected this selection, such as the effective range for fighter-cover, the necessity for a quick turn round of shipping, exit communications from the beaches, etc. These factors, combined with the need for a security-cover plan, indicated that the detailed consideration of the planning staff would be directed to a stretch of coast extending from the Scheldt estuary to the western shores of Brittany. Between these points, it was desired to investigate the configuration and condition of the beaches so that, combined with other essential conditions, a final choice could be made for the allied assault.

Early moves. In January, 1942, an officer with special air survey qualifications, was attached to H.Q. Army Co-operation Command, responsible technically to the Director of Survey Home Forces. His prime task was to arrange with the R.A.F. whatever programmes of air survey photography were required for mapping purposes. He was approached by the Central Interpretation Unit (Medmenham), on the problem of determining the gradients of enemy beaches. Attempts to obtain this information by parallax measurements on air photographs had not been successful. The possibility was suggested of obtaining the information by photographing the beaches at different states of the tide, measuring the horizontal distances between the apparent water-lines as shown on the photos, and computing the tide heights from the actual recorded times of photography.

Experiments were carried out on home beaches where the results could be checked against actual ground measurements, and these were sufficiently favourable to justify going into production without further delay. Much valuable help during these trials was given by Mr. Vaughan Lewis (Department of Geography, Cambridge University), and Major W. B. R. King, R.E. (Geology Professor at Cambridge), the former for his description of beach formations and coast erosion, and the latter for his geological advice, both of which were very helpful when trying to correlate beach formations on either side of the English Channel. Major King had studied the geology of northern France during the 1914-18 war.

A small section of topographical draughtsmen was formed at the G.H.Q. Home Forces Survey Directorate. They started work on 30th April, 1942, on a programme of beaches selected by the planning staff. The objective was to provide technical beach data from which the Admiralty Hydrographic Department would produce beach-gradient charts.

Z or Z(M) Beach Charts. The procedure for producing these was as follows:—

- (a) The R.E. Section calculated the flying programme so that the beach should be photographed at high and low spring-tide levels and at four uniformly intermediate levels.
- (b) The flying programme was passed to the R.A.F. Squadron which was to take the photographs, and sorties were arranged to fit in with weather and other conditions.
- (c) The R.E. Section prepared mosaics from the low-water photos, determined the scale, transferred the water-lines from sorties taken at other states of the tide and measured the horizontal variances between them.
- (d) A statement of the exact times of photography was sent to the superintendent of the Tidal Branch, Hydrographic Branch, Admiralty, who computed tide levels. These were then entered against the water-levels on the mosaics.
- (e) At this stage, the mosaics were sent to the Superintendent of Charts, Admiralty, who drew cross sections at selected points along the beach, and published the final "Z" Charts. At first these were bromide prints, but gridded half-tone reproductions were also made.
- (f) Before publication, geological notes about the beaches were compiled for inclusion on the final charts.
- (g) 140 Squadron R.A.F. (34 Wing) undertook the photography between the Dutch Islands and the western side of the Cherbourg peninsula. From this point westwards photography was undertaken by the Photo Reconnaissance Unit (P.R.U.), based on St. Eval in Cornwall.

Further research. Two further lines of research were undertaken as a result of these early beach investigations to determine water depths from the measurement of wave velocity and investigate the causes of runnels and banks on sandy beaches.

- (a) *Wave-velocity method.* It is apparent that the water-line method described above made it possible to determine gradients between high and low spring-tide levels. Generally speaking, gradients for a short distance outside these limits could be reasonably assessed by intelligent extrapolation, but this was not always the case, especially where the tidal range was small.

Wave behaviour was known to depend to some extent upon the nature of the sea bottom so, following up this line of argument, a mathematical formula was supplied by Dr. H. Jefferies (Reader of Geophysics, Cambridge University), which gave a relation between water depths and wave velocity. Further research was carried out, the results of which were published by the Directorate of Military Survey in a pamphlet entitled "Beach Gradients—Analysis of Wave Velocity Method and its Practical Application. Bideford Bar Experiment."

- (b) *Runnels.* A feature of many sand beaches is a system of undulations running parallel with the shore. These are familiar features on many beaches round the British coast where they are found to vary in size and depth from place to place and undergo periodic changes. The resulting dangers and inconveniences when landing vehicles and personnel on enemy beaches will be apparent.

Experiments were therefore conducted on the beach at Dymchurch, in Kent, in November, 1942, to find out if it was possible to determine not only how deep the runnels were, but also under what conditions

they changed and how rapidly, and to what extent they moved position. The results of these trials were published in a pamphlet—"Runnels and Banks on Sand Beaches." It is fair to state that, as a general rule, the positions of the runnels could be located correctly, but the probable depth of water in them was most difficult to determine.

Formation of No. 1 Air (Survey) Liaison Section R.E. In order to regularize the existence of the R.E. Section which had been working on the beach gradients No. 1 Air (Survey) Liaison Section R.E. was established in November, 1942. Its function was to represent the survey service with R.A.F. photographic units in connection with programmes of air survey photography required for mapping and other survey purposes. There was, at that time, a big programme of new 1/25,000 mapping to cover large areas of northern France for which air photographs were required and, with this section living on the airfield alongside the squadron concerned, it was possible to brief the pilots technically for the sorties, and so help in many ways to attain the output of photography so urgently needed. Cover diagrams were maintained as a complete record of all sorties flown, and in addition to this work, the section continued to carry out the investigation work for the determination of beach gradients.

Beach-gradient investigation in the Mediterranean. In view of the promising results which had attended research work on the wave-velocity method, it was decided to train personnel in its use in connection with further projected operations in the Mediterranean area. As the latter was a tideless sea the water-line method could not be employed, and the wave-velocity technique appeared to offer favourable prospects of success. No. 2 Air (Survey) Liaison Section R.E. was therefore formed in North West Africa, and beach gradients were determined for landings in Sicily and on the Italian coast. Eventually this unit was sent out to S.E.A.C.

Summary of work undertaken. Some notes on the American approach to the problem will be given later but, in the meantime it may be of interest to summarize the beach gradient work undertaken by British survey units for "Overlord."

Flying began on 6th May, 1942, and was completed by 12th May, 1944. By "D"-day (6th June, 1944) the beach situation was as under:—

Number of beaches completed and Z(M) Charts issued	151
Ditto (2nd edition)	16
Total	167
Number of beaches completed and charts sent for reproduction	56
Ditto (2nd edition)	15
Total	71
Number of sorties flown by 34 Wing R.A.F.	371
Number of sorties flown by P.R.U. (St. Eval)	116
Total	487

Beach investigation by U.S. Engineers. During 1943, Major Hugo van Kuyck (Corps of Engineers) had conducted research at the Engineer Amphibian Command in Massachusetts on methods of securing information on underwater beach configuration by the use of air-photos. On arrival in the United Kingdom and while stationed at the Assault Training Centre at Woolacombe, Devon, his proposals were submitted to the Intelligence Division of the Chief Engineer, E.T.O.U.S.A., and a beach intelligence sub-section was formed. Liaison was established with the Inter-Service Topographical Department (I.S.T.D.) at Oxford, and the Hydrographic Department of the Admiralty. The latter had already started to publish the Z(M) Charts described above. Information already accumulated by British sources was made available to the American sub-section and they started by producing preliminary editions of chart maps for the Omaha and Utah beaches which were scheduled as assault beaches for American forces on 'D'-day.

Early in April, 1944, a photo-interpretation team specially trained in the development of information about beach areas, was attached to the sub-section. Its work was now divided into two main functions, the development of beach profiles, and the identification and plotting of beach obstacles on plans of the assault areas.

After seeing preliminary editions of the chart maps, First U.S. Army now asked for large scale plans, profiles and tidal curves to be prepared for the Omaha and Utah beaches. The method developed by Major van Kuyck required a precise photo procedure involving close control of exposures, angles of approach and flight lines, and exact records of time and sunlight angles. Photography was undertaken by 34 Wing R.A.F., which had done the work for the British investigations. Owing to uncertain weather conditions, enemy interference, and other causes it was seldom possible to secure the ideal type of photography aimed at but, as in the case of the British requirements, the R.A.F. pilots put up a remarkable performance in the face of all the difficulties.

The chart maps were produced at a scale of 1/5,000, and soon after their publication, which of course was effected under conditions of the highest security, the Chief Engineer, 21 Army Group asked for similar maps to be made of the beaches assigned for the British assault units. A team of R.E. topographical draughtsmen was formed to assist in their preparation.

Soon after "D"-day, check surveys were made on the beaches to determine the accuracy of the chart maps and profiles and the results showed that few of the individual profile points were more than 1.5 feet in error, the average showing an inaccuracy of just under one foot.

On the American beach charts, each profile was accompanied by information about the surf, velocities and direction of the current, the depth of water over the beach obstacles, and the amount of beach to be traversed after the landing craft had grounded. Other data included details of illumination at all hours of the day and night.

Beach information in S.E.A.C. (See Sketch Maps Nos. 8 and 14)

Interest in this matter was first developed in India in September, 1943. As there were at that time no survey personnel trained in beach investigation work, the first attempts at determining gradients came from the Combined Photo Interpretation Centre.

The Arakan coast of Burma was an area where assault landings might be

required and, as Akyab Island was likely to be the scene of an assault by the landing forces, combined with the fact that it was one of the few Burma ports for which tide data were known, it became the first object for treatment. The only photos available were intelligence sorties taken during the previous season, and the water-line method was tried.

The technical paper describing the use of the wave-velocity method had already been distributed to overseas commands, and one of the Eastern Fleet hydrographic officers had become interested in the subject. The Director of Survey, India, realizing that the problem would, as in other theatres, become a survey commitment, arranged for a small team to be trained for the work, and by the beginning of 1944, it was reasonably equipped to meet any demand which might arise. Training in the work had also been started in survey units.

Between January and April, 1944, sorties were flown by R.A.F. Mosquitoes carrying K-8. AB. cameras in an attempt to obtain photos of wave formations along the Arakan coast and the east and west coasts of the Andaman Islands. The wave-patterns were disappointing, and there seemed to be little likelihood of an extensive use of the wave-velocity methods which had been developed elsewhere.

When 11 Army Group was formed, a few draughtsmen were transferred to the Survey Directorate at Army Group H.Q. and became the nucleus of a H.Q. Air Survey Section. Amongst other duties it was responsible for beach-gradient work and air surveys for beach-assault maps. By the autumn of 1944, No. 2 Air (Survey) Liaison Section R.E. had completed its beach work in the Mediterranean and was transferred to S.E.A.C. It arrived too late to take any part in the preparatory work for operations at Akyab Island, the beach studies for which were completed by the 11 Army Group team.

Following a visit to S.E.A.C. by officers from H.Q. Combined Operations, it was agreed that No. 2 Air (Survey) Liaison Section would form a suitable nucleus for a beach intelligence team, and it was strengthened on the hydrographic and tidal side. After its arrival in February, 1945, it became a Command unit under the control of D.D. Survey at H.Q. S.A.C.S.E.A. Its functions included the collection and recording of beach information for the preparation of beach maps and the determination of beach gradients. The water-line method now appeared to be the only one suitable to local conditions, so its use became general.

On the photographic side, the K-18 camera, taking a 9 inch \times 18 inch picture, proved satisfactory for beach photography except for the small size of the magazine which limited the area that could be covered in one sortie. The need for incorporating a clock in the air-cameras was stressed in S.E.A.C. as in other theatres. It was essential to have a record of the exact time of photography, without which it was impossible to make use of tidal computations in connection with the photographs.

For operation "Dracula," the assault on Rangoon, which began with an amphibious landing at the mouth of the river, the following information was provided by the Section:—

A report on the beaches and landing possibilities.

Beach and terrain report on the Pegu River.

Landing places in the Rangoon River dealing especially with the dock and wharf areas.

Collation overprints on 11 standard 1/25,000 sheets.

Then followed preparatory work for operation "Zipper," the projected assault landings along the Malayan coast. A provisional study was made in March, 1945, of the stretch of coast between Port Swettenham and Malacca using some poor 6-inch photos. This was followed by a report made up from intelligence information, Admiralty manuscript charts, and 6-inch photographs taken by an American Bomber Group. Altogether reports were prepared for 45 beaches between Selangor and Pontian Kechil. Seven beach maps covering the "Zipper" assault beaches were produced at 1/10,000 scale, and the compilation of five more was begun but was discontinued after 15th August. Collation overprints were prepared for 29 1/25,000 sheets, and gradient profiles were plotted for all the beaches and were kept up to date from the latest air-cover available. A preliminary report was written on landing possibilities in the Gulf of Siam near Bangkok, beach photography for which was ordered and flying programmes worked out. Several possible beaches in Sumatra were also examined.

For Singapore Island itself, a preliminary report was written but did not get beyond the manuscript stage. It was prepared before suitable photography was available. Flying programmes were worked out and beach photography ordered for beaches in the vicinity of Songkla, Kota Bahru, Kuantan, Endau, and Mersing, but these flying programmes were postponed after 15th August.

The beach maps were printed in five colours at a scale of approximately 1/10,000, a grid being drawn from the most accurate map available. They gave as much detail as, but no more than, was considered necessary for the troops, the beach masters, and the group controlling the beach. An attempt was made to indicate the runnels by superimposing a blue stipple on a buff beach. It was explained on the map itself that changes in these runnels were probable. Bright clear colours were used which could be read clearly in a poor light. Tidal curves for an eight-week period were printed on the reverse side of the maps.

Experience in the use of collation maps in the Mediterranean had showed that the clearest way of showing enemy defences and general beach and hydrographic information was to overprint in two colours on a grey base map. In the case of the maps prepared for "Dracula" the standard four-colour map was used as a base to save production time, and it was found difficult to make the overprint show up clearly. For "Zipper," however, the overprints were in black and red on a grey base. There was some criticism that the grey was so dark that there was little contrast between the base detail and the black overprint, but the defences were few and the defect was not serious. Beach limits and sectors were shown, the limits of mangrove swamps were defined where necessary, and various general beach, hydrographic and port notes were included.

There was some argument on the merits or otherwise of overprinting topographical notes across the face of the collation maps. The general opinion of the planners was that this information was redundant if the base map itself was clear.

SECTION 11. MAP SUPPLY FOR AIRBORNE FORCES

Historical Note

Individuals and small groups were dropped from the air on many occasions during the war for purposes of sabotage in enemy-held territory, intelligence

work, and the organization of resistance movements. There were, in addition, planned operations by Airborne Forces to assist the ground troops in the attainment of their objectives.

The first large scale airborne action took place in November, 1942, during the Allied invasion of North West Africa. The original plan was that a battalion of the 1st Parachute Brigade should assist the assaulting troops by seizing the airfield at El Aouina, near Tunis. This project involved a sea journey to Algiers, which was to be reached soon after the Allies had landed, and then an immediate take-off from there so as to forestall the arrival of German forces on the airfields round Tunis. As an alternative, the capture of the airfield at Setif was to be undertaken. Maps were delivered to the ship under the strictest "security" conditions and, after sailing, the sealed orders and maps were opened and studied during the voyage. In a subsequent report it was stated that "the briefing material in the form of maps and air-photos was excellent."

Unfortunately there were delays due to the initial resistance of the French to the allied landings, and German troops reached El Aouina airfield while the Parachute Battalion was still at sea. There were further delays in connection with the unloading of the ship and the transportation of the battalion to the airfield outside Algiers, with the result that both the Tunis and Setif operations had to be cancelled. The battalion was then warned to prepare for a new operation in the Beja area, which entailed fresh map supply for which no requirement had been foreseen. In spite of this, the operation was carried out with considerable success.

When the time came for the invasion of Sicily, both British and American airborne formations were available, and these were used on the early morning of "D"-day to capture airfields and to assist the allied troops in their assault landings, both parachute and glider units being employed.

In South East Asia some of Wingate's "Chindit" troops were flown in to Central Burma to operate behind the enemy lines, references to which will be found in Chapter VIII. Later, in the Burma campaign Gurkha parachute troops were dropped near the mouth of the Rangoon River to capture the forts protecting the river entrance so as to assist in the seizure of the city.

For operation "Overlord," airborne forces were organized in strength, both British and American, and with the formation of H.Q. First Allied Airborne Army in August, 1944, survey representation was installed at Army H.Q. to look after its mapping interests. As this was the first occasion on which the survey service had been directly represented at the headquarters of an airborne formation it will be of interest to record in some detail the problems which arose in connection with map supply and how they were dealt with.

During 1943, and early 1944, British and American airborne formations, including both parachute and glider units, were organized and trained in the United Kingdom. In the early morning of "D"-day one British and two American airborne divisions landed on the flanks of the assault area in Normandy. In addition to the standard tactical maps of their respective battle areas, these divisions were provided with specially prepared "dropping zone" maps which will be described later on. During succeeding weeks, in connection with the break-out from the bridgehead, the closing of the Orleans gap, the crossing of the Rivers Seine and Somme, and the clearance of the Pas de Calais, a large number of airborne operations were planned but never took place owing to the speed of the advance by ground forces. There followed the historic

operations at Arnhem in September, and in March, 1945, airborne forces were dropped on the east bank of the river to assist the forcing of the Rhine.

Many subsequent airborne operations were planned during the advance into Germany including parachute drops to protect prisoners of war, but they were all cancelled as the allied armies rapidly overran western Germany.

In the following paragraphs, some notes are recorded, firstly on the special problems involved in mapping up airborne forces, secondly on the types of maps which were required and provided, thirdly a brief description of the survey organization which was evolved for effecting map supply, and finally a short summary of the operations which were either carried out or planned, and the action taken to make map provision for the troops concerned.

The special problems of providing maps for airborne forces

Planning. Unlike ground forces who can, on occasions and within certain limits, send out patrols or establish observation posts to obtain information about enemy-occupied terrain and dispositions, airborne commanders and staffs have to rely almost entirely on maps and air-photos when planning an operation. Tactical appreciation by means of stereoscopic examination of air-photos, aided by a study of the largest scale maps available, is carried out by staffs and commanders of formations and units. The quantity of maps required for planning airborne operations is therefore abnormally large and of a detailed nature.

Area cover. The area over which airborne operations may take place is, in theory, limited only by the radius of action of the troop carriers or glider-towing aircraft. In practice, however, where an early junction is planned between the airborne and ground forces, the area in which airborne troops may be called upon to operate is not likely to lie very far ahead of an advancing front. There is a tendency, however, to plan far ahead in order to make all possible provision for future likely drops, and to study and complete the mapping up arrangements for a succession of operations such as a series of river crossings or the clearance of defended areas sited in depth. When the movement of ground forces is rapid, as in the case of the allied advance from Normandy through north-eastern France and Belgium, it becomes necessary to plan in detail for several possible operations ahead.

With regard to the holding of map stocks, it was considered wasteful for the Airborne Army to carry stocks covering the whole possible operational field, which might well cover the area of two or more army groups. Reliance was therefore placed on obtaining small and medium scale maps for particular operations either from map depots of the higher ground formations, or from base map depots, and, in the case of large scale maps from map production resources at the War Office, G.H.Q. (or its equivalent), or with the headquarters of army groups or armies.

The urgency of map supply for airborne operations. With ground forces advancing rapidly into enemy territory, as was the case during "Overlord," the tendency for ground force commanders to call for airborne assistance at short notice involved the very rapid assembly and distribution of maps. The First Allied Airborne Army was working on a basis of 72 hours' notice during the pursuit through north-eastern France and Belgium in August and September, 1944. This necessitated very close liaison between D.A.D. Survey at Airborne Army H.Q. and those ground formations from whom map supplies

would be drawn. It meant also that considerable map stocks and printing resources had to be available to meet urgent demands.

The characteristics of airborne troops, and their effect on map provision. From the nature of his duties, the airborne soldier is, by training and indoctrination, somewhat of an individualist. He has to be prepared to fight either in large orthodox formations, in small groups or, if necessary, alone. The uncertainties and hazards of opposed parachute or glider landings, with the subsequent possibility of confusion until reassembly, and the need for rapid deployment and attack on scattered objectives, entails a liberal scale of issue of tactical maps, particularly for night drops. It follows that issues of tactical maps must be considerably higher in airborne than in normal infantry divisions.

Map issues for the carrying and towing aircraft. Complete co-ordination and confidence between the airborne troops and their carrying or towing aircraft is essential. For this reason, the mapping up of both elements was controlled by D.A.D. Survey at Army H.Q. The latter was thus faced with the problem of map supply involving an understanding of navigational charts of all kinds including those for use with radar aids, and the production of special briefing maps, landing and dropping zone maps, and aeronautical approach maps, about which some notes are given in a later paragraph.

Security. For pending airborne action, as for other forms of planned operations, security is of first importance. Map supply and issue is one of the easiest ways in which security can be broken if proper care is not taken. For example, if maps of an operational area are collected from a map depot by airborne troops wearing their special and easily recognized clothing and insignia such as red berets, smocks, jump-boots, parachute and glider emblems, and divisional patches, it would immediately indicate to the depot personnel that an airborne landing in the particular area covered by the maps was likely to take place. It is therefore advisable that the personnel who are sent to collect the maps should not carry any airborne indications on their persons, vehicles or map-demand documents. The survey staff at Airborne H.Q. also should remain as anonymous as possible when dealing with producers and suppliers of operational maps. In the case of the survey officers at H.Q. F.A.A.A. they wore S.H.A.E.F. patches rather than the F.A.A.A. insignia. This helped to camouflage their real activities.

The transit of maps by lorry constitutes a threat to security, and stringent means were always taken to ensure that loads were carefully checked, covered, and guarded while on the road.

Naturally the above security problems are of general application, but they are particularly important in connection with airborne operations, where the need for surprise is vital, and where even a few hours' knowledge of an impending drop will enable the enemy to prepare an adequate defence which may result in serious casualties to personnel and aircraft, and perhaps endanger the success of the whole operation.

Special maps for airborne use

In addition to the standard tactical maps which were used by the ground forces, a number of special maps were required and produced for airborne use during "Overlord." Some of these are mentioned below:—

Layered maps. In the case of France, Belgium, and Holland the large scale (1/25,000) maps showed relief clearly enough by their contours to

enable them to be used as they stood. When areas in Germany were being studied, however, it was found that the closeness of detail and contours was such that the maps were indistinct and difficult to read, and there were insistent demands from the airborne formations, both British and American, for colour-layered maps to be provided for planning and briefing. Layers were therefore printed in tints ranging from pale yellow, through buff and brown, to sepia, sometimes up to as many as six layer plates being involved. Up to 500 copies were printed of each sheet, an extravagant procedure involving a lot of extra time in preparation, but great use was made of them, and much time and trouble were saved to staffs of lower formations in interpreting and studying the terrain.

Defence overprints. Considerable numbers of 1/25,000 and 1/12,500 maps were produced with defence overprints for the many airborne operations which received planning study. The traces for the overprint matter were produced by photo interpreters working under the research sub-section of G-2 (Intelligence) at Army H.Q. D.A.D. Survey acted solely as the printing agent for these maps. Distribution was effected by G-2. The standard style and symbols as laid down by D. Survey (S.H.A.E.F.) were employed, i.e., a purple overprint on a grey base, with the defence legend on the back of the map sheet. About 1,000 copies of each sheet for each airborne division were required, and in some cases, for a long-planned operation, two or three editions were produced at, say, weekly intervals so as to keep the planners up to date.

"Flak" overlays. Each airborne plan was accompanied by a "flak" overlay, printed in black on tracing paper to fit over a 1/100,000 sheet. The flak detail was compiled by G-2 (flak sub-section), and Survey was responsible only for the printing. The numbers of each sheet printed varied from 120 to 500 copies.

Landing and dropping zone traces. The principal use of these, which must not be confused with the "maps" of the same name referred to below, was for briefing aircraft and glider pilots on the exact points of landing. They were used in conjunction with enlarged photo-mosaics of the area concerned. The A-2 (Intelligence) of IX Troop Carrier Command (U.S.) was responsible for their compilation, and printing was arranged by D.A.D. Survey.

Half-tone mosaics. Survey was frequently called upon to produce half-tone photo-litho mosaics of dropping and landing zone areas. Material for reproduction was supplied by G-2 (photo section).

Night landing and dropping zone maps. These were usually on a scale of 1 inch to 1 mile, and were a special form of bomber-type night target maps. They showed water features in white, fields in grey, woods in black, and roads and built-up areas in purple. Their object was to help aircraft and glider pilots to find the landing and dropping zones under conditions of moonlight or semi-darkness. (See Plate 57.)

Fly-in maps. Under this heading were included all photo-maps and diagrams which were designed to aid the troop carriers and gliders in their approach to the landing and dropping zones. Some were diagrams showing the courses to be steered between marker beacons. Considerable assistance was necessary to make the pilot's task as simple and fool-proof as possible under battle conditions, so as to assure the landing of the troops at the appointed place.

Village photo-plans (1/5,000). In their role as surprise assault troops, airborne units were much concerned with villages, hamlets, and small towns lying in, or adjacent to, their dropping and landing zones. These villages were often their first objectives, being frequently situated on road junctions and at river crossings, or forming enemy command posts, billets, dumps, or communication centres. Resistance in a village could often be crushed by the rapid seizure of certain houses. When this principle had been amply demonstrated during early airborne operations, there arose an insistent demand for plans of all such villages in the areas of airborne operations.

