

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 kodamine 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
	Normal drawing stores <i>pro rata</i> .		
Drawing Bromide Printing	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 hatted 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 strategical 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 generalization 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.

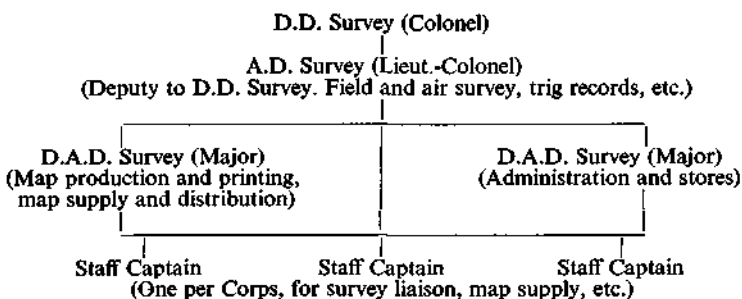
The organization of the Survey Directorate with British Second Army as shown in Diagram 14 was typical of normal standard practice. It should be understood, however, that there will often be variations in the allocation of work between the officers, dependent on their characteristics and qualifications,

* 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.