It was found that the quickest and most satisfactory method of production was to retouch an air-photo enlarged up to 1/5,000 scale, accentuating and annotating salient features such as roads, streams, railways, power-lines, bridges, principal buildings and installations, and adding approximate grid lines and road destinations. They were then reproduced by half-tone photo-litho. Approximate contours were added where possible, giving as close a vertical interval as could be obtained from the data available. The scale of issue was about 350 to each division.

Scale of map issues

Taking as an example the airborne operation which was mounted in connection with the crossing of the Rhine in March, 1945, the following figures per sheet give an idea of the scale of map issues:—

<i>Scale</i>	<i>Corps H.Q. British/ U.S.</i>	<i>U.S. Airborne Div.</i>	<i>British Airborne Div.</i>	<i>Total Initial Issue</i>	<i>Reserve</i>
1/1,000,000 (4 sheets)	26	42	—	68	42
1/500,000 (2 sheets)	20	40	50	110	40
1/500,000 road map (2 sheets)	700	850	900	2,450	900
1/250,000 (4 sheets)	240	305	300	845	445
1/100,000 (4 sheets)	340	5,930	3,500	9,770	6,430
1/50,000 (9 sheets)	330	2,170	2,900	5,400	2,430
1/25,000 (24 sheets)	330	2,170	2,900	5,400	2,430
1/12,500 (4 sheets)	330	2,170	2,900	5,400	2,430

Survey organization with First Allied Airborne Army

The forces involved. The formations under the operational control of H.Q. First Allied Airborne Army were:—

- 1 British Airborne Corps.
 - 1 Airborne Division.
 - 6 Airborne Division.
 - S.A.S. Regiment.

XVIII U.S. (Airborne) Corps.

101 Airborne Division.

82 Airborne Division.

17 Airborne Division.

13 Airborne Division.

(Note. The last-named division did not arrive in the European Theatre until early in 1945 and did not take part in an operation, although it was on the alert to do so on several occasions.)

Air Forces.

IX Troop Carrier Command, U.S. Army Air Force.

38 Group R.A.F.	{ Under F.A.A.A. control only for specific operations, but routine mapping arrangements were under the control of D.A.D. Survey F.A.A.A. by agreement with Air Ministry.
46 Group R.A.F.	

Survey organization. The survey staff at H.Q. F.A.A.A. originally consisted of a D.A.D. Survey (Major J. H. Adam, R.E.), one British liaison officer, one U.S. liaison officer, one sapper (clerk, field survey) and one sapper (storeman, survey).

During the period when H.Q. F.A.A.A. was located in England, the Director of Military Survey, War Office, placed a small map depot at Newbury, and the printing resources of 523 Field Survey Company R.E. under the operational control of D.A.D. Survey F.A.A.A. Control of 523 Coy. was relinquished when H.Q. F.A.A.A. moved over to France in February, 1945, but the depot at Newbury continued to supply maps to British airborne troops.

Army H.Q. was established at Maisons-Lafitte, near Paris, and U.S. Communications Zone assigned No. 3083 Map Depot Team to operate F.A.A.A. Map Depot No. 24 at Army H.Q. It remained there until the disbandment of the Airborne Army.

No. 2800 Engineer Survey Liaison Team (U.S.) was formed on 15th April, 1945, and arrived at H.Q. F.A.A.A. on 21st April. The team remained with the army until its disbandment, but was too late to take much part in the mapping up for airborne operations, despite the keenness and efficiency of its personnel.

A Corps Engineer Topographical Company (U.S.) was assigned to XVIII Corps from August, 1944, to May, 1945. It was employed solely on local mapping and printing for Corps H.Q.

Source of map supply. At the date of the formation of F.A.A.A. in August, 1944, all the British and American airborne troops were based in the United Kingdom. The greater part of the American map stocks and printing resources was in process of shipment to the Continent. A decision was therefore arrived at whereby the Directorate of Military Survey, War Office, would undertake to supply all the mapping requirements of airborne troops (both British and American) who were based in, or mounted from, the United Kingdom. This simplified the procedure for obtaining large quantities of maps required at short notice. The topographical organization with Com. Z., which would normally have met the demands of U.S. airborne troops, was thus relieved of any responsibility in this connection until such time as the airborne formations were based on, or mounted from, Continental bases. At a later stage, when American airborne troops were based in France, their map demands were largely met by Com. Z., with 21 Army Group undertaking supply for maps of its own operational area.

It should here be noted that, throughout the phase of airborne operations

in western Europe, the Airborne Army was located close to large base map supplies and printing resources. In the United Kingdom these were provided by the War Office, and in France S.H.A.E.F., 21 Army Group and Com. Z. were available. For this reason it was not necessary for H.Q. F.A.A.A. to have large map producing facilities incorporated in its establishment. It seems likely, however, that in the event of an Airborne Army being based far from large map stocks and printing installations, it would have to be equipped with considerable resources of its own, if it is to meet the requirements of its troops adequately in the time available.

Methods of Mapping up

The issue of maps fell into three distinct functional categories:—

Phase A. The library issue. Each U.S. airborne corps and division was provided with a map library of 20 copies of each sheet on scales of 1/25,000, 1/50,000, 1/100,000, 1/250,000, 1/500,000 (Air) and 1/1,000,000, giving complete cover of the whole enemy-held territory within the range of troop-carriers and gliders from their bases. Automatic distribution of new and revised sheets was made by the Airborne Army Map Depot through the Corps Engineer. A similar, but smaller, library was carried by 1 British Airborne Corps, but not by British airborne divisions, who relied on obtaining their maps at short notice from survey depots in the United Kingdom. H.Q. F.A.A.A. had a very comprehensive map library, holding 30 copies of each sheet.

Phase B. The planning issue. On receipt of the outline plan, issued by the planning section at Army H.Q., corps and divisional commanders did their initial planning on the Phase A (library) stocks already in hand. As soon as possible, however, Phase B (planning) stocks, consisting of 150 copies of each relevant sheet, were issued by D.A.D. Survey at Army H.Q. to all corps and divisions concerned, on which the more detailed studies were made.

Phase C. The operational issue. For planned operations action was taken to assemble or earmark the necessary stocks with a view to actual issue to troops on or about "D"—15, though in the great majority of cases the time available was much less. In this connection, it is of interest to note that, where operations of divisional size were concerned, "D"—1 was always regarded as a day of rest, "D"—2 as a day of study, and "D"—3 as a day of briefing. Hence all maps had to be in the hands of the troops by "D"—4. As it took up to two days for corps and divisions to break down and distribute to lower formations, it was necessary to aim at delivering the bulk stocks to corps by "D"—6, or "D"—5 at latest.

Issues for troop-carrier and glider-pilots. In view of the large number of troop-carrier aircraft and glider-pilots involved, considerable attention had to be paid to their requirements. Although the issues to them were small as compared with those required for the troops, their needs were of great importance, and fell very largely into the same categories as those described above for planning and operations.

Method of issue. Maps were assembled at F.A.A.A. map depots in the United Kingdom and on the Continent, were carefully checked, sorted and

made up into rolls of 50 and then broken down into unit-lots (one lot for Corps H.Q., and one for each division, carrier command, or R.A.F. group). At an appointed time, each formation sent its own transport to the specified map depot, together with an officer and armed escort. Careful checking of loads was important, not only to avoid shortages, but also to assist in tracing any losses. All maps were conveyed in covered trucks, with an armed man in each truck guarding the load. Further break-down was effected at Corps and Division H.Q.s for issue to lower formations, under the guidance of G-2/Intelligence staffs at Corps H.Q.

Depot reserves for air re-supply. Where air re-supply appeared likely (i.e., where immediate link-up between ground and airborne forces was not expected) a generous reserve was held at Army and Divisional H.Q.s for re-supply and maintenance. Approximately 33½ per cent to 50 per cent were so held in reserve by F.A.A.A., the exact figure depending on availability, and on the estimated time of isolation of the airborne force.

Transfer of responsibility for map supply after link-up. It was most important that no possible doubt should exist in the minds of all those concerned with the supply and distribution of maps in the field about responsibility for supply, and procedure for procurement and distribution. As a result of experience gained in the Arnhem operations H.Q. F.A.A.A. issued "Instructions on the Maintenance and Issue of Maps," giving exact details to all concerned.

It was agreed between H.Q. F.A.A.A., army groups, and armies in the field that F.A.A.A. was responsible for all map supply to airborne formations including initial issues and re-supply by air until responsibility passed to the ground formation concerned. The latter took over responsibility for issue as soon as physically possible after command had passed to them. It was normal for this to happen as soon as a firm link-up had been established. In operation "Varsity" (the Rhine crossing), for example, responsibility for map supply was transferred from F.A.A.A. to Second Army as soon as contact could be made with, and command pass to, Second Army. The decision of the exact time of change of responsibility was made mutually by D.D. Survey, Second Army and the senior airborne formation on the ground. F.A.A.A. was then informed of the change, and thenceforward was not required to meet any requests for map supplies in connection with the operation. At the same time, the senior airborne formation informed its lower and attached formations of the change-over.

Liaison during operations. Profiting from the experience gained during the Arnhem operations, an airborne map liaison officer was attached for operation "Varsity" to Second Army Survey Directorate, to represent the needs of, and arrange delivery to, the airborne forces during and immediately after the link-up. This was found to be most successful.

Map distribution. The F.A.A.A. was partly based in the United Kingdom and partly in France. The needs of each type of formation had to be ascertained and recorded, and a system of map procurement and distribution had to be devised which would guarantee the quickest and most efficient service combined with economy in personnel. A rule that no demand should remain unattended to overnight was rigidly adhered to. Besides large operational issues in bulk, a constant stream of smaller demands for training maps, maps for historical reports, flying maps (including radar charts), and road maps poured through the survey office at H.Q. F.A.A.A. Constant small issues of

maps for Special Air Service operations were made under cloak of strictest security.

Survey Liaison

With General Staff sections at H.Q. F.A.A.A. As was the case with all survey directorates it was imperative that the survey staff at H.Q. F.A.A.A. should be kept in constant touch with the changing operational situation. On the whole, the information supplied to D.A.D. Survey was adequate. Much unnecessary work had to be done, as operations were often prepared and then cancelled for one reason or another. This was generally because the ground forces who had called for airborne assistance moved so fast that they no longer required it. D.A.D. Survey attended daily war-room briefings, and consulted G-2 and G-3 chiefs as frequently as the situation required.

With higher formations. As the F.A.A.A. was entirely dependent on higher formations such as S.H.A.E.F., War Office and Com. Z. for its map supply, a constant liaison was maintained on survey matters with those headquarters so as to enable priorities to be fixed and plans prepared to meet future commitments. D.A.D. Survey represented the Airborne Army at mapping conferences held at S.H.A.E.F. and at the Directorate of Military Survey, and kept the survey directorates informed of operational trends and plans.

With Army Groups. As soon as firm plans were developed, warranting the actual assembly of maps, particularly on the Continent, contact was made with the army group concerned, so as to settle the many points at issue, avoid duplication, co-ordinate operational procedure, and ensure that maps used by the airborne forces did not differ in detail from those in use by the ground formations.

With lower formations. The British and American survey liaison officers who worked with D.A.D. Survey at H.Q. F.A.A.A. kept in constant touch with the British and U.S. Airborne Corps respectively, processed their map demands, and represented their needs, particularly those of a routine nature.

Map supply during the closing stages of the War

During the last two months of the war in Germany, an interesting phase was met which demonstrated the need for flexibility in mapping arrangements. Until the assault crossing of the Rhine in March, and the subsequent breakthrough into central Germany, the strategic principle was to employ airborne troops in large formations, two or three divisions at a time. After the breakthrough east of the Rhine, it soon became apparent that the need for such large scale operations no longer existed. The disintegration, chaos and lowered morale of the enemy made it possible that the Nazis might run amuck and start a massacre of allied prisoners of war. To meet this threat, plans were prepared for small bodies of airborne troops of regimental and brigade strength to drop on any of the numerous camps where such trouble might occur. This meant that the entire stocking and issuing arrangements had to be switched over from holding large quantities of sheets of relatively few areas to the assembly of smaller quantities of a large number of sheets covering areas scattered over northern, central and southern Germany. The stocks held in the Airborne Army Depot had to provide entire coverage of the country on 1/100,000 scale and smaller, and a large number of particular 1/25,000 sheets and town plans had to be procured, and held ready for issue at very short notice (about six hours). In actual fact, none of these map stocks were ever required for the purpose anticipated.

Survey narrative for First Allied Airborne Army from 15th August, 1944, to 20th May, 1945

PHASE I. THE BATTLE OF NORTHERN FRANCE AND BELGIUM (15TH AUGUST TO 17TH SEPTEMBER, 1944).

H.Q. F.A.A.A. was formed at Ascot, England, on 15th August, 1944, and replaced H.Q. Combined Airborne Forces. Major J. H. Adam, R.E., was appointed D.A.D. Survey at Army H.Q. to look after the mapping interests, assisted by a very small staff. When he reported for duty on 14th August, he found that all the maps required for operation "Transfigure" (three divisions to drop in the Rambouillet area) had already been issued, and troops were at airfields ready to take off at 48 hours' notice. On 15th August, this operation was postponed to the 17th, and on that day it was cancelled owing to the swift advance of the allied forces from the Normandy bridgehead to the Seine. The troops thus released returned to billets but were to be ready to mount an operation to assist the Seine crossings at very short notice. Maps to cover any likely eventuality were immediately requisitioned by D.A.D. Survey, and large quantities of planning maps were supplied to the staffs at army, corps, and divisional level.

Looking well ahead, the airborne planners were, on 18th August, studying all areas north and north-east of the Seine as far as the Rhine. On the following day, two outline plans were issued by H.Q. F.A.A.A., one covering the Louviers area and the other covering Méhun. Operational stocks were applied for, and large quantities were moved, some being specially printed on first priority by the War Office. Next day both plans were cancelled and an entirely new one, known as the "Tedder Plan," which was later narrowed down and termed "Boxer," was being prepared. By this time, only one week after formation, a standing operational procedure for map supply had been worked out and tentatively agreed between H.Q. F.A.A.A. and the airborne corps.

The "Tedder Plan" lasted for several days. Its main aim was to cut off the enemy in the Pas de Calais and capture the flying bomb sites in that region, as the flying bomb menace in southern England was still very serious at that stage. A rapid succession of airborne operations was planned to achieve this object, but by this time the ground forces were moving almost non-stop through the area and the operations did not take place. On 24th August full scale preparations were in hand for operation "Boxer" on highest priority, only to be cancelled next day in favour of a top-priority plan "Linnet," to capture the Lille-Arras-Douai area with three airborne divisions and a parachute brigade. Map preparations were feverishly switched over to this area, the target date for the operation being 5th September. On 27th August a further division was added to the force, again altering the map supply arrangements so as to cover the entire Airborne Army. Moreover the target date was moved back from the 5th to the 3rd September. By 31st August all the forces were at their airfields, fully mapped up and ready to take off.

1st September was a day of numerous rumours, alternately confirmed and contradicted. On 2nd September conditions became further unsettled and confused by the appearance of a new plan called "Linnet 2" with target date 5th September, thus leaving only about 36 hours for the distribution of approximately 1,750,000 maps to the entire Airborne Army which was dispersed over several dozen airfields. This offered a full size problem to D.A.D. Survey, but by now he was accustomed to these almost daily changes of plan, and his small

but efficient organization never faltered, always producing the goods when and where wanted.

On 2nd September "Linnet 1" was cancelled owing to weather conditions, but the troops remained at their airfields. Next day, Sunday, 3rd September, "Linnet 2" was also cancelled. During that night the "Comet" plan appeared. This aimed at the capture of bridges in south-eastern Holland with "D"-day on 7th September. Once again map activity became frenzied. Even as late as 6th September it was stated that "Comet" would still be required, probably on 8th September. Troops, who were still at their airfields, were ready mapped-up by midnight 5/6th September. "Comet" was postponed for 24 hours on 7th September, for a further 48 hours on the 9th and was cancelled altogether on the 10th. At this juncture a new operation "Infatuate" for the capture of Walcheren Island was put into preparation.

Operation "Comet" was replaced on 10th September by operation "Market" which covered the same general area with a target date of 14th September. On 11th September it was announced that further divisions would be employed, once again embracing the whole Airborne Army. On 12th September "D"-day was fixed for 17th September. All troops were mapped up by the 15th, and on the 17th the historic Arnhem operation was launched. Map distribution was made by the small depot at Newbury to British units, and by H.Q. XVIII Corps to U.S. units. First re-supply was handled entirely by the British Airborne Corps and divisions.

PHASE II. THE WINTER MONTHS AND THE CROSSING OF THE RHINE (17TH SEPTEMBER, 1944, TO 22ND MARCH, 1945)

During the pause following "Market," planning was continued for operations "Infatuate" and "Naples I and II" (Düren and Bonn). Planning maps for the latter were delivered to XVIII Corps on 20th September. On 26th September planning maps for "Choker I" (Mainz) were delivered to XVIII Corps, and operational stocks were prepared by the War Office. Next day the plan for "Talisman," later renamed "Eclipse" was issued and maps were demanded from the War Office. This plan dealt with possible airborne activities that might be required in connection with the occupation of Germany. During the remainder of the month, mapping arrangements were also made for "Choker II" and "Milan II" (Saar and Coblenz).

Planning maps for "Choker II" were issued on 7th October. On the 9th October, XVIII Corps requested that, in future, town plans on 1/5,000 scale should be provided. These requirements were confirmed by G-2 and the necessary work of preparation was put in hand at the War Office. On 28th October, operation "Varsity" (Rhine Crossing) was proposed by 12th U.S. Army Group as an alternative to "Naples II," and the necessary mapping arrangements were undertaken.

By 31st October, operational map stocks for "Infatuate," "Talisman," and "Naples II" were ready at the Newbury depot for distribution. During November, map supply activity kept level with the developments of the planning section of H.Q. F.A.A.A. Various mapping tasks were carried out in connection with "Choker I." By the end of the month stocks of all the standard maps required for "Varsity" were assembled in the depot, though the production of town plans and defence overprints was still in progress. Library issues of 1/25,000 maps of Germany on a wide coverage were made to H.Q. XVIII Corps, H.Q. 82 Airborne Division, and H.Q. 101 Airborne Division for planning.

During the first half of December, mapping-up preparations were continued for the various airborne operations which were planned to take place. Stocks were assembled, broken down, and prepared for issue at the Newbury depot.

The German offensive in the Ardennes in December, 1944, caused extra activity for mapping-up the airborne units which were used to stem the enemy advance. Stocks of maps covering the routes to divisional assembly areas and for use immediately on arrival were rushed to the divisions concerned before their departure from the United Kingdom. Air re-supply of the Bastogne area increased the consumption of maps by the air forces.

In mid-January, tentative map arrangements were made for operation "Tripod" (Mannheim), but map stocks were not actually assembled.

While the depot at Newbury still functioned to supply British airborne formations in the United Kingdom, active preparations were made during December and January for the transfer of stocks and the setting up of a map depot on the Continent. On 7th February, the new F.A.A.A. Map Depot No. 24 was opened at Maisons-Lafitte. It was manned by Map Depot Team No. 3083 under the operational control of D.A.D. Survey, and administered by Com. Z. By the second week of February, about 80 tons of maps had been flown over from the United Kingdom to No. 24 Depot involving the lifting of some 35 loads by IX Troop Carrier Command aircraft. While this was going on, the move of Main H.Q. F.A.A.A. from the United Kingdom to the Continent was begun. By 22nd February, D.A.D. Survey's detachment was in France, the British liaison officer remaining temporarily in the United Kingdom to form a link with 1 (British) Airborne Corps, the Director of Survey at the War Office, and the Newbury depot.

At the beginning of March, it became apparent that "Varsity," the airborne action in connection with the Rhine crossing at Wesel, would take place on or about 24th March. The area of coverage had to be extended to include possible landing and dropping zones and objectives further to the east. The additional map sheets and town plans were produced during the early days of the month and all issues were completed by 16th March. The operation was successfully launched on 24th March.

PHASE III. THE ADVANCE TO THE ELBE

During this last phase of operations in Germany, the planning and preparations for airborne operations continued unabated. The first of these was designed to form a large airhead in the Cassel area, using six airborne and four air-landing divisions. Work was carried on at planning stage for this operation ("Arena") during the first half of March. However, the successful advance across the Rhine, and the penetration of the Cassel area by ground forces, rendered the airborne operation unnecessary, so work was cancelled before the assembly of maps had begun.

At the beginning of April, warning was received that airborne landings by small formations were contemplated on numerous scattered points in Germany for the purpose of protecting allied prisoners of war from possible massacre by the Nazis (operation "Jubilant").

The first list of possible dropping points included some 28 localities. On 5th April, this was reduced to 12, but was amended again on 14th April to cover 29 camps. As the German Army was being steadily overwhelmed during April the list naturally dwindled. In every case, sufficient maps for a regimental drop on any one locality were assembled, broken down, and held ready for

immediate issue. Planning issues for several areas were made, but no call was in fact made on operational stocks. Assembly was effected largely from War Office stocks, up to 1,000 copies of some 57 sheets on 1/25,000 scale being required at 24 hours' notice. In some instances special printings were needed, use being made of S.H.A.E.F. and Com. Z printing resources in Paris; 200 copies of each sheet were held in the United Kingdom to provide for possible employment of United Kingdom based airborne troops on this task.

Operation "Effective" was planned to drop 13 (U.S.) Airborne Division, plus two regiments, at a point north-east of Freiburg to seize an airhead at the southern end of the Siegfried Line, in support of Sixth Army Group's attack in this sector. Map assembly started on 2nd April, and a number of special photo-background town plans were prepared. Between 3rd and 6th April, planning and operational issues totalling nearly 200,000 maps were made, but the operation was ultimately cancelled when the advancing ground troops overran the area.

To assist 21 Army Group in the crossing of the Kiel Canal operation "Red Admiral" was planned. At the end of April the exact area was narrowed down to the Rendsburg locality and it was planned to use troops of 1 (British) Airborne Division mounted from the United Kingdom. On 1st May, D.A.D. Survey was informed that the operation had been cancelled.

In addition to the above, there were preparations for numerous other operations to be mounted by small airborne forces at short notice in Holland, Denmark, Norway, and in the Austrian Redoubt area. Small planning stocks were assembled, but no bulk operational stocks were prepared. The maps for the small airborne units which were subsequently sent to Denmark and Norway were provided direct by War Office to airborne troops based in the United Kingdom.

On 4th May, there was a plan to mount a small operation at very short notice on the Island of Zeeland on which Copenhagen is situated. At 1300 hours, the plan was announced, and by 1500 hours the necessary maps were *en route* from 21 Army Group map depots in Brussels and Com. Z. depots in Paris. Assembly and breakdown was to be completed at the F.A.A.A. map depot by midnight, distribution to troops of 13 Division (one regiment only) by 0500 hours, with take-off from airfields at 0600 hours. At 1615 hours on 4th May, just over three hours after planning action had been started, the operation was called off, but assembly and breakdown was completed according to plan in case the operation should be called for again. This was the last operational activity of the survey detachment at H.Q. F.A.A.A. as victory in Europe was officially celebrated on 9th May, 1945.

The F.A.A.A. ceased to exist on 20th May. The Survey Detachment remained at Maisons-Lafitte until 3rd June when it was withdrawn and returned to S.H.A.E.F. (Main) at Versailles before dispersal. During its short life this small detachment, under Major Adam's efficient, untiring and inspiring leadership, had performed prodigies of useful work. Although the number of operations which actually took place was small, the number which had been planned, and for which D.A.D. Survey made all the necessary mapping arrangements, was large. In spite, however, of frequent changes of plan, postponements and cancellations, the work went on cheerfully and thoroughly, and the maps which F.A.A.A. required or might have required, were always available.

APPENDIX I

S.H.A.E.F. OPERATION MEMORANDUM

SUPREME HEADQUARTERS ALLIED EXPEDITIONARY FORCE

OPERATION MEMORANDUM
NUMBER 28

25 April, 1944.

Artillery and Engineer Survey

1. *Object*

The object of this Memorandum is to ensure that Artillery and Engineer Survey units shall:—

- (a) Adopt a common procedure for the initiation of grids covering a limited area.
- (b) Record their results in a manner that will ensure co-ordination of effort in the case of mixed or adjacent U.S. and British forces.
- (c) Be informed as to the situation in the theatre with regard to the national basic triangulation data available and its degree of reliability.

2. *Technical Survey Data and Methods*

- (a) It is neither desirable nor necessary to insist on a standardization of Field Surveying Methods as between U.S. and British units, which must vary according to methods of training and circumstances.
- (b) Information on the basic triangulation data and grid zones in France, Belgium, Holland, and Western Germany, with special reference to Artillery and Engineer Survey co-operation is given in Annexure "A."
- (c) Fuller particulars regarding the Geodesy and Basic Survey data on the Continent can be obtained from this Headquarters.

3. *Policy*

Army Groups will ensure that all Artillery Survey Units down to and including Survey Regiments (Br.) and Observation Battalions (U.S.), and all Engineer Survey units shall:—

- (a) Use the method and nomenclature prescribed in Annexure "A" when it is necessary to initiate grids covering a limited area.
- (b) Record all survey data in the manner specified in Annexure "B."

4. *Cross References*

The following S.H.A.E.F. OPERATION MEMORANDA refer:—

- (a) No. 3. CO-ORDINATION BRITISH AND U.S. FIELD ARTILLERY, and the Field Artillery Notebook.
- (b) No. 9. MAP CO-ORDINATES.

By command of General EISENHOWER.

(Sgd.) W. B. SMITH,
Lieutenant-General, U.S. Army.
Chief of Staff.

Notes on the Basic Triangulation Data and Grid Zones in France, Belgium, Holland, and Western Germany with Special Reference to Artillery and Engineer Survey Co-operation

1. Old French Triangulation

The original triangulation of France consisted of a primary network of good quality, which was broken down to secondary and tertiary points of less accuracy, principally as a basis for the old 1/80,000 map.

2. New French Triangulation

The new triangulation, commenced in 1870, covers only a limited area of North Eastern and Eastern France.

3. Basic Triangulation Data

- (a) Trig lists have been prepared from the best available French records covering the most likely operational areas in France, Belgium, Holland, and Western Germany, and will be issued by this Headquarters to Army Groups.
- (b) Those lists in France which are based on the records of the New Triangulation are believed to be reliable, and the co-ordinate values can normally be used direct except where a cautionary note has been inscribed on the list.
- (c) Those lists in France which are based on the records of the Old Triangulation are unreliable and should not be issued to Survey units for general use. Quite apart from the possibility of gross errors which may exist due to the destruction or rebuilding of structures on which stations are located, the list values may give a possible displacement of about 10 metres from true positions owing to the method of recording the old French data.
- (d) The trig. lists covering Belgium, Holland, and Western Germany are believed to be generally reliable.
- (e) The attached index diagram* shows the approximate areas covered by the above-quoted reliable and unreliable trig. lists.

4. Grid Zones in Western Europe

On British military maps of Western Europe the following different grid zones will be found:—

English Channel

English Coastal Area	British Cassini
N.W. France Coastal Area	Lambert Zone I
N.E. France Coastal Area	Nord de Guerre

France

N. East	Nord de Guerre
N. West	Lambert Zone I
Central	Lambert Zone II
South	Lambert Zone III

* This diagram is not included.

Belgium
Holland
West Germany
S. Germany

Nord de Guerre
Nord de Guerre
Nord de Guerre
Nord de Guerre and Russian
Grid 4
N. European Zone III

Denmark

5. *Boundaries between Grid Zones*

- (a) There is a definite junction line between grid zones. Marginal ticks of the adjacent grid zone are shown on large and medium scale maps in the vicinity of a grid zone junction. Lines may be drawn connecting the corresponding marginal ticks with each other (or with the grid to which they pertain if it appears on the sheet) so as to extend a grid into the adjacent grid zone.
- (b) For internal artillery work, where targets fall across the junction line from the position of the guns, target co-ordinates may be given on this extended grid. The decision as to which grid or grids shall be used in a particular operation will be made by the artillery commander concerned.
- (c) References obtained from such manuscript grid extensions will not be communicated to other Arms and Services and will not be supplied by other Arms and Services. (See S.H.A.E.F. Operation Memorandum No. 9.)

6. *Initiation of Grid Systems by Artillery and Engineer Survey Units*

- (a) In areas already covered by *reliable* trig data it should be possible, on most occasions, to survey gun areas direct on to such control. It may sometimes be necessary for Engineer Survey to supplement such existing control to provide extra points in or near selected gun areas to meet Artillery requirements.
- (b) In areas not sufficiently covered by reliable trig. data, it will often be necessary to carry out new surveys and to prepare new trig. lists. This work will normally be done by Engineer Survey units.
- (c) Engineer and Artillery Liaison will decide what survey action is necessary to deal with circumstances as they arise. Close co-operation between Engineer and Artillery Survey Staffs and units is essential.
- (d) The Director of Survey (Br.)/The Engineer (U.S.) at Formation Headquarters is responsible for advice as to the nature and reliability of the trig. control and maps available, and for the provision of Engineer Survey assistance where needed.
- (e) There will be many occasions when Gun Regiments/Artillery Battalions may have to initiate their own grids covering a limited area. Depending on their value these grids may subsequently be discarded or incorporated into grids later established over a wider area. The number of such grids in any one area will be kept as low as possible so as to reduce to a minimum the necessity of converting co-ordinates from one grid system to another.
- (f) All grids must be the closest possible approximation to the grid printed on the largest scale available map of the area. This is essential to ensure that co-ordinates of targets scaled from the map are in close sympathy with the co-ordinates of gun positions which may be fixed with reference to the grids initiated by units.

7. Grid Nomenclature

The following instructions are issued to obviate confusion and to ensure due utilization of data for later operations in the area:—

- (a) Grids will be specified by the general class of Unit or Formation served by them and will carry an indication of the area, the actual initiating Unit, and the date. The following are examples:—

Regimental Grid	}	114 Fd. Regt.
Winterbourne Area	}	3 Nov. 42
Divisional Grid	}	4 Svy. Regt. R.A.
Larkhill Area	}	10 Nov. 42
Corps Grid	}	9 Svy. Regt.
Larkhill Area	}	12 Nov. 42
Corps Grid	}	519 Fd. Svy. Coy. R.E.
Larkhill Area	}	14 Nov. 42
Army Grid	}	519 Fd. Svy. Coy. R.E.
Larkhill Area	}	16 Nov. 42

- (b) All trig lists and lists of co-ordinates will carry an indication as to the grid on which the co-ordinate values are based. Lists referring to Divisional or higher grids issued to flank or superior Formations will, in addition, carry a full description of the points fixed and a short statement of the elements of the grid, *e.g.*:—

Origin: Water Tower at ORCHES. Co-ordinates scaled from 1/25,000 map—58671234.

Initial Bearing: Origin to FISMES Church. $76\frac{1}{2}$ degrees. Obtained by compass bearing corrected for individual error, variation and convergence.

Scale: Steel tape measure between points B/215 and C/512.

- (c) If likely to be of value later, lists of co-ordinates of points fixed by R.A. Survey Regiments/F.A. Observation Battalions and Engineer Survey units, having been checked, will be forwarded as soon as practicable to the Survey Directorate/The Engineer at Army Headquarters. The latter will evaluate and collate trig. data from Artillery and Engineer sources available to them, publishing in trig. lists the co-ordinates of points whose reliability warrants inclusion.

APPENDIX II

S.H.A.E.F. OPERATION MEMORANDUM

SUPREME HEADQUARTERS ALLIED EXPEDITIONARY FORCE

OPERATION MEMORANDUM
NUMBER 9

14 March 1944.

Map Co-ordinates

1. *Object*

The object of this memorandum is to ensure a standard procedure for indicating a position on a map by means of grid co-ordinates and to ensure a proper use of the grid systems involved.

2. *Grid Systems*

The following grids will be in use for operations against or on the Continent:—

(a) *Home Fighter Grid.* The use of this grid will be restricted to Radar purposes only, subject to the following conditions and limitations:—

- (i) Radar installations in the United Kingdom and warships will use it throughout, within its area of extent, for Fighter Control, radar reporting and aircraft movement reporting.
- (ii) It will be used, as in (a) (i) above, also by ships installations performing Air Force roles (e.g., H.Q. ships and Fighter Direction ships) and Continental-based Radar installations until specifically ordered to the contrary. (See 2 (c) below.)
- (iii) It will be the responsibility of Continental-based Radar installations, when reporting Air information for ground use, to convert, when necessary, from Home Fighter Grid to the appropriate military grid.

(b) *Military Grid*

- (i) The military grid applicable to the area concerned will be used by all Forces at all times for giving references of positions on the ground.
- (ii) It will be used also, when it is so ordered (see 2 (c) below), for referencing positions of aircraft, by Continental-based Radar installations and by ship installations performing Air Force roles (e.g., H.Q. ships and Fighter Direction ships) who, when necessary, will convert and “tell” information in terms of the Home Fighter Grid.

(c) For Radar purposes, the Air Commander-in-Chief, A.E.A.F., will be the authority to declare the termination of the procedure outlined in (a) and the initiation of the procedure outlined in (b) above. Such

orders will be given when the broadcasts from Home-based installations cease to be the main source of information for the Continental-based Radar system.

- (d) Aircraft engaged on support missions will *not* employ maps bearing a grid other than the Military Grid of the area concerned.

3. Map References

- (a) Map references will be quoted on one common system, namely that known as the British (Modified) Grid Reference system.
- (b) For map grid purposes, Western Europe is divided into a number of grid zones, and the Military maps on scales of 1/250,000 and larger will have the appropriate military grid of the zone concerned printed on them. The 1/500,000 and 1/250,000 air maps will have grid "ticks" and grid intersection marks of the military grid over-printed on them so that the grid squares can be completed by hand when required. Adjacent grid zones do not overlap and, *for normal use*, one point can have only one grid reference, namely that referring to the grid zone within which the point is situated.
- (c) Under certain special conditions, when operations are taking place astride a junction between two grid zones, it may be necessary for Artillery units to extend the grid squares of one zone arbitrarily into the adjoining zone in order that the co-ordinates of gun and target may be determined in terms of the same grid zone. To facilitate such action, the map sheets concerned have printed on them round their margins grid ticks representing extensions of grid lines of the adjoining zone. These ticks can be joined up by hand so as to extend the squares of one grid zone into the adjacent zone.
- (d) In each grid zone the area, if large enough, is divided into squares of 500 kms. side, each of which is designated by a letter. Letters read from left to right starting at the top left square, and run from A to Z (omitting I) in rows of five.
- (e) Each of these large squares is sub-divided into 25 squares of 100 kms. side which are also lettered from A to Z (omitting I). Letters again read from left to right starting at the top left square.
- (f) These squares are again sub-divided, each into 100 squares of 10 kms. side. On maps of scale 1/100,000 and larger, these squares are sub-divided again into squares of 1 km. side.
- (g) The grid lines running North-South are numbered from WEST to EAST and are termed Eastings. Those running East-West are numbered from SOUTH to NORTH and are termed Northings. A *full* grid reference for any particular *square* on, say, a 1/50,000 map is given by designating in order:—

The letter indicating the 500-km. square.

The letter indicating the 100-km. square.

The Easting } grid lines which intersect at the south-west corner
The Northing } of the square in which the point is located.

Thus PS 7358 indicates 500-km. square P, 100-km. square S, Easting 73 km., Northing 58 km. The position of the point is thus fixed within a certain 1-km. square.

- (h) To fix the position of a point with greater precision (on medium and large scale maps) the 1-km. square may be subdivided (estimating tenths by eye) thus adding one additional digit to Easting and one additional digit to Northing: *e.g.*, PS 732586.
- (i) Grid letters will be obtained from the face of the map or from marginal information on the map.
- (j) The number of letters necessary varies with the scale and circumstances.
- (k) Instructions for quoting map references will normally be found printed on the face of the map.
- (l) The normal requirements of a grid reference are as follows:—

<i>Scale</i>	<i>Reference</i>
1/500,000	Two letters, four figures.
1/250,000	Two letters, four figures.
1/100,000	One letter, four (or six) figures.
1/63,360 (one inch)	Six figures.
1/50,000	Six figures.
1/25,000	Six figures.

4. *References to Map used*

In written orders, messages, etc., where grid references are given, it is necessary to quote early in the document the actual map to which the map reference refers. This can be done in a variety of ways depending on circumstances but should indicate clearly the Map Series or G.S.G.S. number, the name or number of the map sheet and the scale of the map.

5. *Security*

The security code to be used in the transmission of Map Co-ordinates is described in Operation Memorandum Number 17.

By command of General EISENHOWER.

(Sgd.) W. B. SMITH

Lieutenant-General U.S. Army
Chief of Staff.



Plate 1. GSGS 4042. N.W. Europe. 1 : 250,000.
 Sheet 7. "Rouen-Paris" (Edition of 1938).
 For comparison with Army/Air Edition see Plate 41.

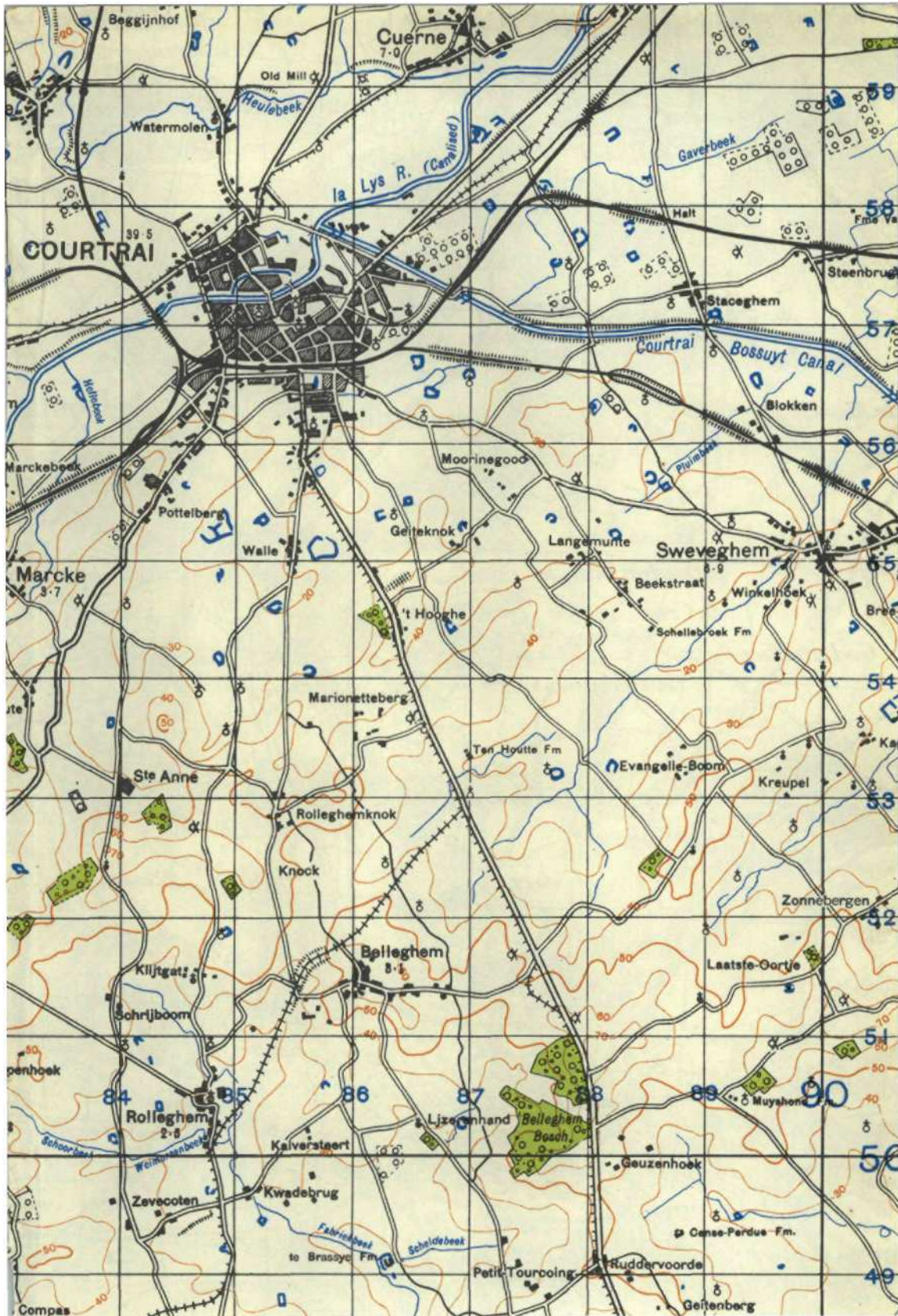


Plate 3. GSGS 4040. France and Belgium. 1:50,000.
 Sheet 53. "Courtrai" (Edition of 1937).
 For comparison with later edition see Plate 36.

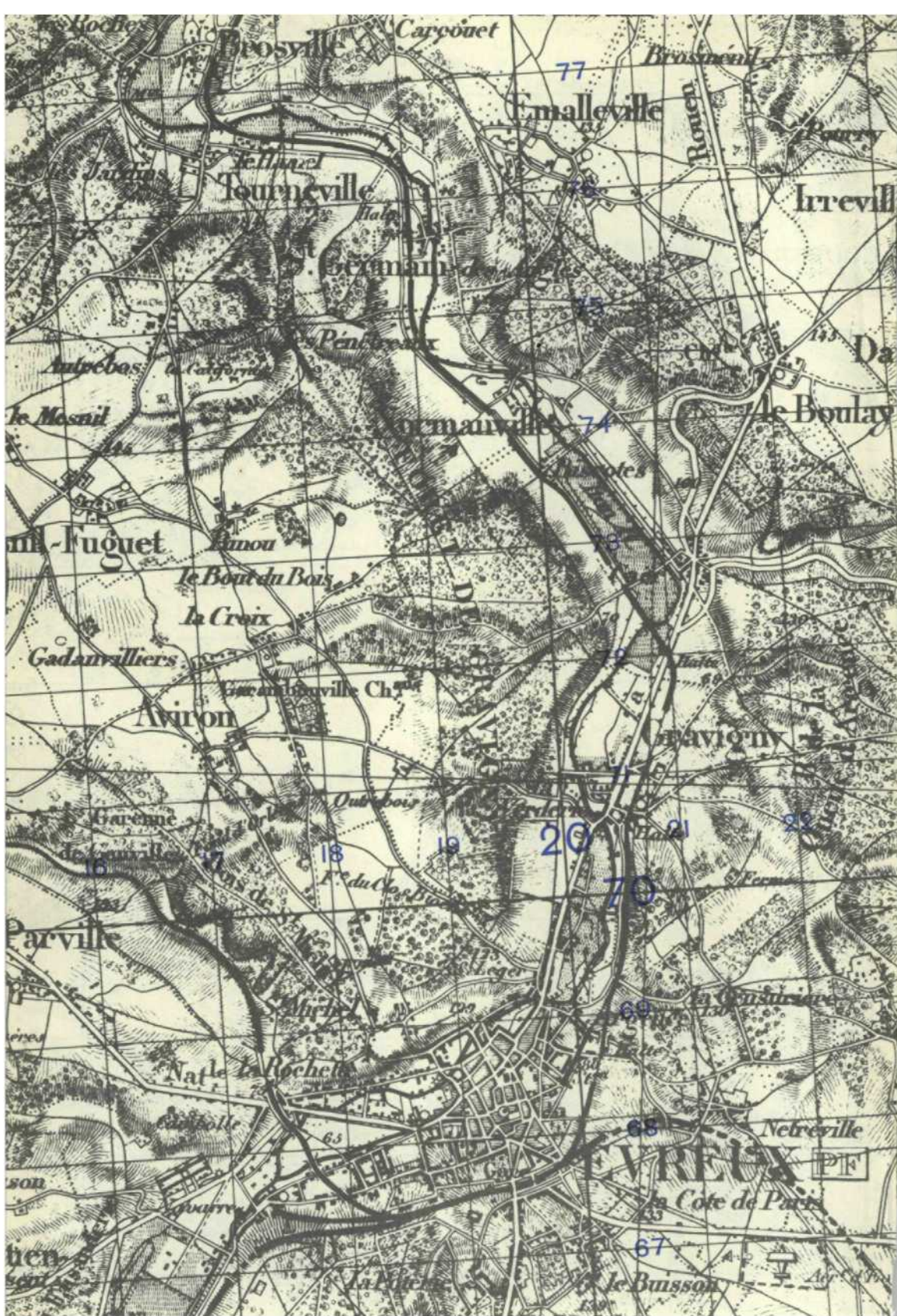


Plate 4. GSGS 4040A. N. France. 1 : 50,000.

Sheet 47.N.W. "Evreux" (Edition of 1938).

For comparison with later 1/50,000 Edition covering this area see Plate 37.



Plate 5. GSGS 4041. N.E. France and Belgium. 1 : 25,000.
 Sheet 36.N.W. "Bree" (Edition of 1939).
 For comparison with later edition see Plate 43.

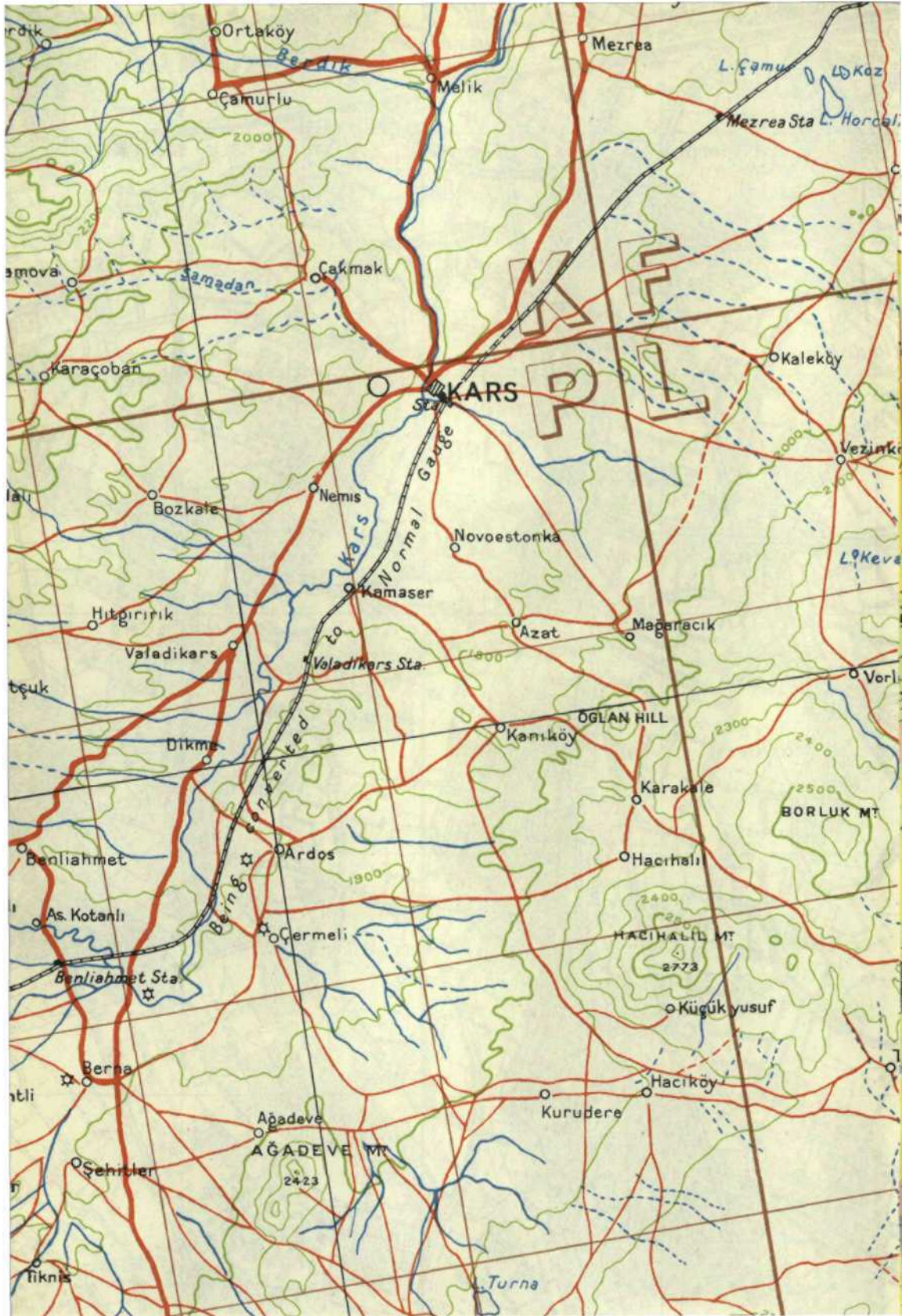


Plate 6. GSGS 4193. Turkey. 1 : 200,000.

Sheet B.16. "Kars."

Compiled from various Turkish maps. First Edition 1941.

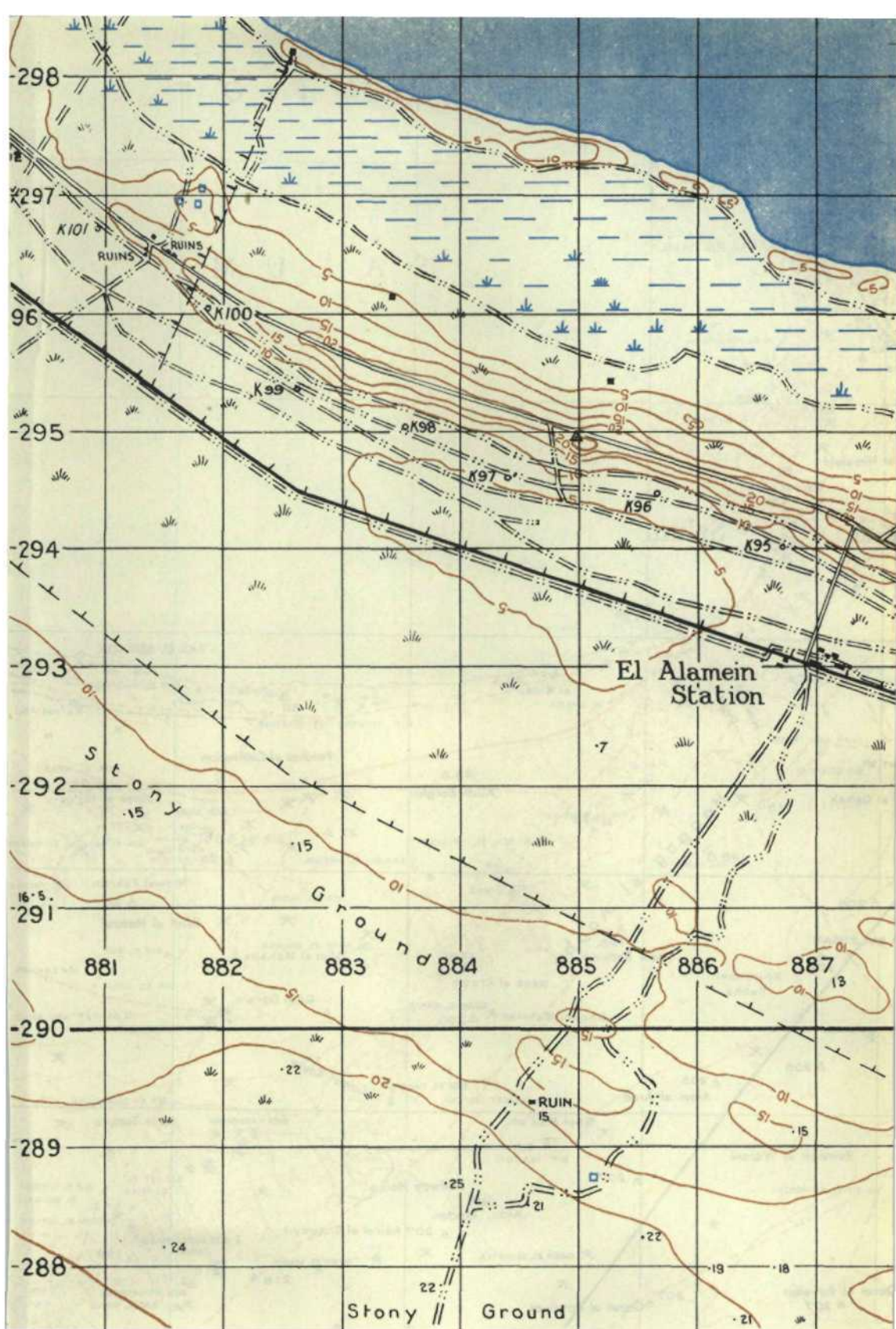


Plate 7. GS 4362. Daba-Alexandria Series. 1 : 50,000
 Sheet 5. "El Alamein."
 Surveyed by S. African and 514 Fd. Svy. Coys. 1941.



Plate 8. GSGS 4386. Egypt and Cyrenaica. 1 : 250,000.
Sheet 3. "Salum-Tobruch" 1st Edition (1943).

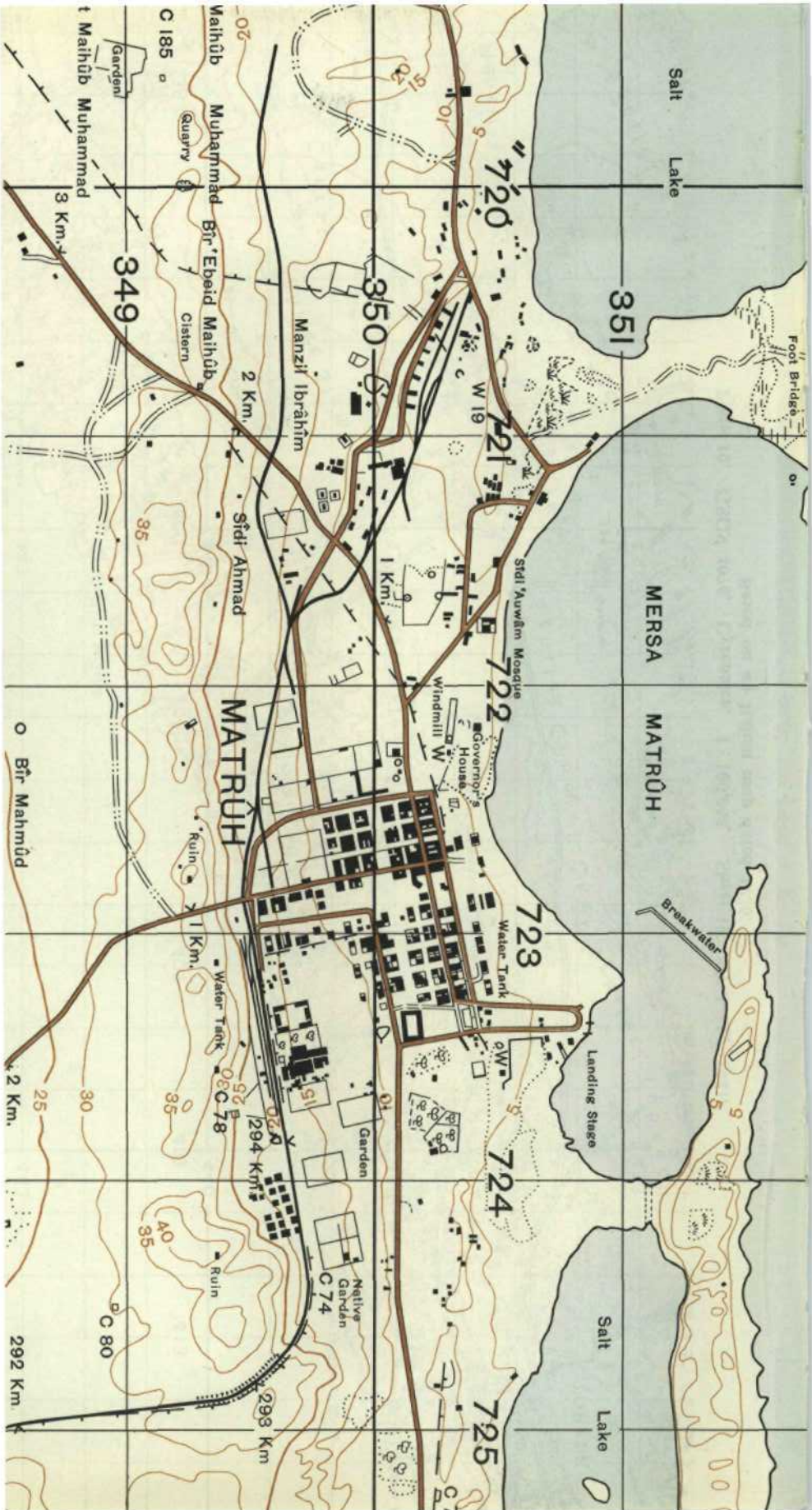


Plate 9. Middle East 1 : 25,000. Matruh area.
 Compiled from an Egyptian map and ground survey by 512 (Army) Fd Svy
 Coy R.E. 1940

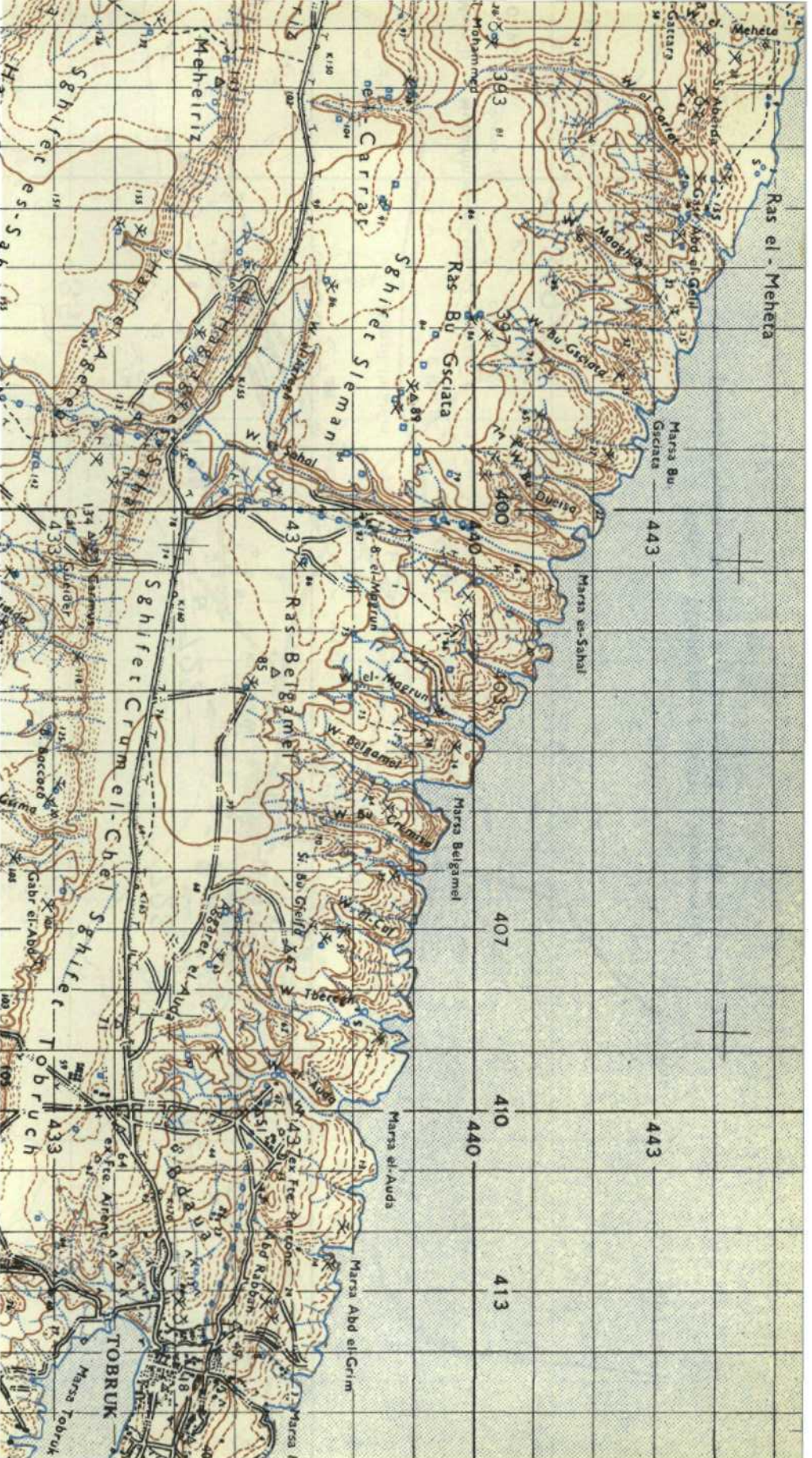


Plate 10. GSGS 4076. Cyrenaica. 1 : 100,000. Sheet 19. "Tobruk," 1941.
Based on an Italian map dated 1936.

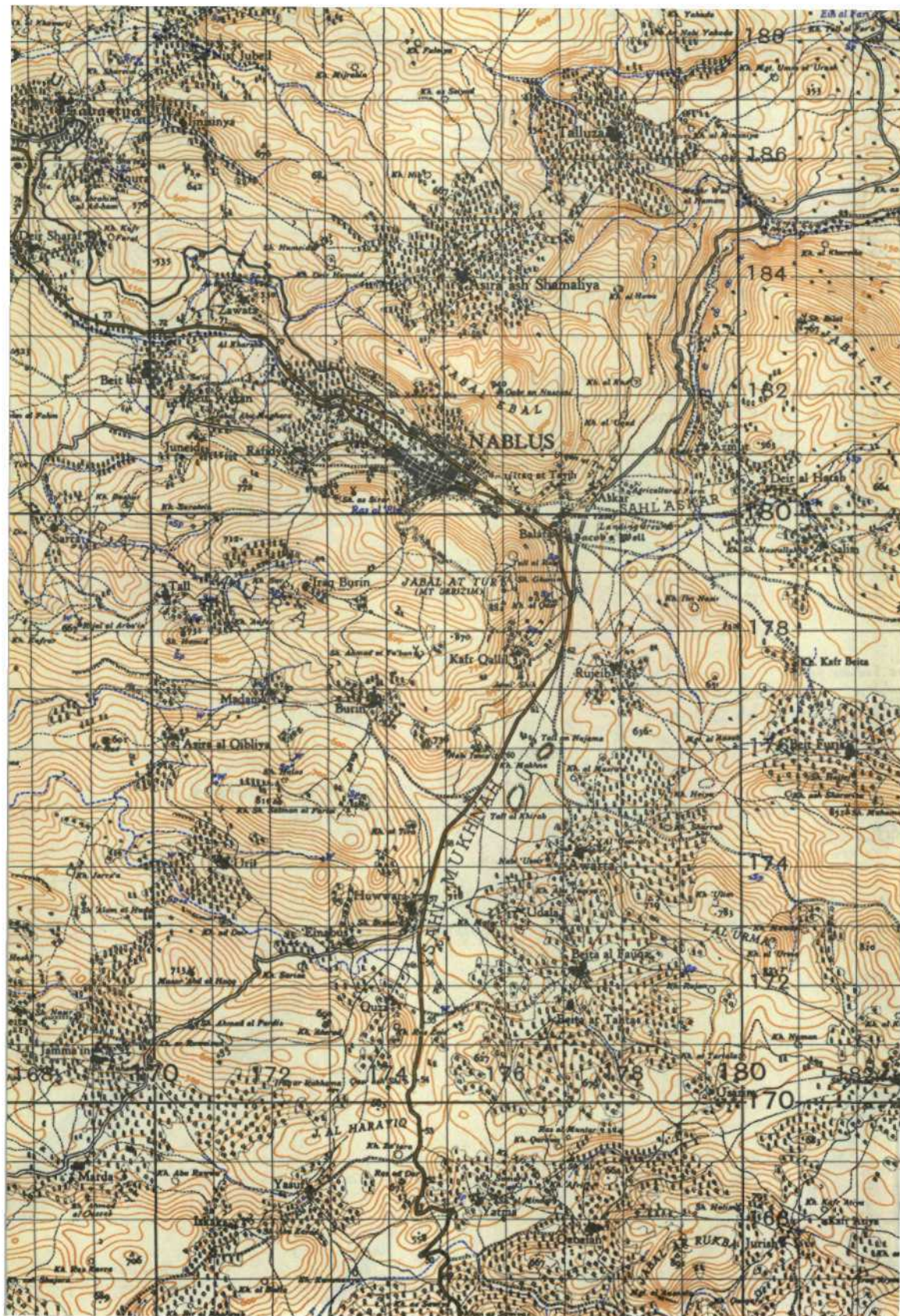


Plate 12. GSGS 4078. Palestine. 1 : 100,000.
Sheet "Nablus," 1941.

Copied from a map published by the Dept. of Lands and Surveys.

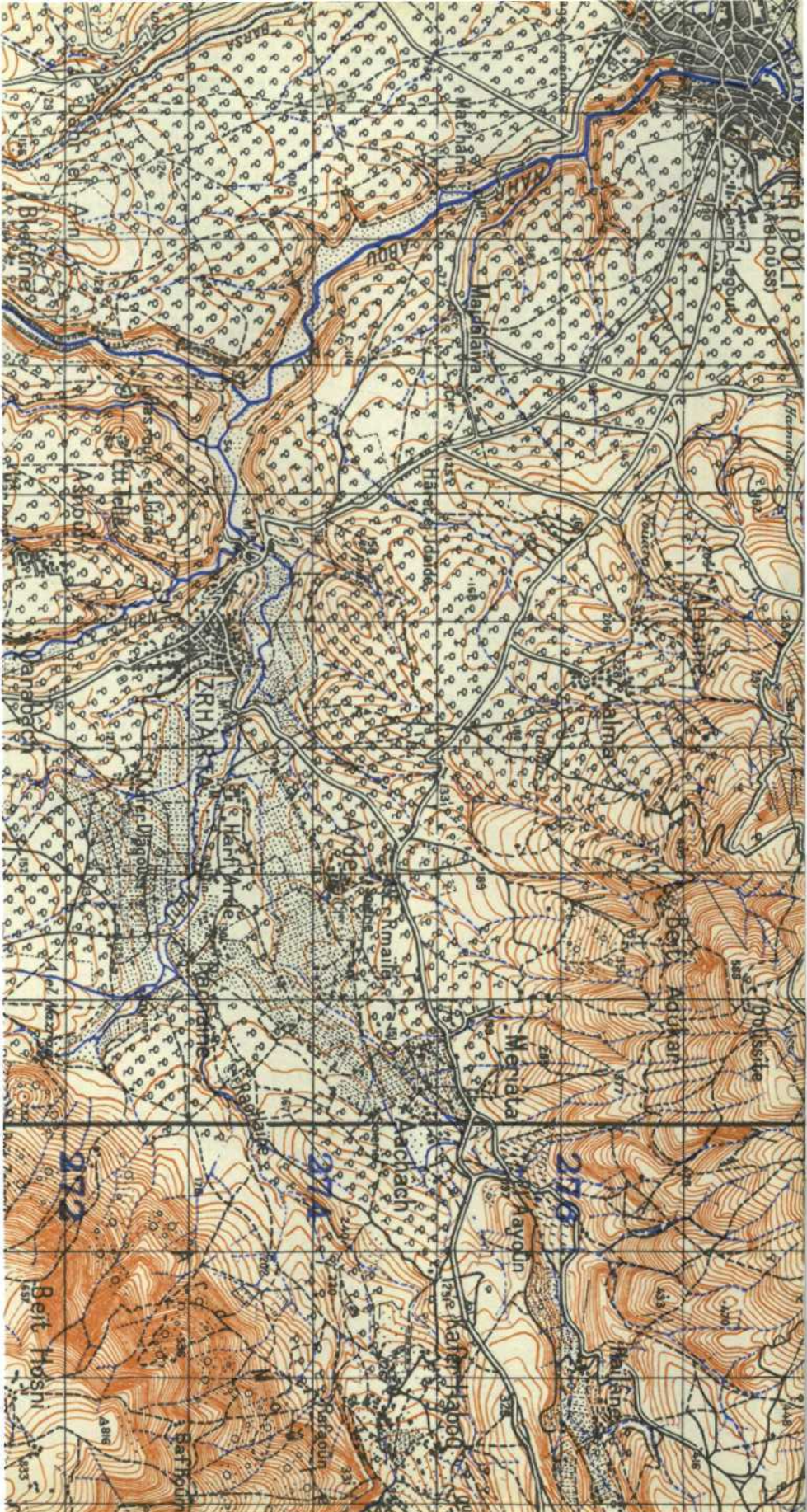


Plate 13. The Levant. 1 : 50,000.
Sheet "Tripoli."
Published by the "Service Géographique."

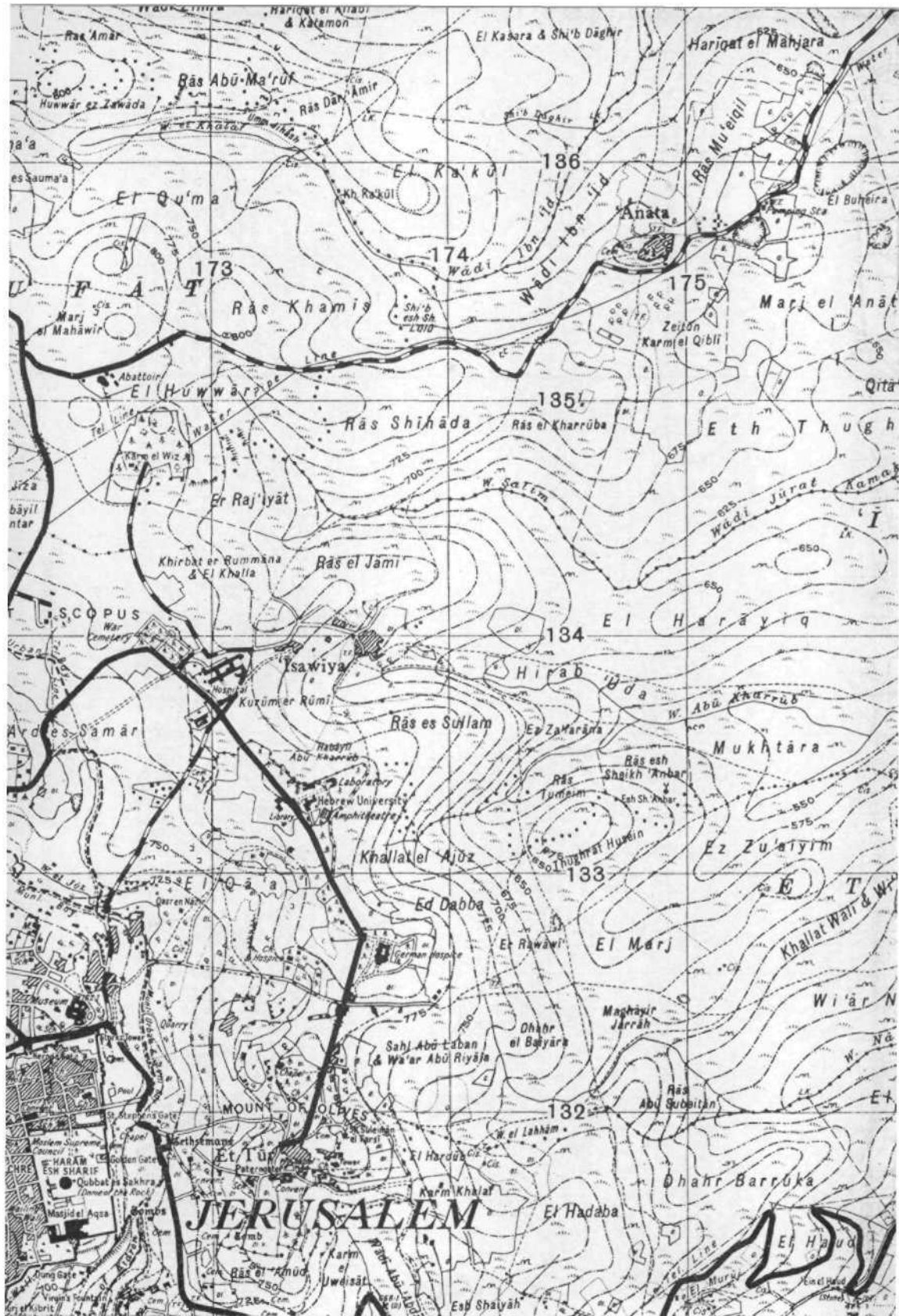


Plate 14. Palestine. 1:25,000.
Sheet 17-13. "Jerusalem," 1943."

Compiled from 1:10,000 Cadastral Survey (1933) and other material.



Plate 17. Eritrea. 1:50,000. (Keren area.)
 Surveyed, drawn and printed by 514 Fd Svy Coy R.E. from air
 photographs taken by 14 Sqn R.A.F. Feb. 1941.

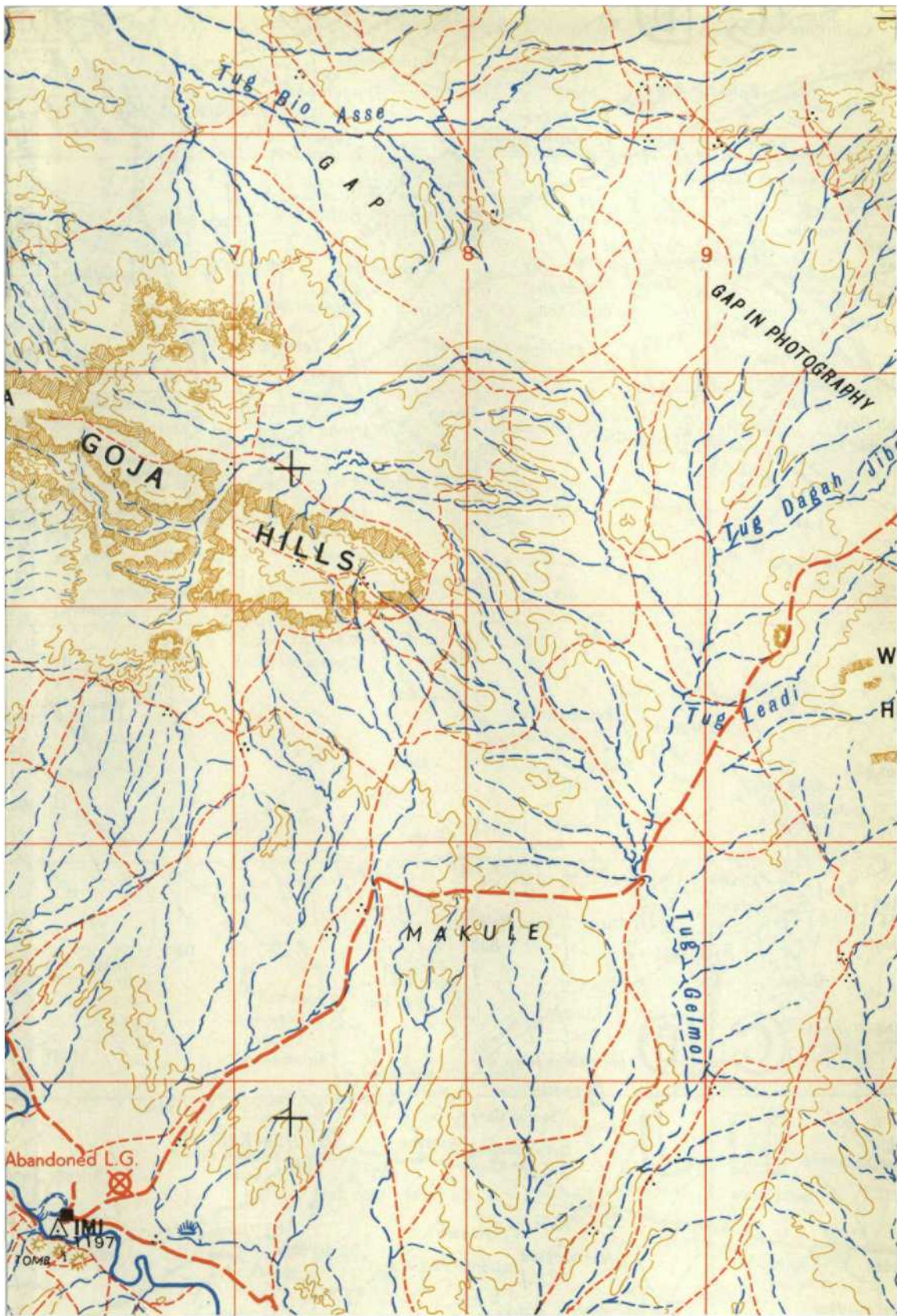


Plate 19. E. Africa. 1 : 250,000.

Sheet "Fich-Imi."

Compiled, drawn and printed by 157 (E.A. and S.R.) Svy Coy E.A.E. from
air photographs taken by Ogaden Flight R.A.F. 1944.

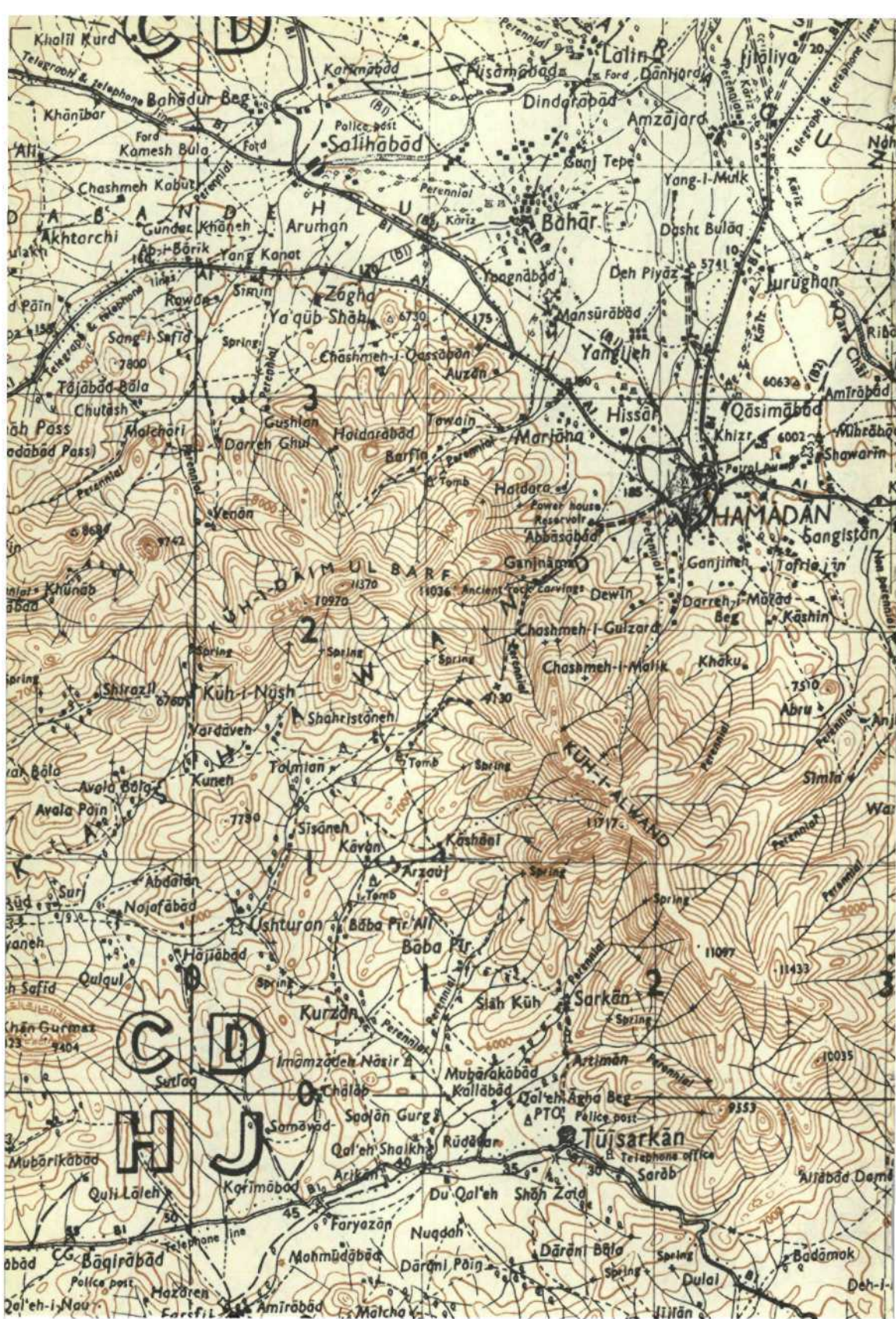


Plate 20. GSGS 3919, Iran. $\frac{1}{4}$ inch to 1 mile.

Sheet I-39G. "Hamadan."

Based on M.E.F. Surveys (1919) and subsequent rapid surveys and revision (1942.) 2nd Edition 1943.

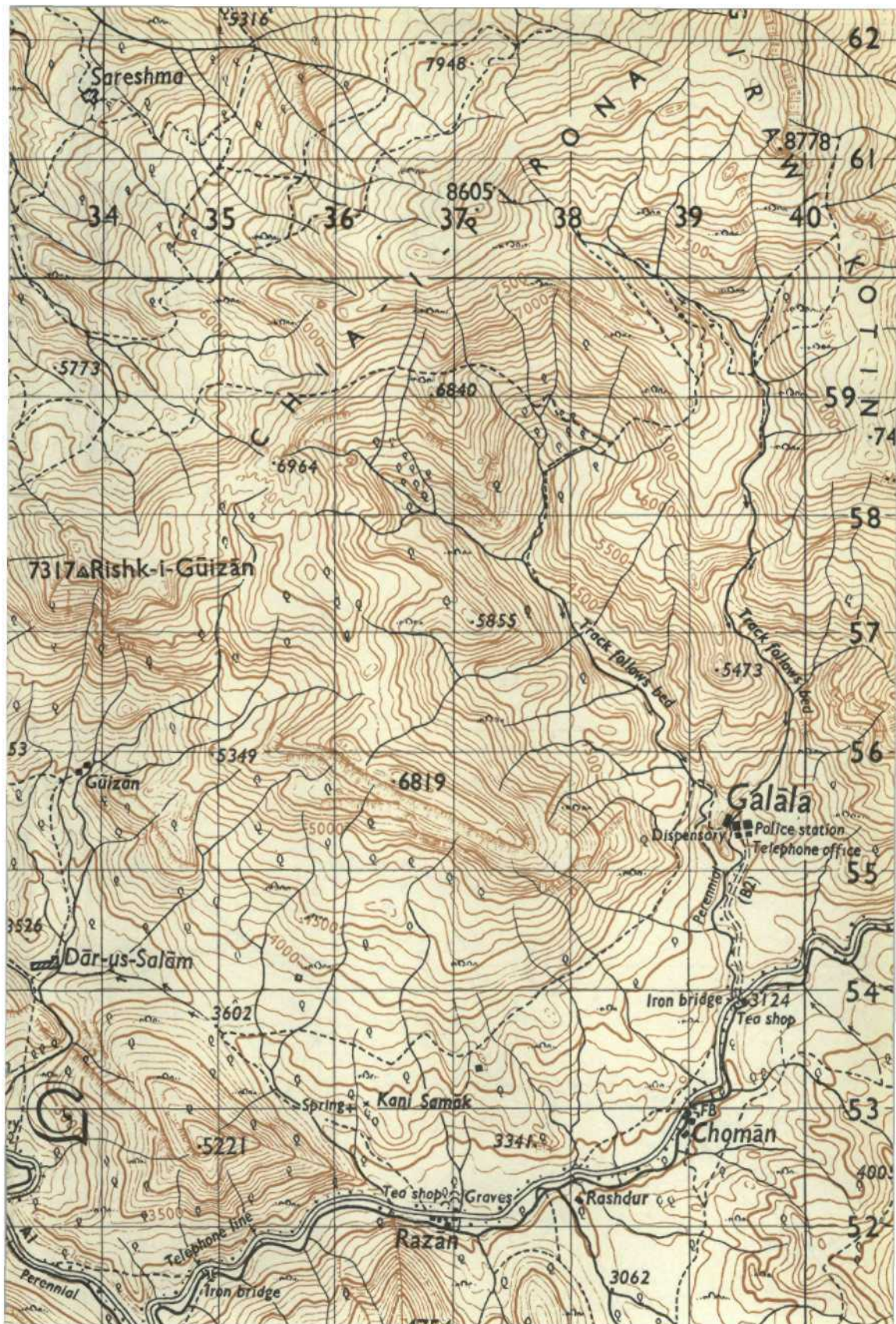


Plate 21. Iraq. 1:50,000. (Ruwanduz area.)

Sheet 3. "Galala."

Compiled from air photographs, and verified on ground by No. 4 Indian
Fd Svy Coy I.E. (Feb. 1943).

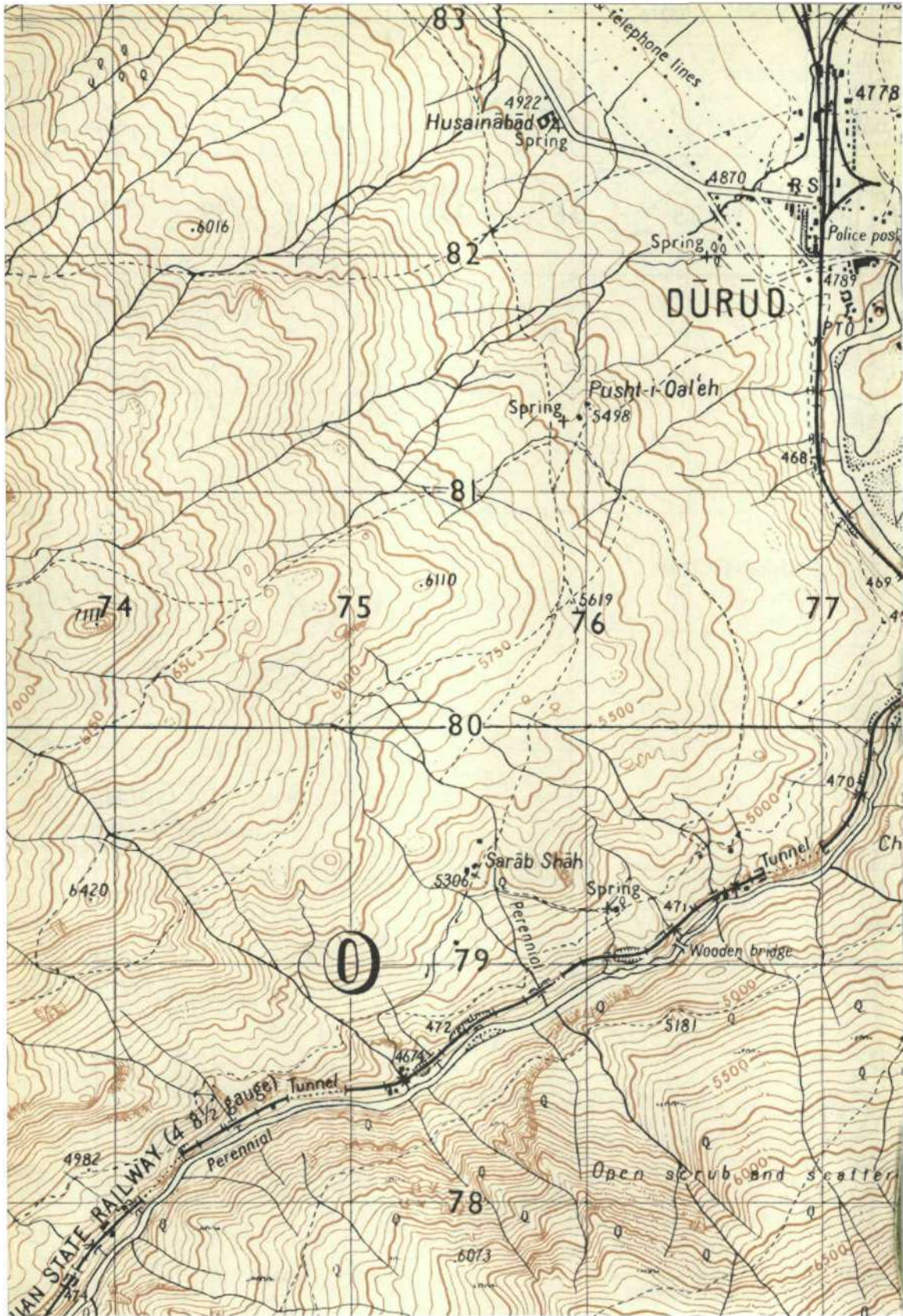


Plate 22. Iran. 1 : 25,000. (Razan area.)
Sheet 16. "Durud."

Compiled from air photographs and supplemented by ground survey.
Edition of Sept. 1942.

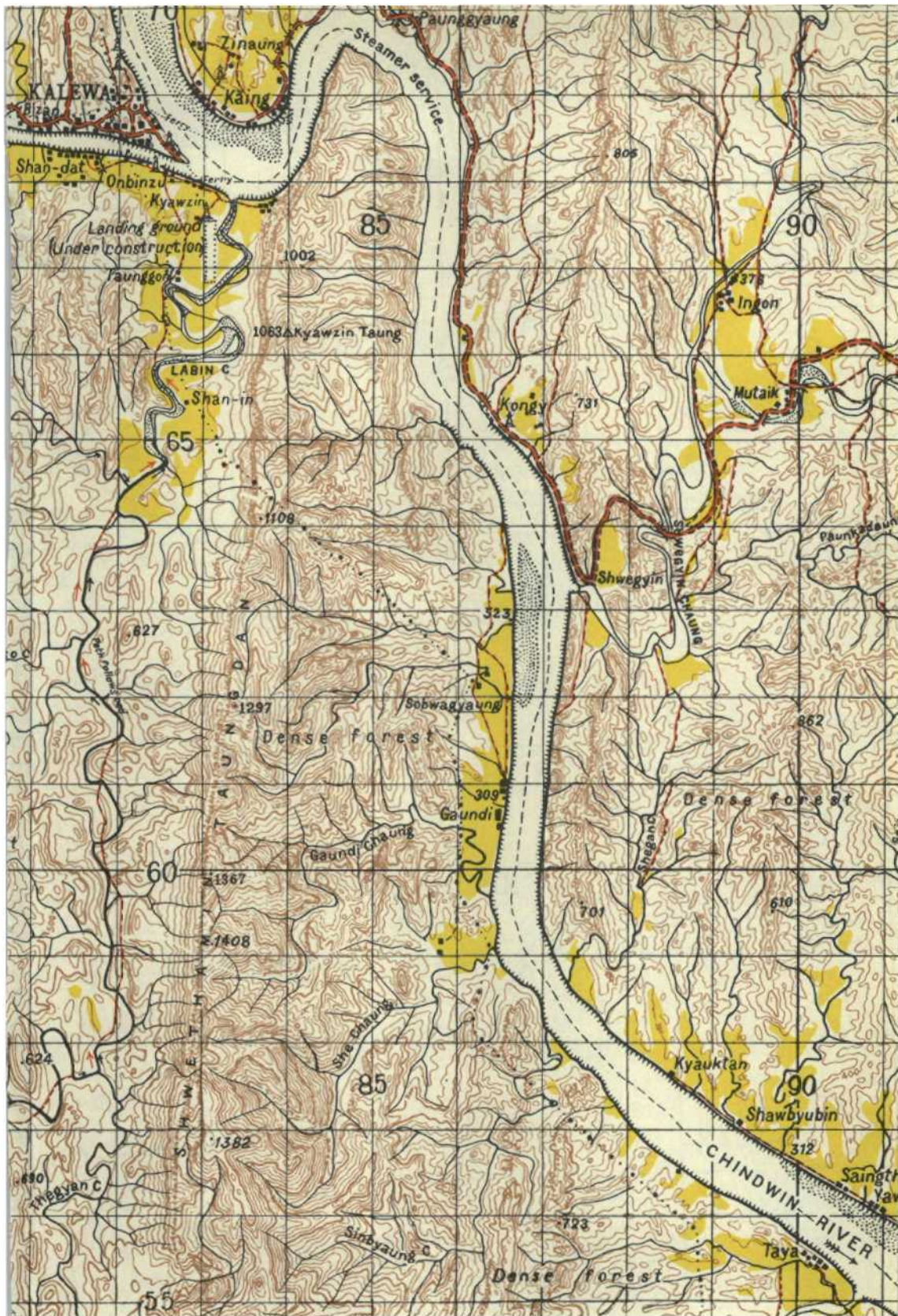


Plate 23. Burma. 1 inch to 1 mile.
Sheet 84 I/8. 2nd Edition 1943.

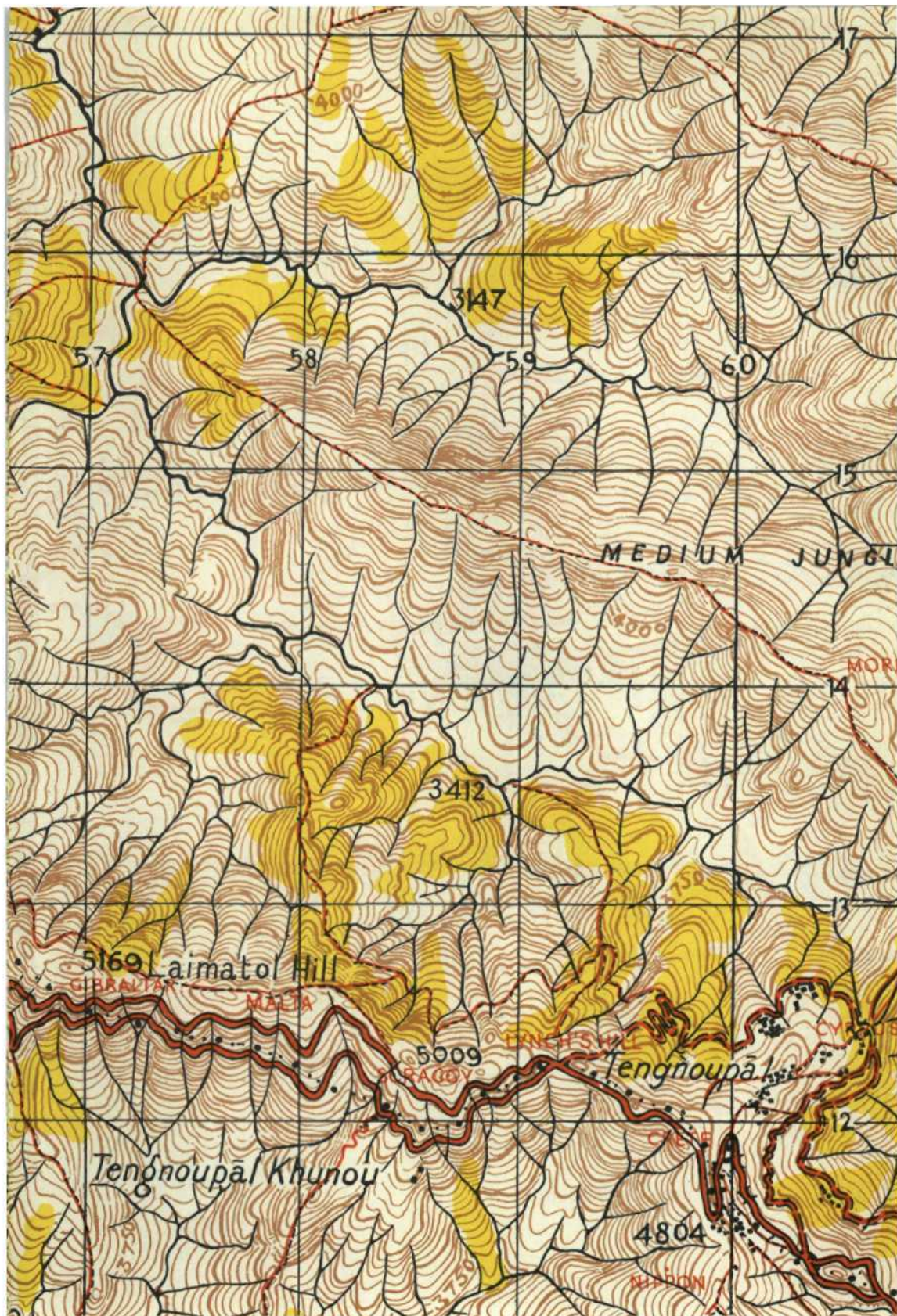


Plate 25. India. 1 : 25,000. (Palel area.)

Sheet 4.

Surveyed from air photographs, and contours taken from Palel-Tamu Road ground and air survey 1944.



1 2 730.000 ME.

Plate 28. GSGS 4230. Italy. 1 : 250,000.

Sheet 35. "Napoli."

Copied from Carta Aeronautica d' Italia 1 : 250,000. 2nd (Revised) Edition 1943.

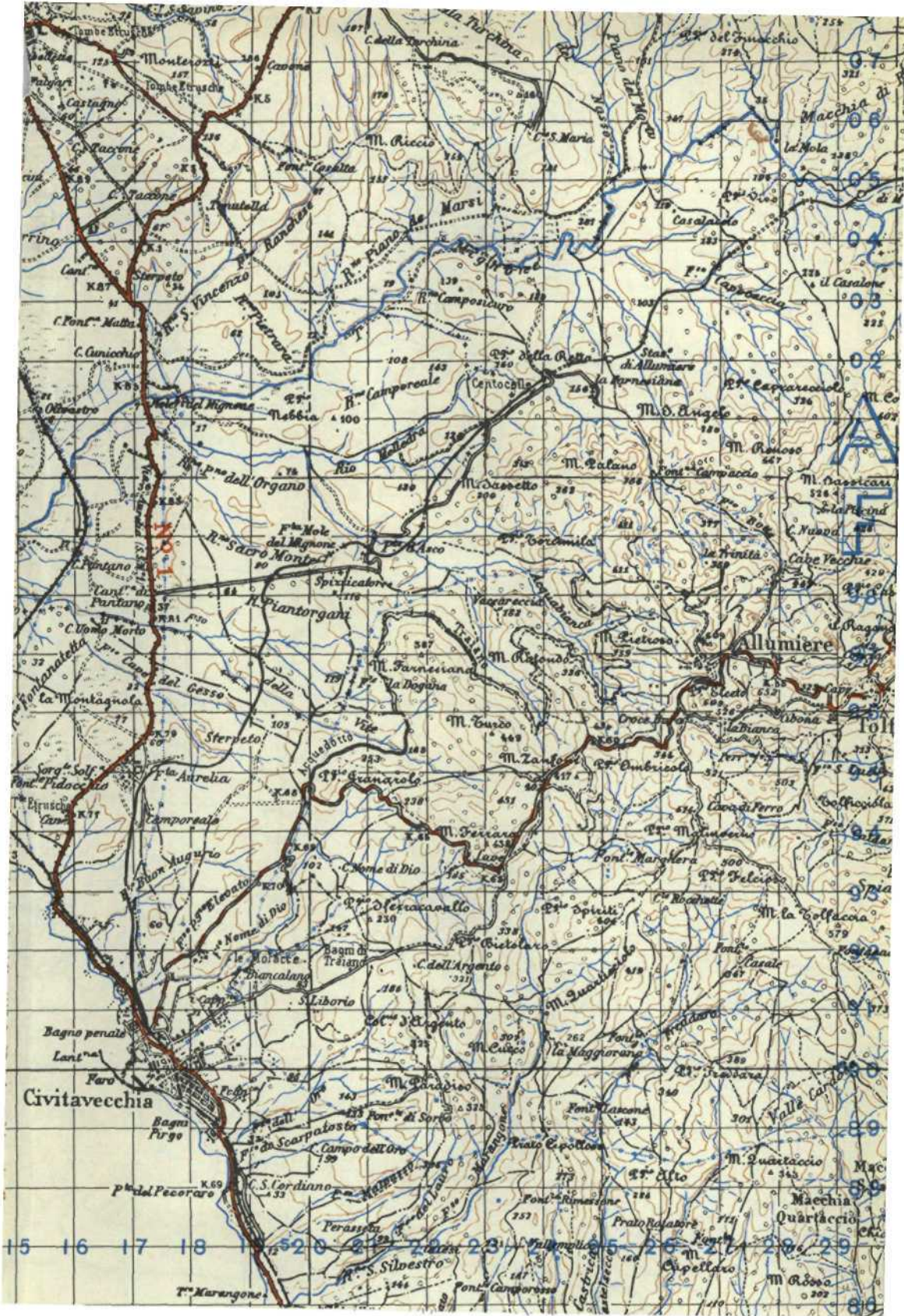


Plate 29. GSGS 4164. Italy. 1:100,000.

Sheet 142. "Civitavecchia."

Copied from the Italian Carta Topografica 1:100,000 (1936.)

2nd Edition (including partial communications revision) 1943.



Plate 32. GSGS 4228. Sicily. 1 : 25,000.

Sheet 262-I.S.W. and I S.E.

Enlarged from Italian 1 : 50,000 Map. 1st Edition 1943.

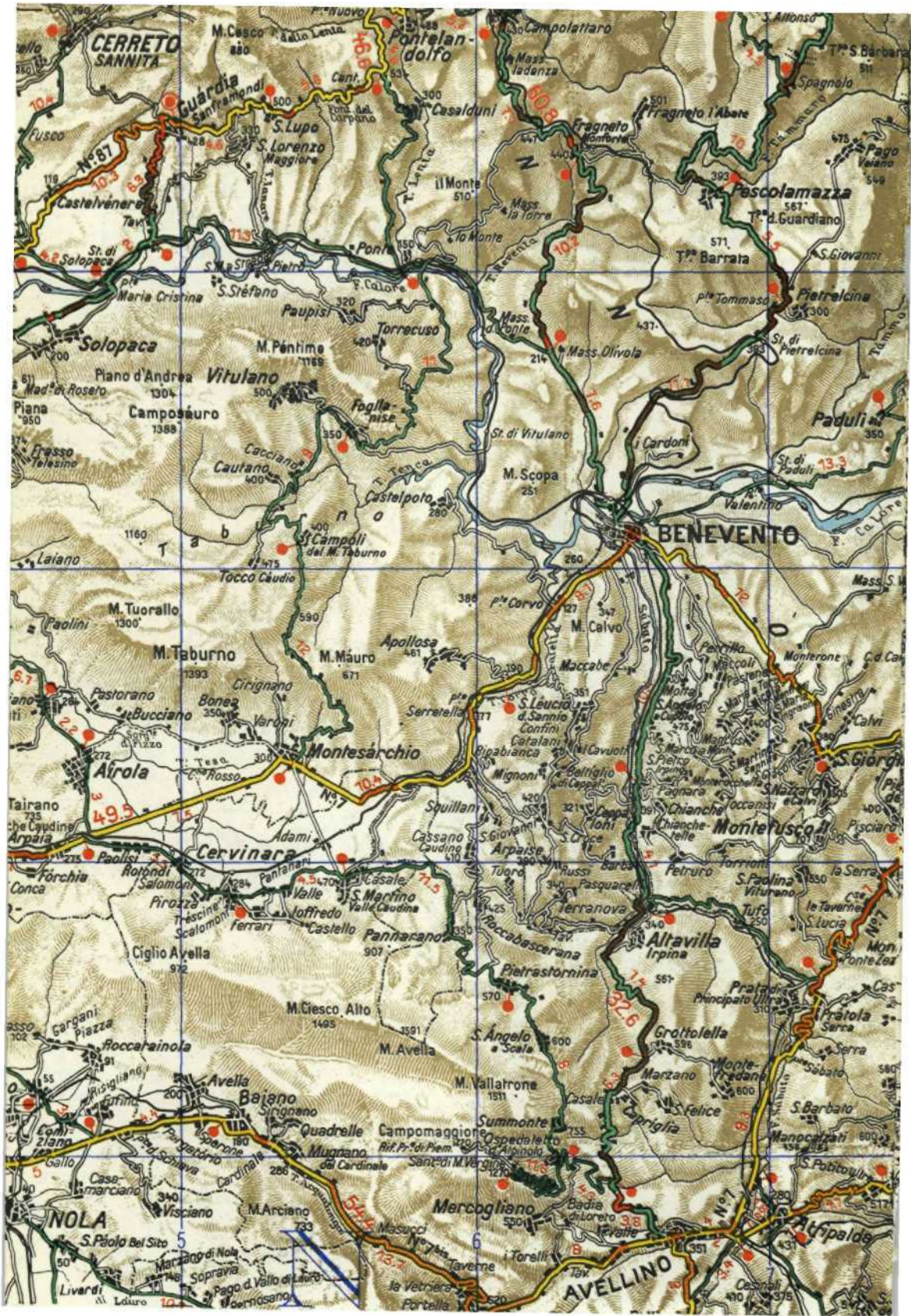


Plate 34. Italy. 1 : 200,000 Road Map.

Sheet 19.

Published by Army Map Service, Washington (1943) on the basis of the Italian Touring Club map.



Plate 35. GSGS 4164. Italy. 1 : 100,000.
 Sheets 245 & 246 with "Going" overprint, based on air photo information.
 Fair ■ Bad ■ Impassable. ■



Plate 36. GSGS 4040. N.E. France and Belgium. 1 : 50,000.
 Sheet 53. "Courtrai" (Edition of 1943).
 (For comparison with earlier edition see Plate 3.)

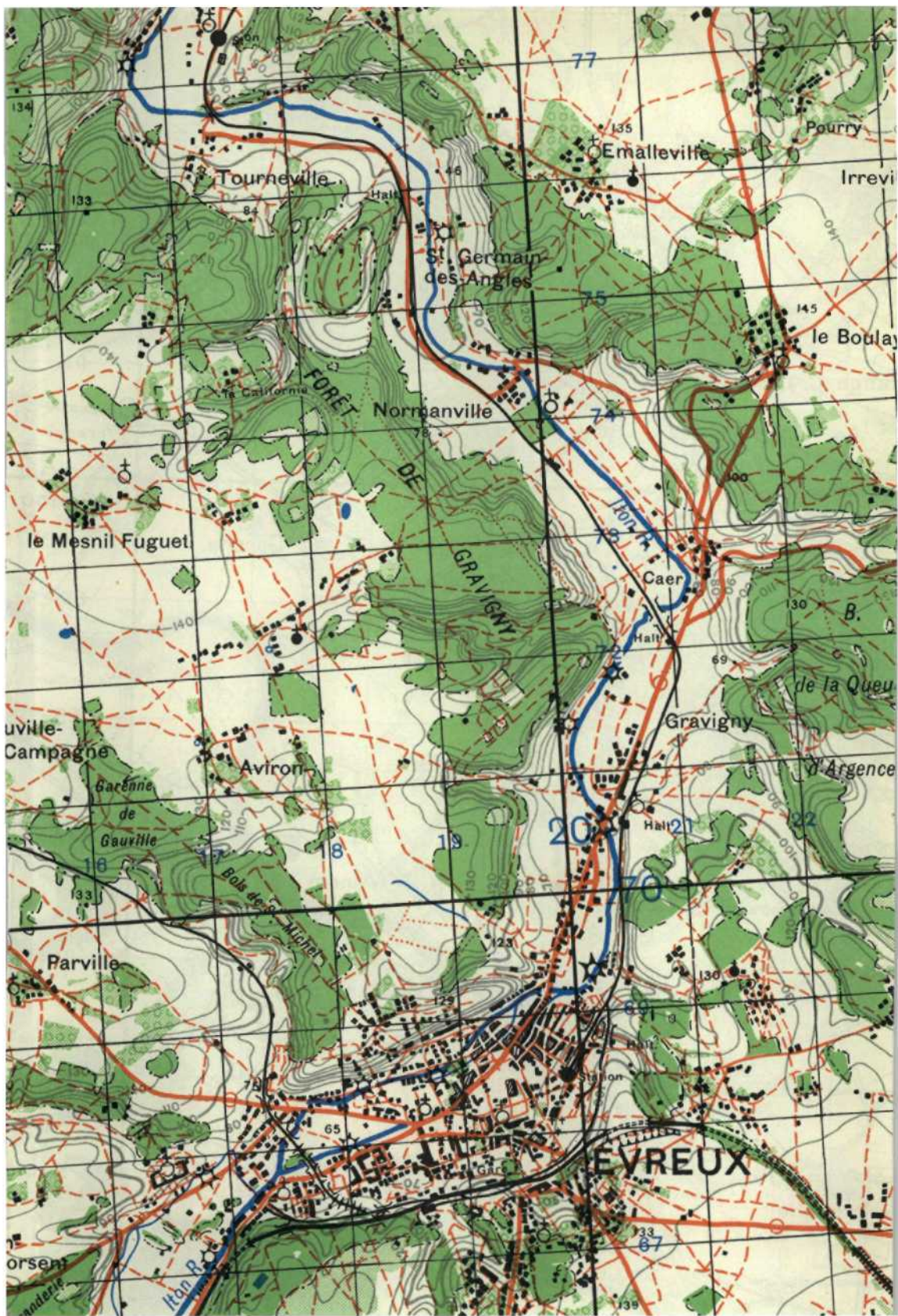


Plate 37. GSGS 4250. N. France. 1 : 50,000.

Sheet 9 F/3 "Evreux." Edition of 1943.

(For comparison with earlier 1/50,000 edition covering this area see Plate 4.)

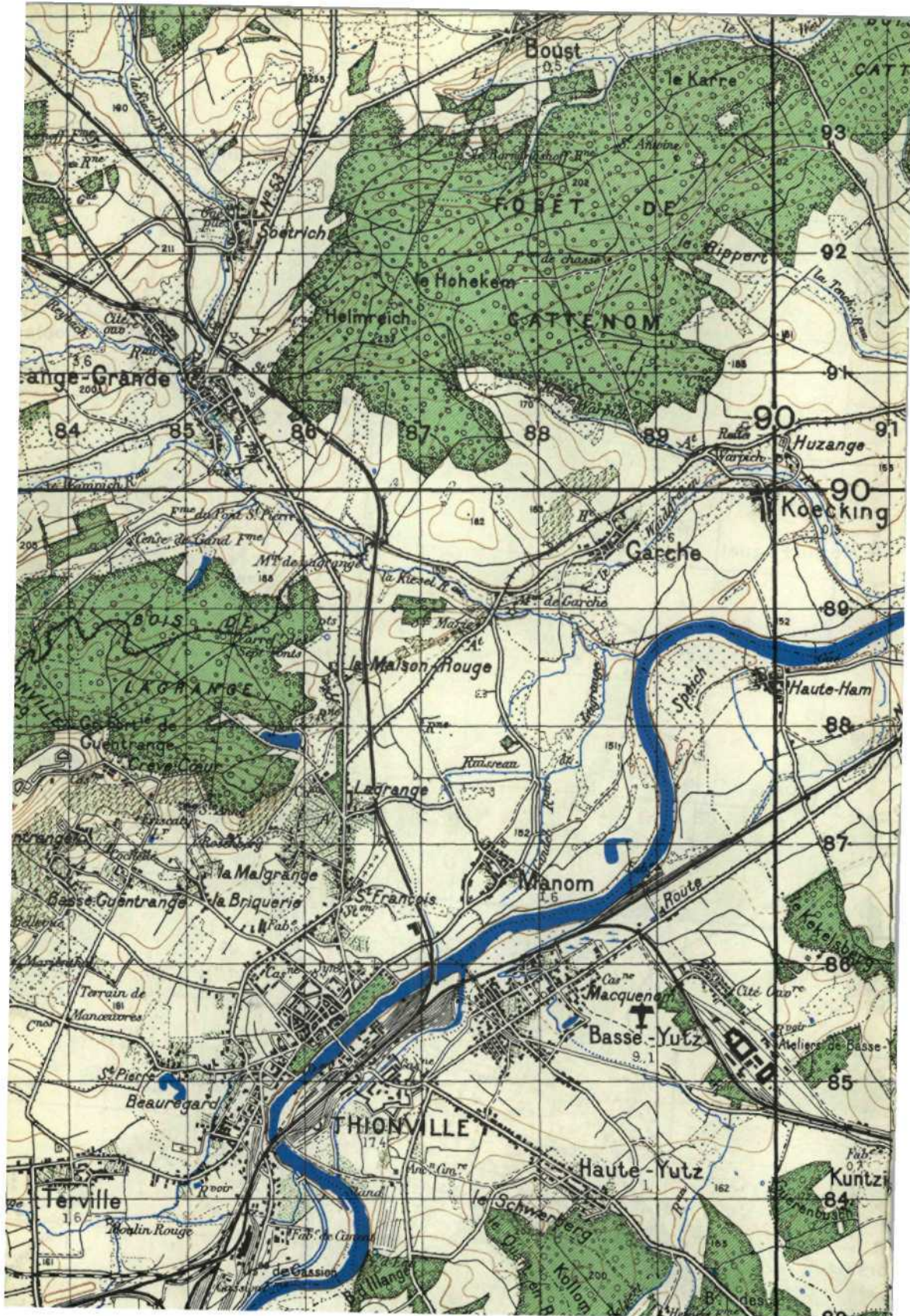


Plate 38. GSGS 4471. E. France. 1 : 50,000.
 Sheet XXXIV-11. "Thionville." Edition of 1944.
 (Reproduced from French map dated 1939.)



Plate 39. GSGS 4336. N.E. France and Belgium. 1 : 100,000.
Sheet 18. "Beauvais." Edition of 1943.

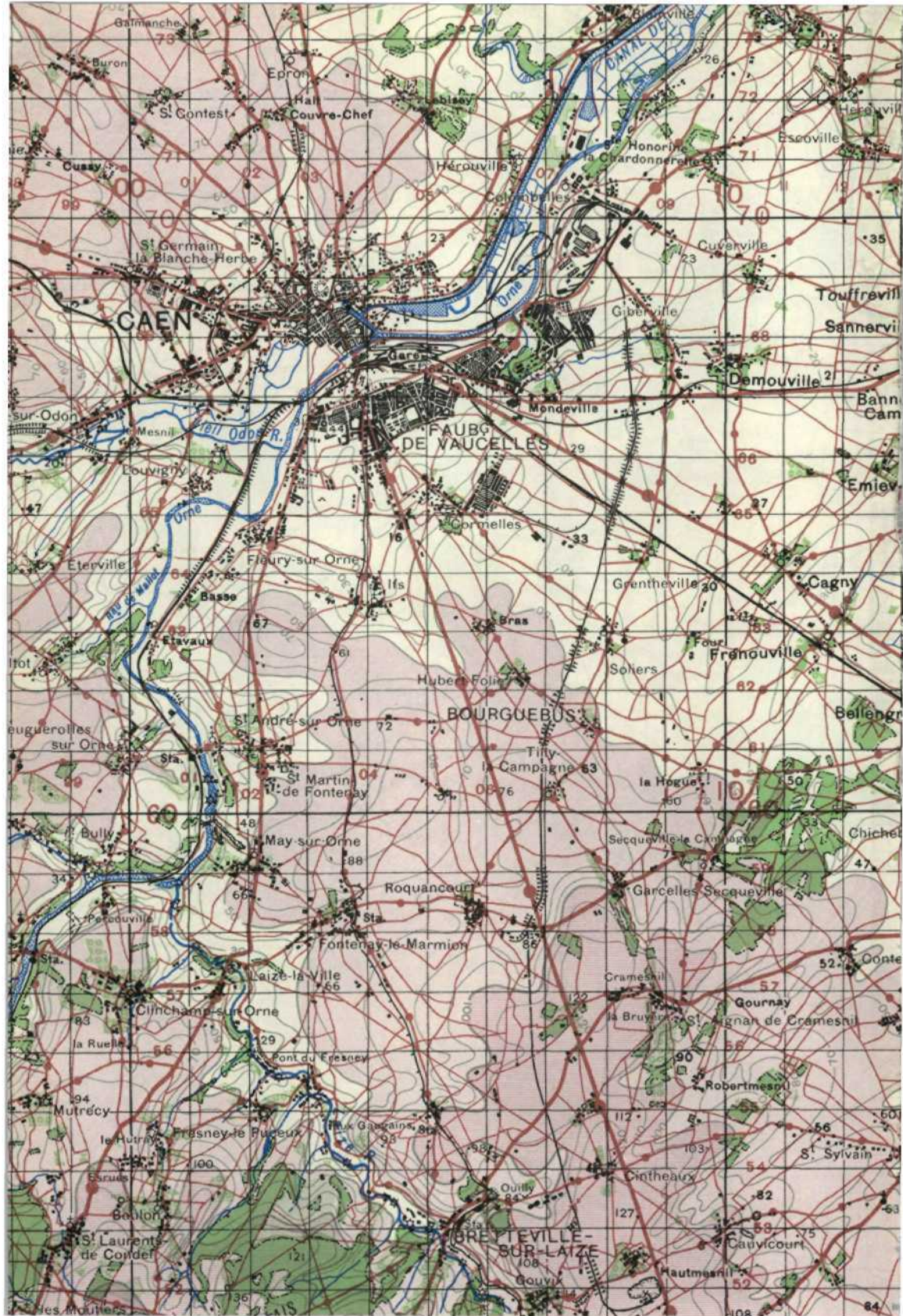


Plate 40. GSGS 4249. France. 1:100,000.
Sheet 7F. "Caen-Falaise" (Edition of 1943).



Plate 41. GSGS 4042. North West Europe. 1 : 250,000.
 Sheet 7. "Rouen-Paris." Army/Air Edition 1943.
 (For comparison with earlier edition see Plate 1.)

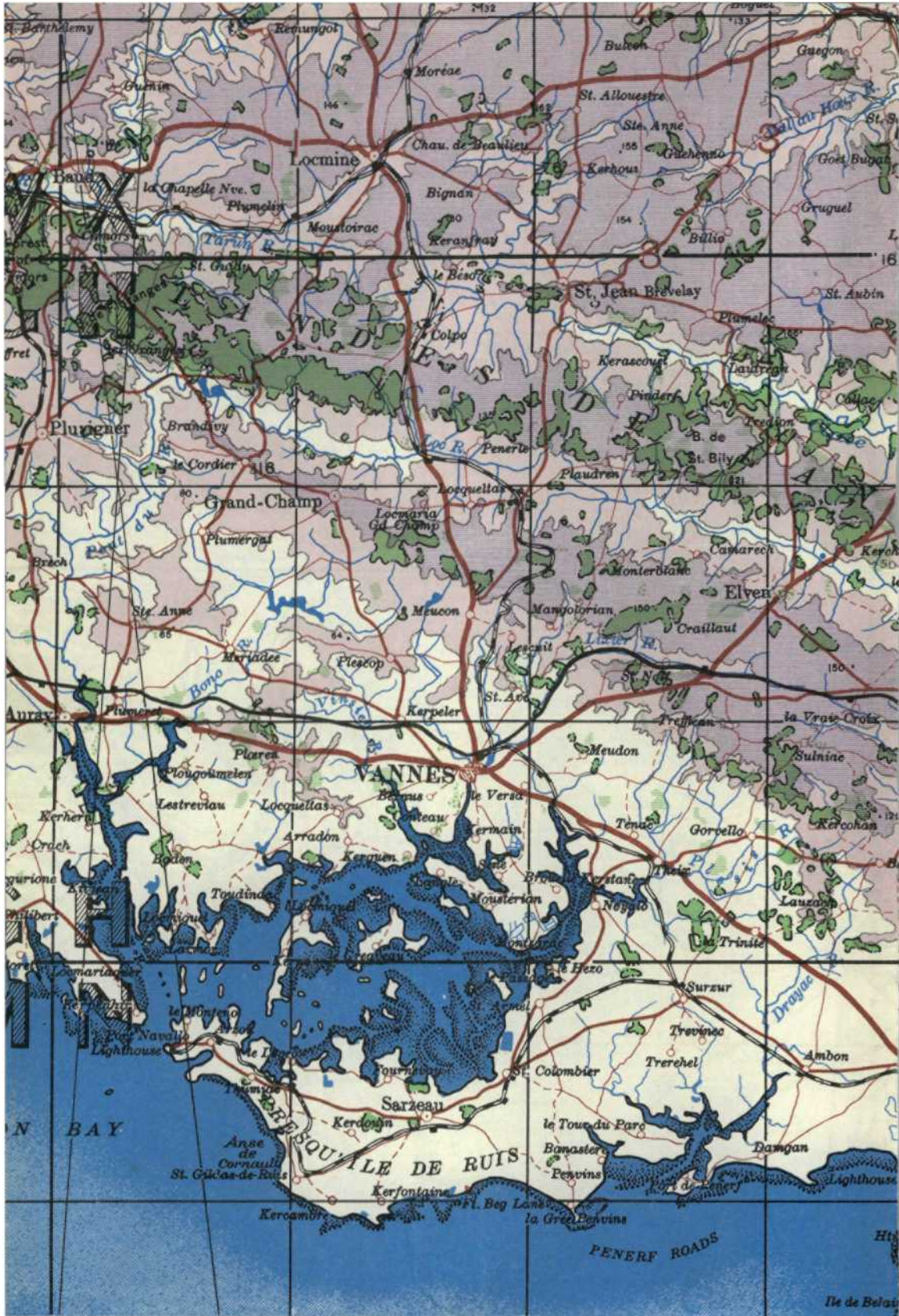


Plate 42. GSGS 2738, France. 1 : 250,000.
 Sheet 13, "Vannes" (Army/Air Edition of 1943.)
 (For comparison with earlier edition see Plate 2.)

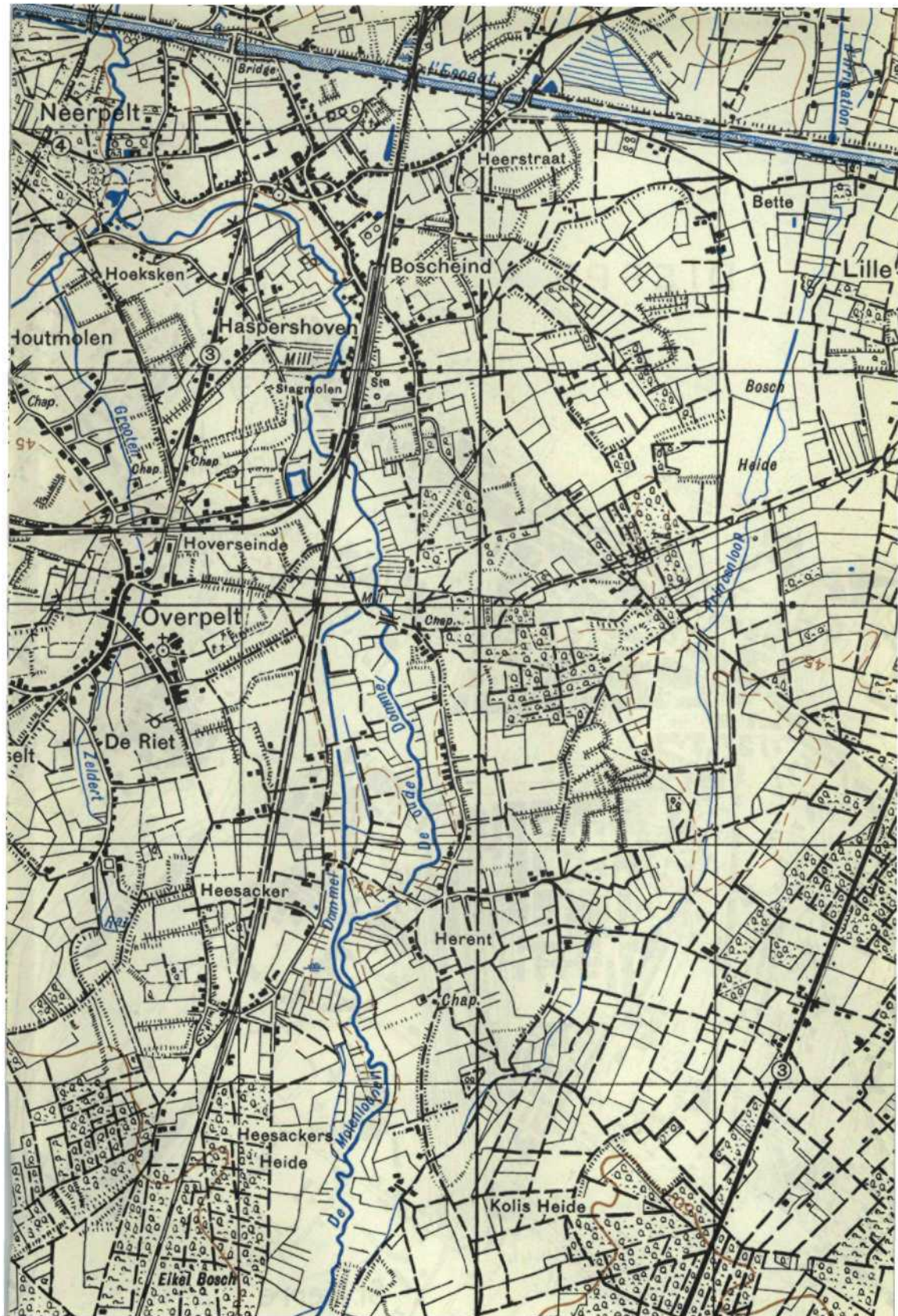


Plate 43. GSGS 4041. N.E. France & Belgium. 1 : 25,000.
 Sheet 36 N.W. "Bree" (Edition of 1944).
 (For comparison with earlier edition see Plate 5.)

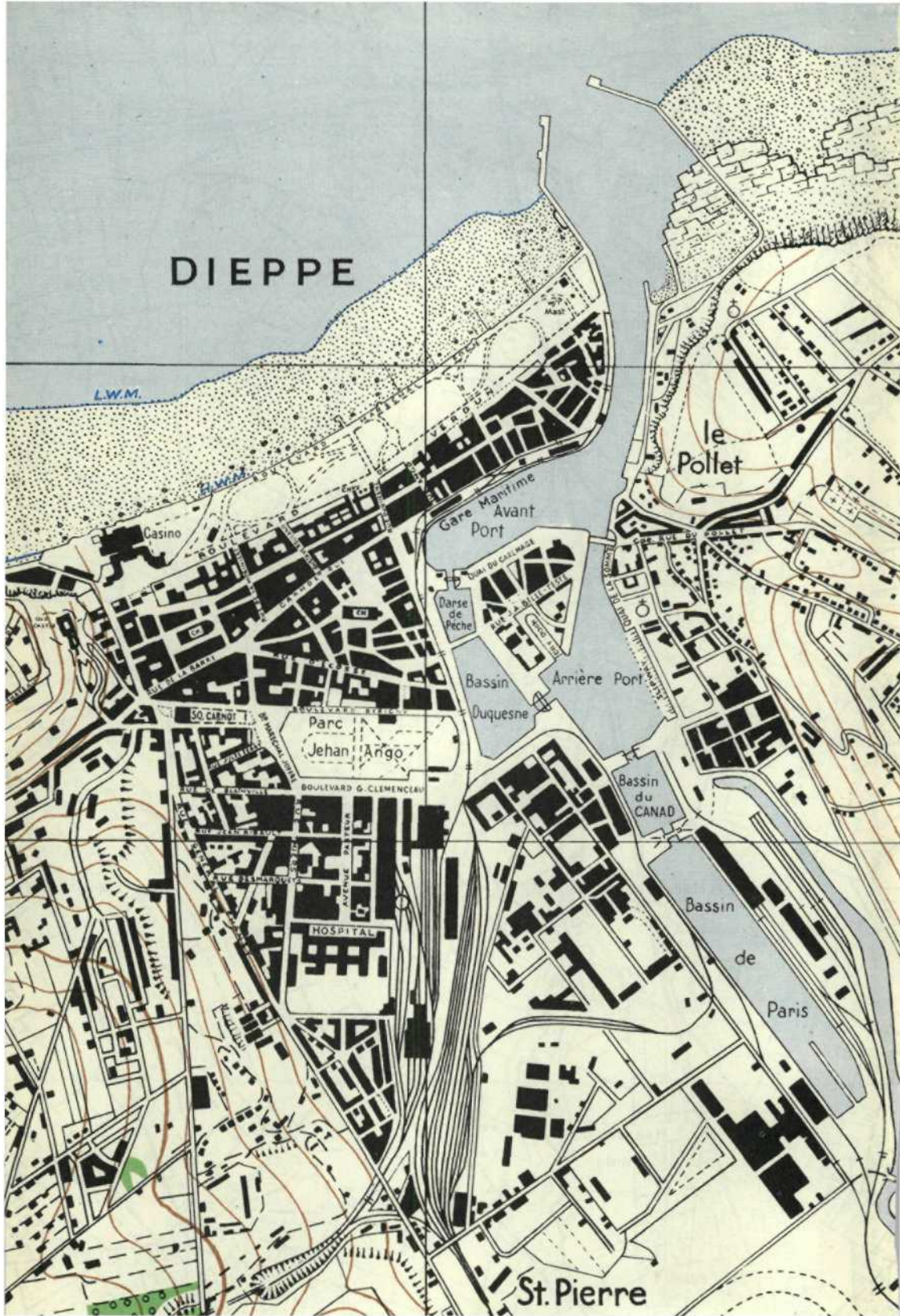


Plate 44. 1 : 12,500 special map "Dieppe" (Edition of 1942.)
Compiled and published by GHQ, Home Forces, from air photographs.

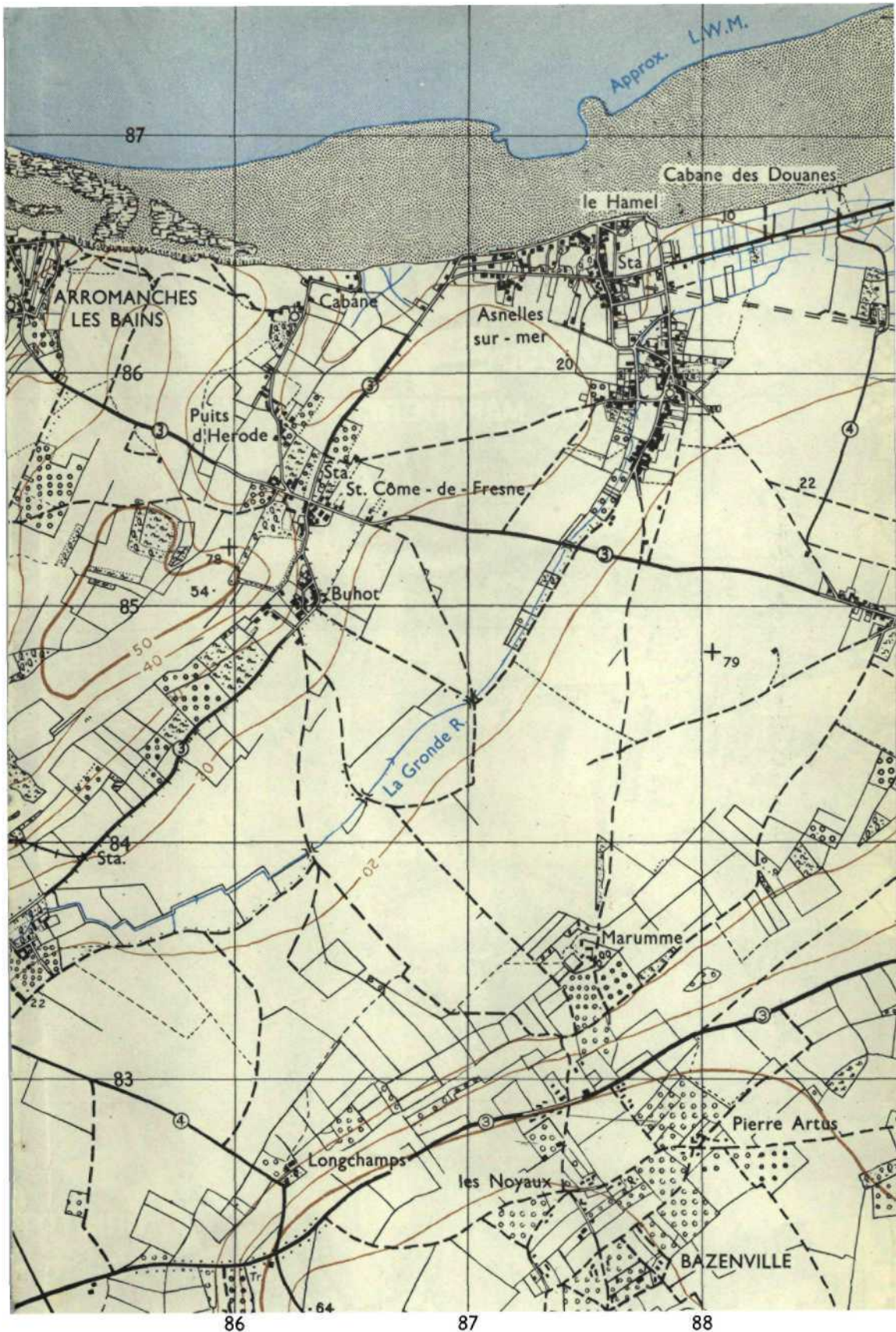


Plate 45. GSGS 4347. N. France. 1 : 25,000 ("Benson" Series).
 Sheet 37/18.S.E. "Creully." Edition of 1944.
 Compiled from air photographs by British and U.S. Field Survey Units.



Plate 46. 1 : 25,000 Photo-Map. N. France.
Sheet 1-23. (Cherbourg Series) Edition of 1944.
Compiled from air photographs by U.S. Topographic Units.

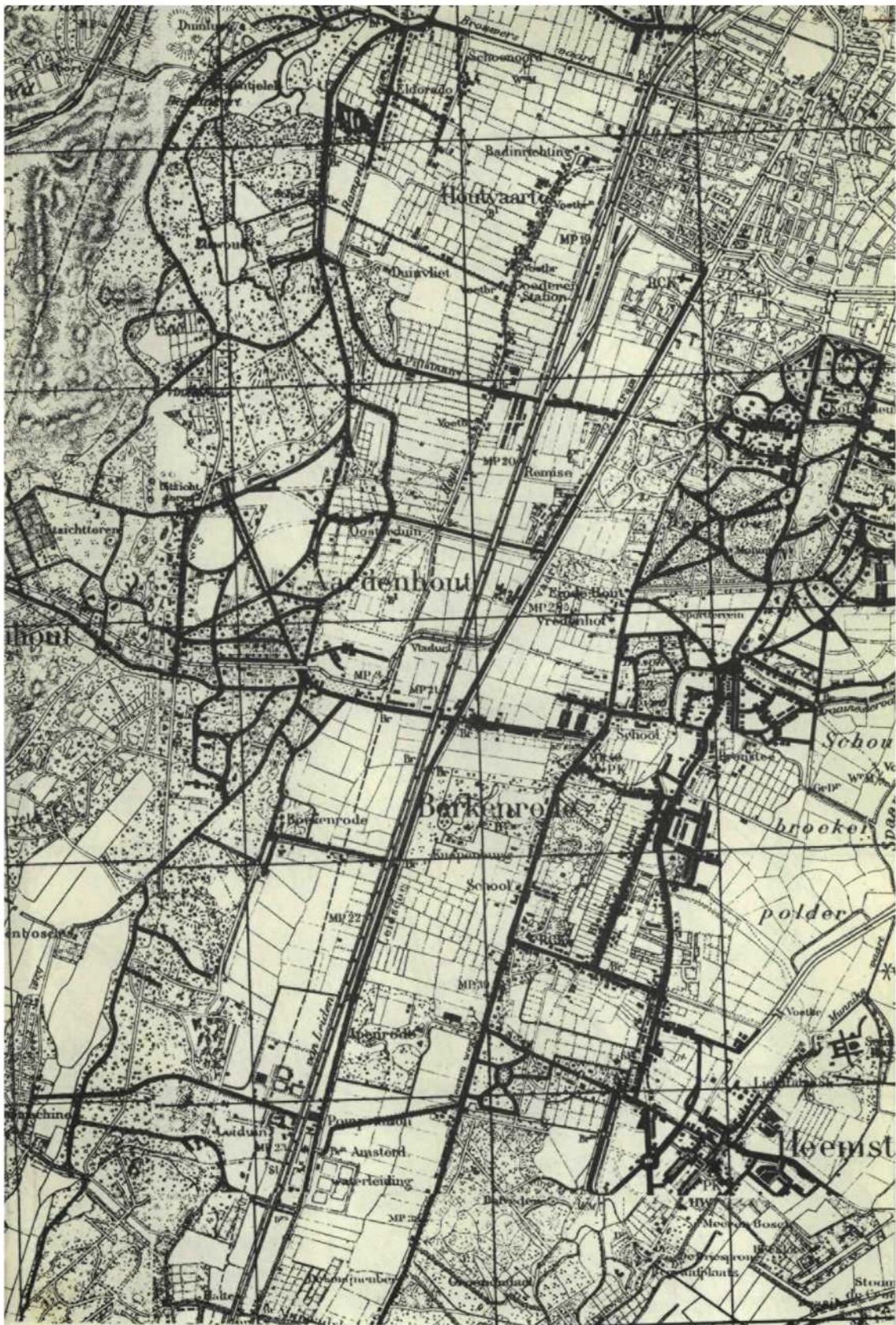


Plate 47. GSGS 4096. Holland. 1:25,000.
 Sheet B. 345 (Edition of 1941).
 (For comparison with later edition see Plate 48.)

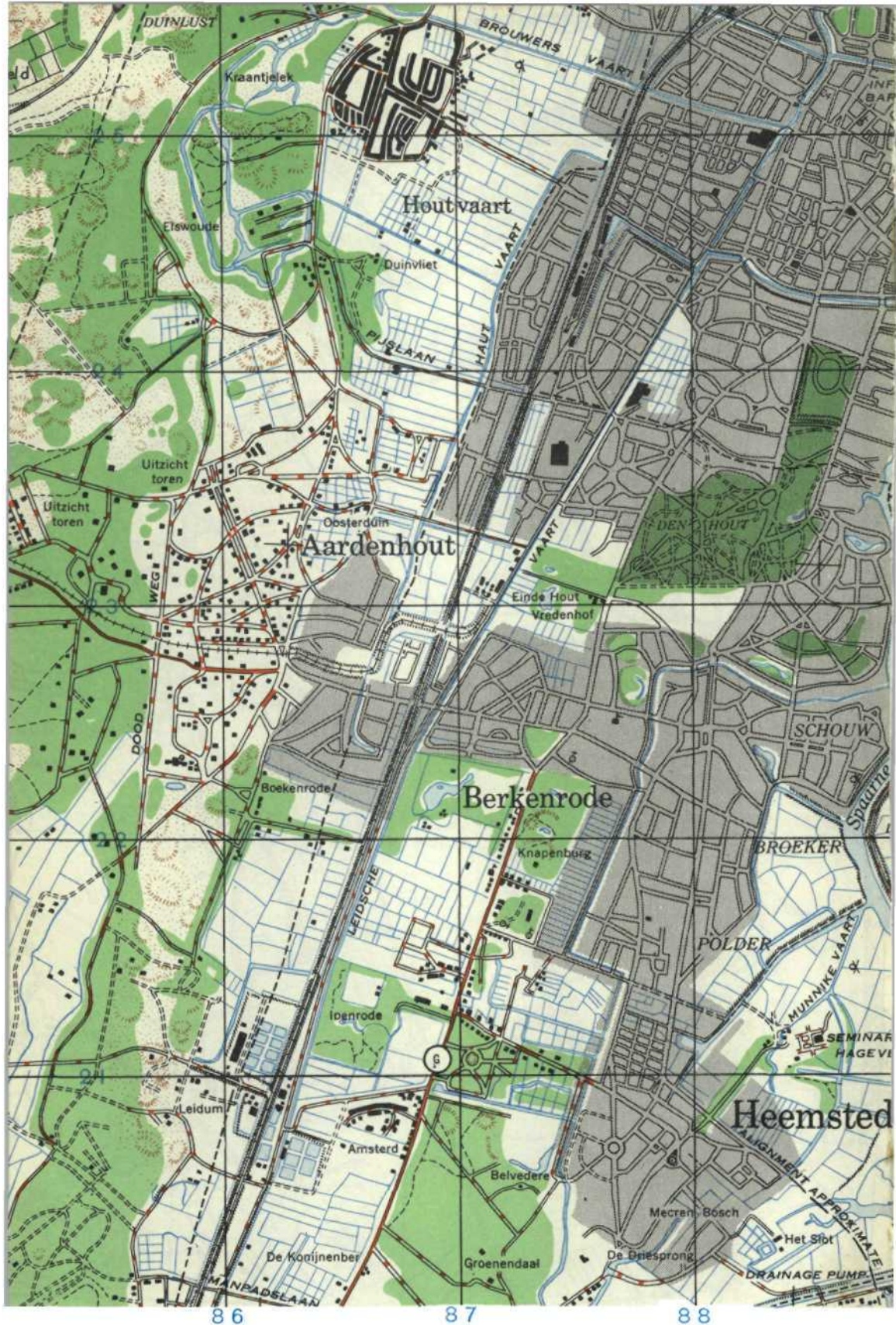
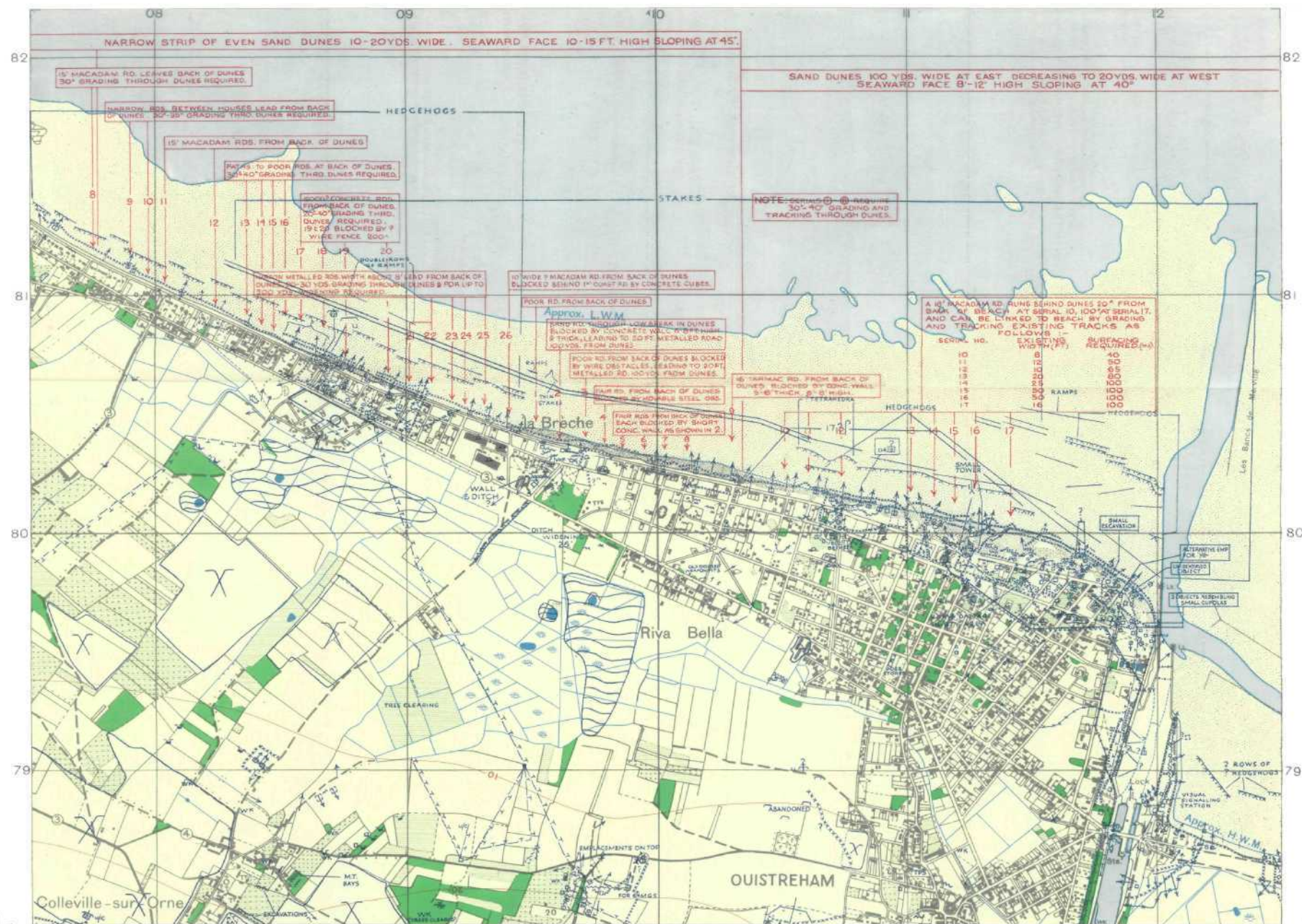


Plate 48. GSGS 4427. Holland. 1:25,000.

Sheet 353. "Haarlem."

Prepared by Army Map Service, Washington, 1943.

(For comparison with earlier edition see Plate 47.)



Geographical Section General Staff (Misc.) 435/6

Plate 49. GSGS 4490. France. 1/12.500.
Sheet "Quistrehem." Second Edition of May 1944, showing enemy defences
and beach information on a section of the invasion coast shortly before
D-Day.
Compiled from air photographs on a control provided by the French
Triangulation.

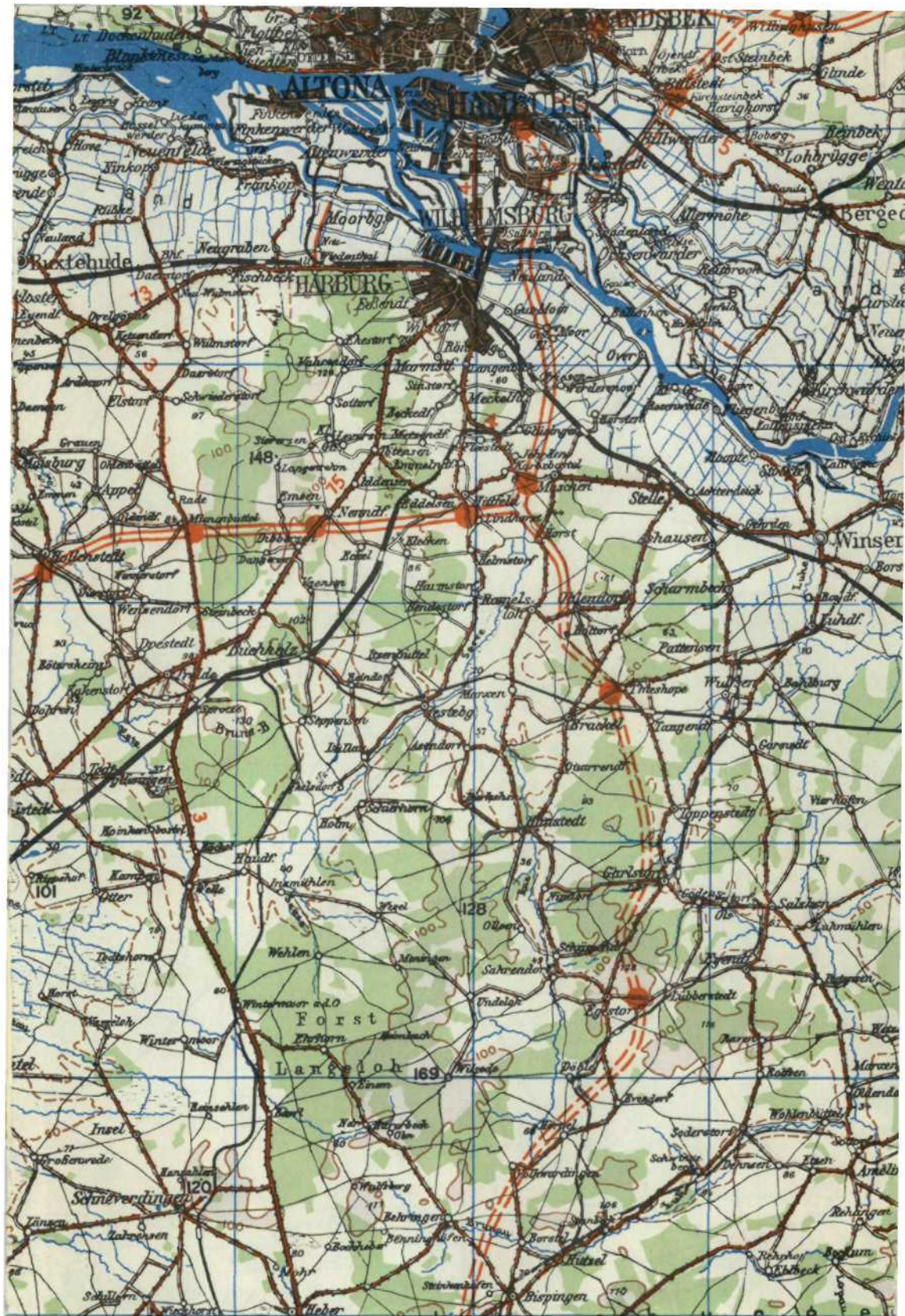


Plate 50. GSGS 4346. Germany. 1:250,000.
Sheet L.54. "Hamburg" (Army/Air Edition of 1943).

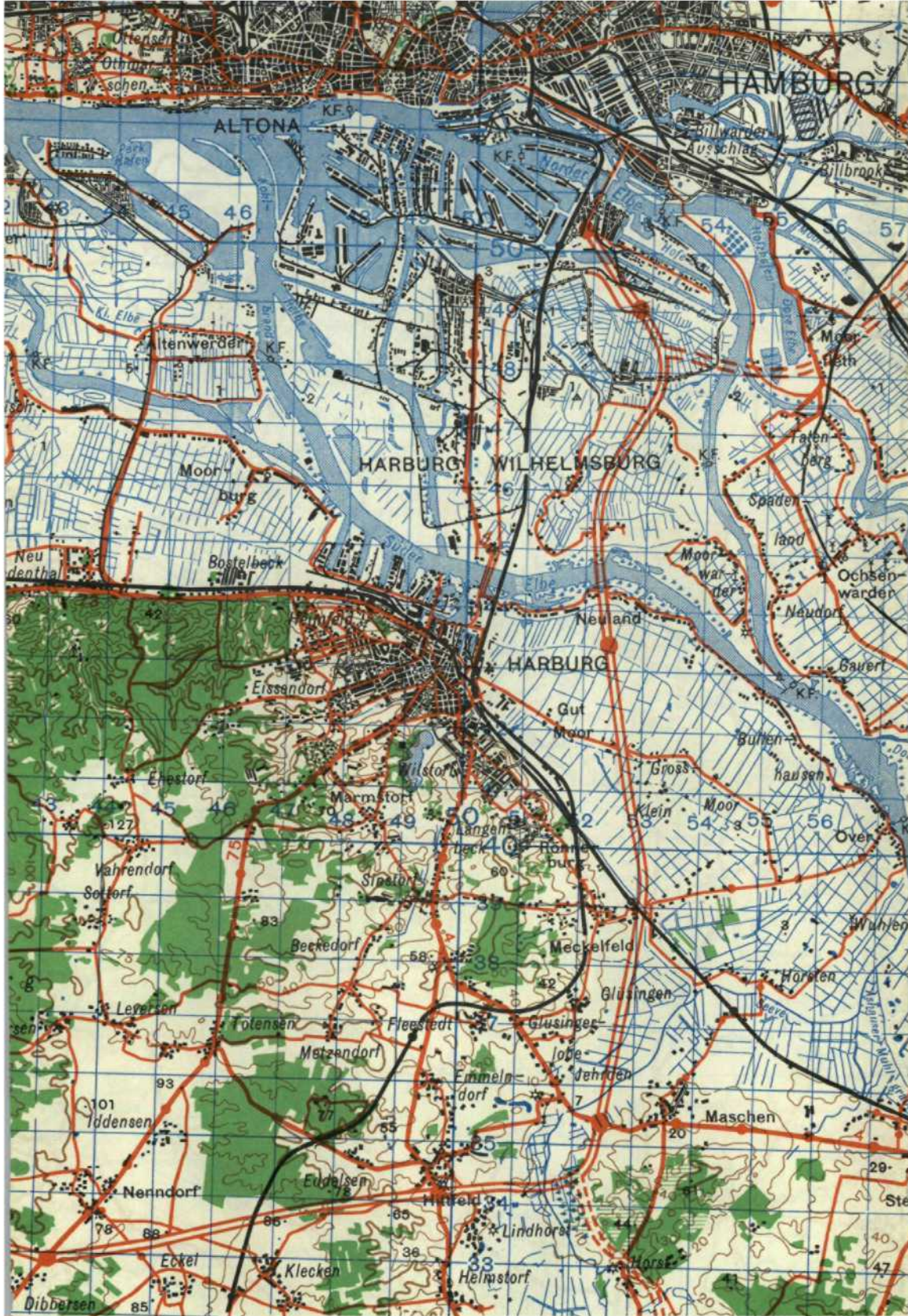


Plate 51. GSGS 4416. Germany. 1:100,000.
Sheet L.4 "Hamburg" (Edition of 1943).

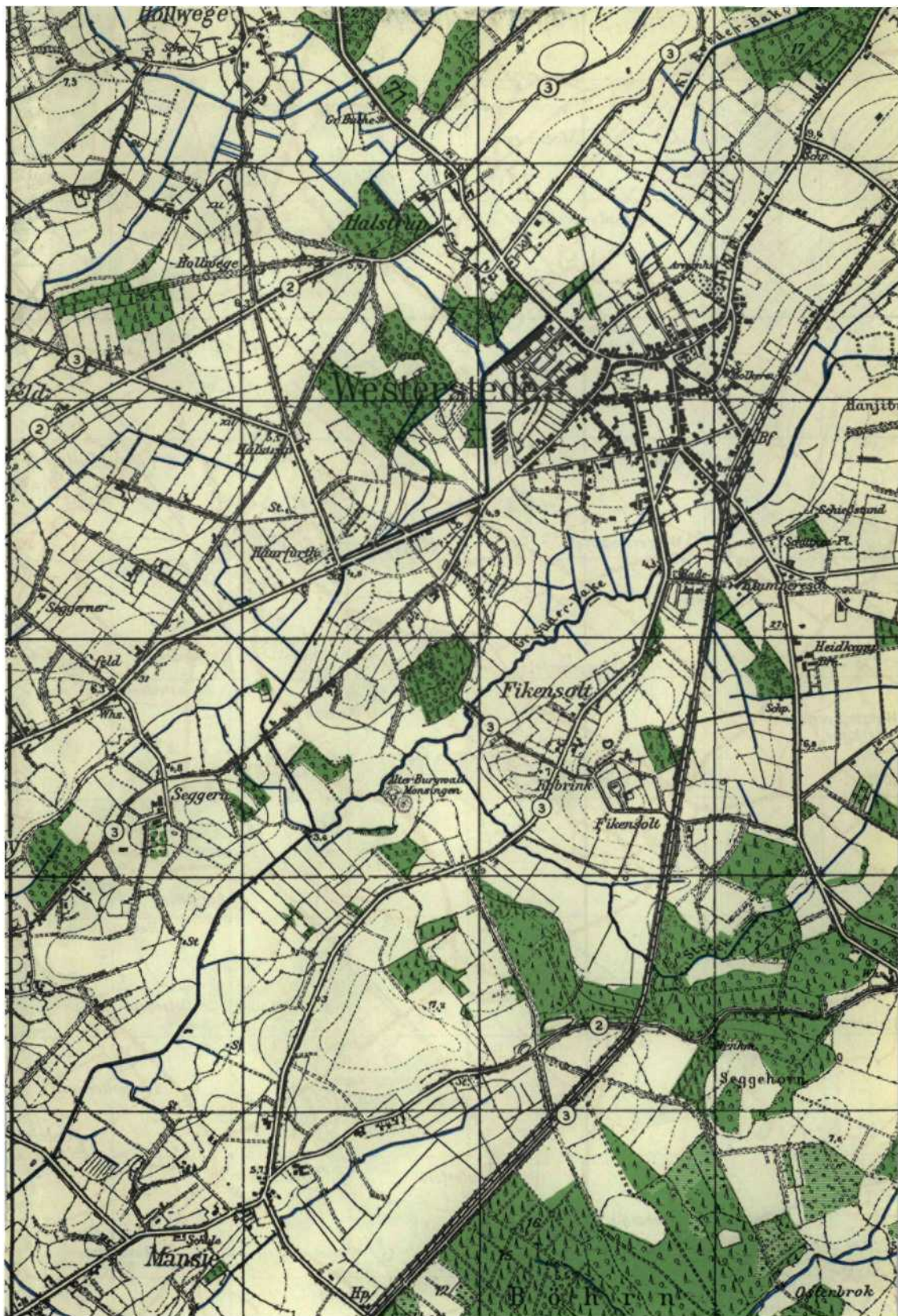


Plate 52. GSGS 4414. Germany. 1 : 25,000.
Sheet 2713. "Westerstede" (Edition of 1944).

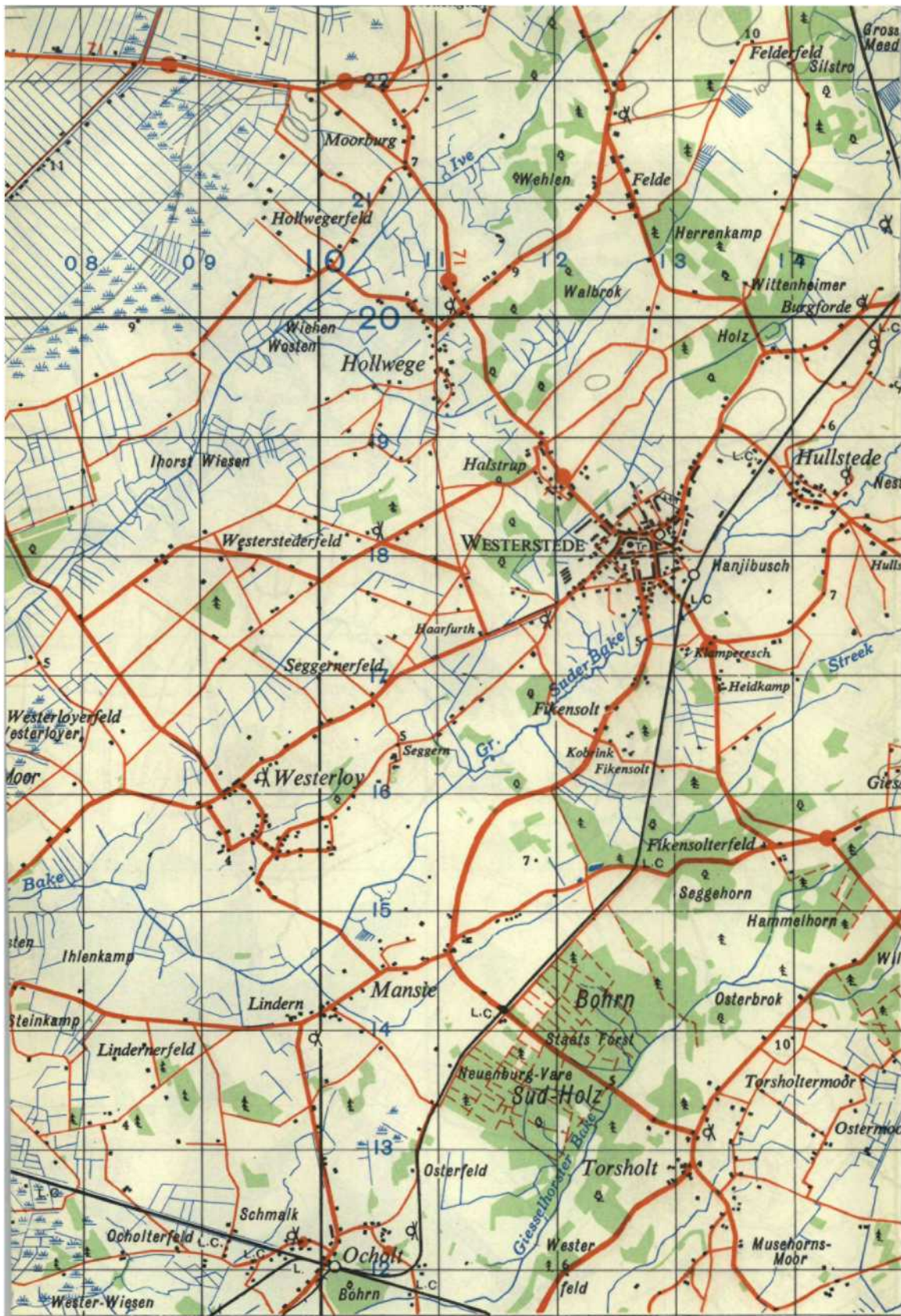


Plate 53. GSGS 4507. Germany. 1:50,000.
Sheet 91. "Westerstede" (Edition of 1945).

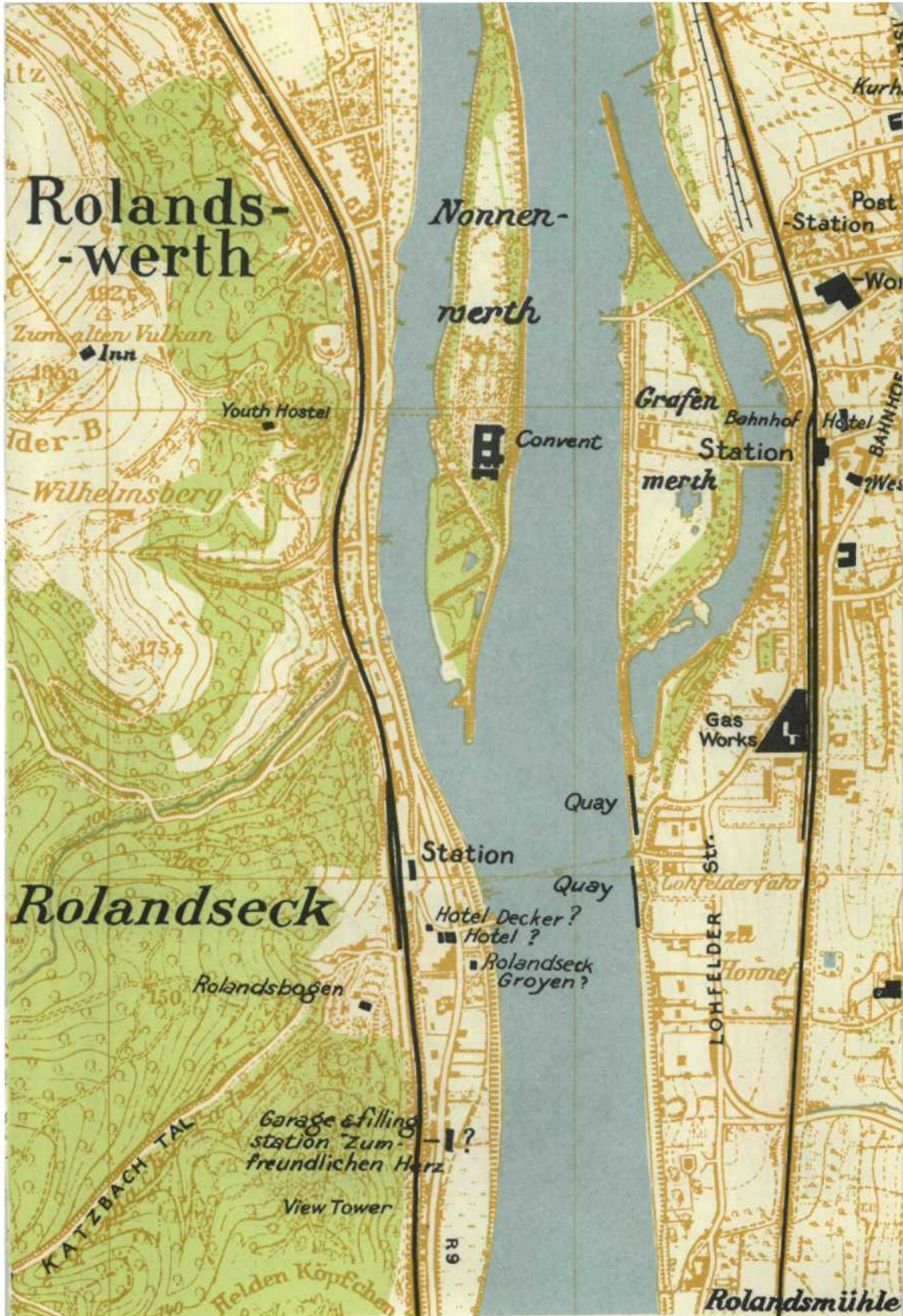


Plate 54. GSGS 4517. (R. Rhine.) 1 : 12,500.
Compiled from enlargements of sheets of GSGS 4414 1 : 25,000.

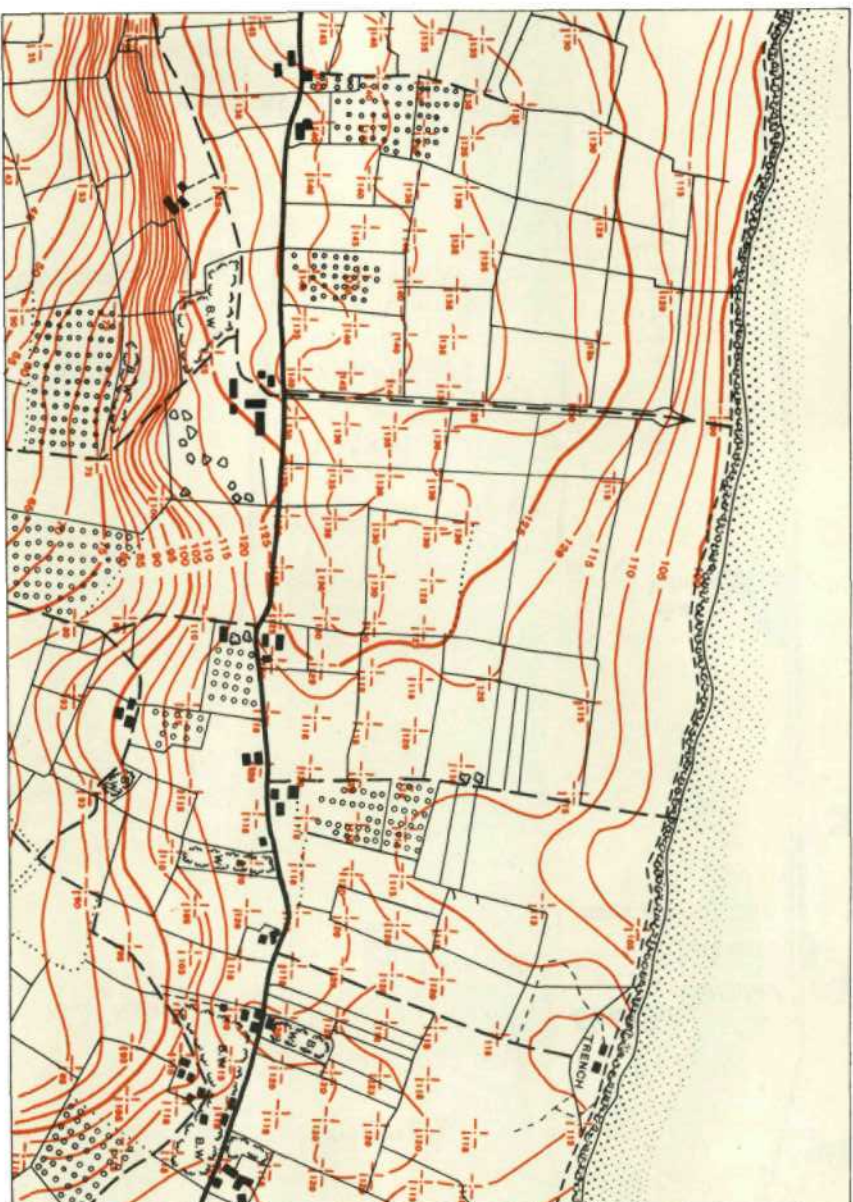


Plate 55. Airfield Reconnaissance Diagram 1 : 10,000.

Site located on sheet 6E/6 of GSGS 4250.

Compiled by 660 Engineer Battalion U.S. Army using Multiplex projectors.

Vertical control from British 1 : 50,000 maps of N. France. Air photo Sortie RB/60 Nos. 5001, 5002.

(This plate is at a reduced scale of 1 : 14,450 approx.).

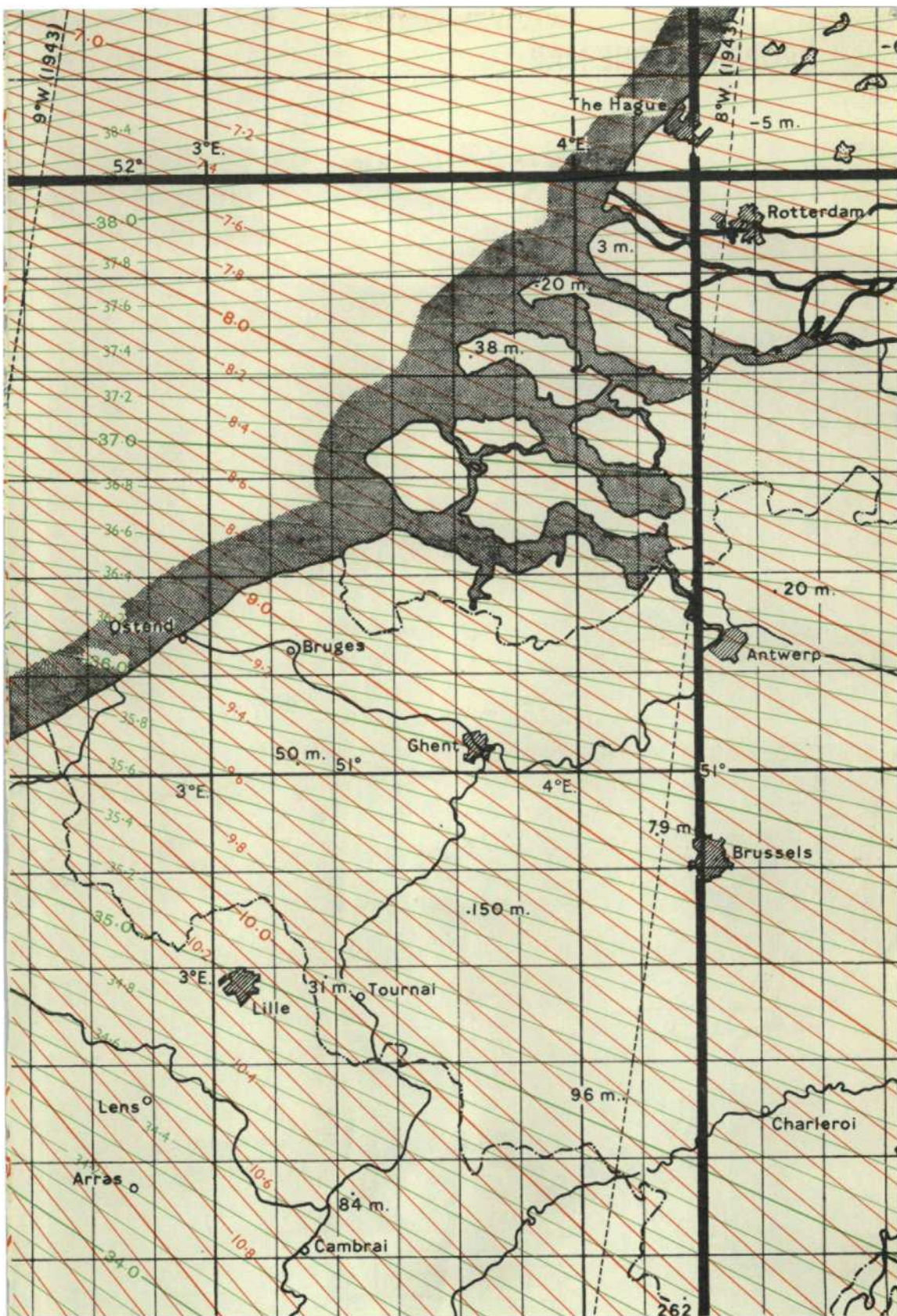


Plate 56. GSGS 4493. "Lattice" Map (Mercator Projection.)
Scale 1 : 1,000,000 at 56 N.

DROPPING ZONE MAP

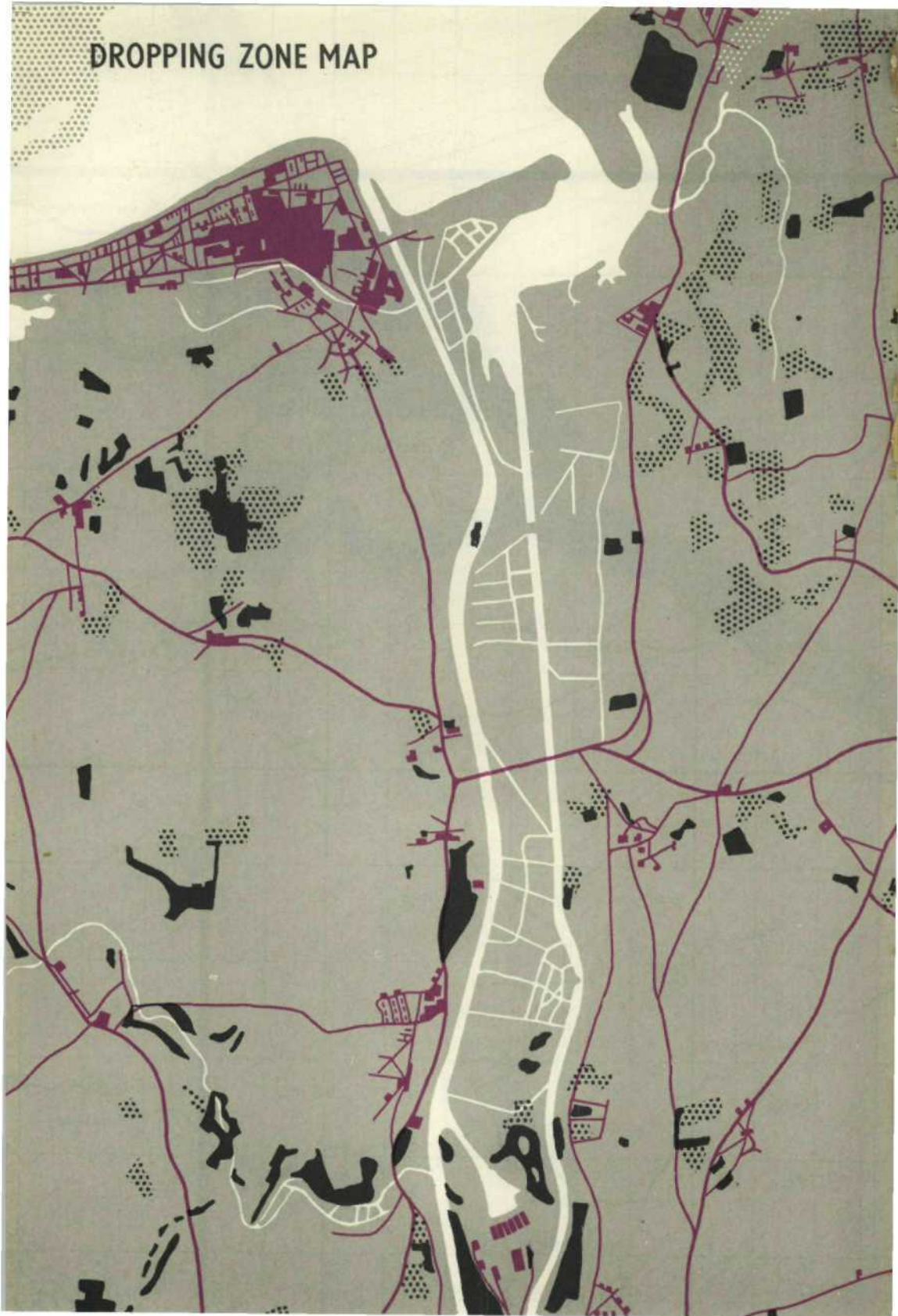


Plate 57. Dropping Zone Map. 1 : 50,000.

Used by Airborne Forces for the first Paratroop and Glider Landings in Normandy. D. Day 6th June, 1944.

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- Notes* (1) Military formations have not been page referenced. Reference to Army Groups and Armies will be found in a Table following the Index.
 (2) The Directorate of Military Survey (Geographical Section General Staff) War Office, is mentioned so frequently in the pages of this history that only those items of importance and interest have been page referenced. The same applies, in lesser degree, to the Ordnance Survey.

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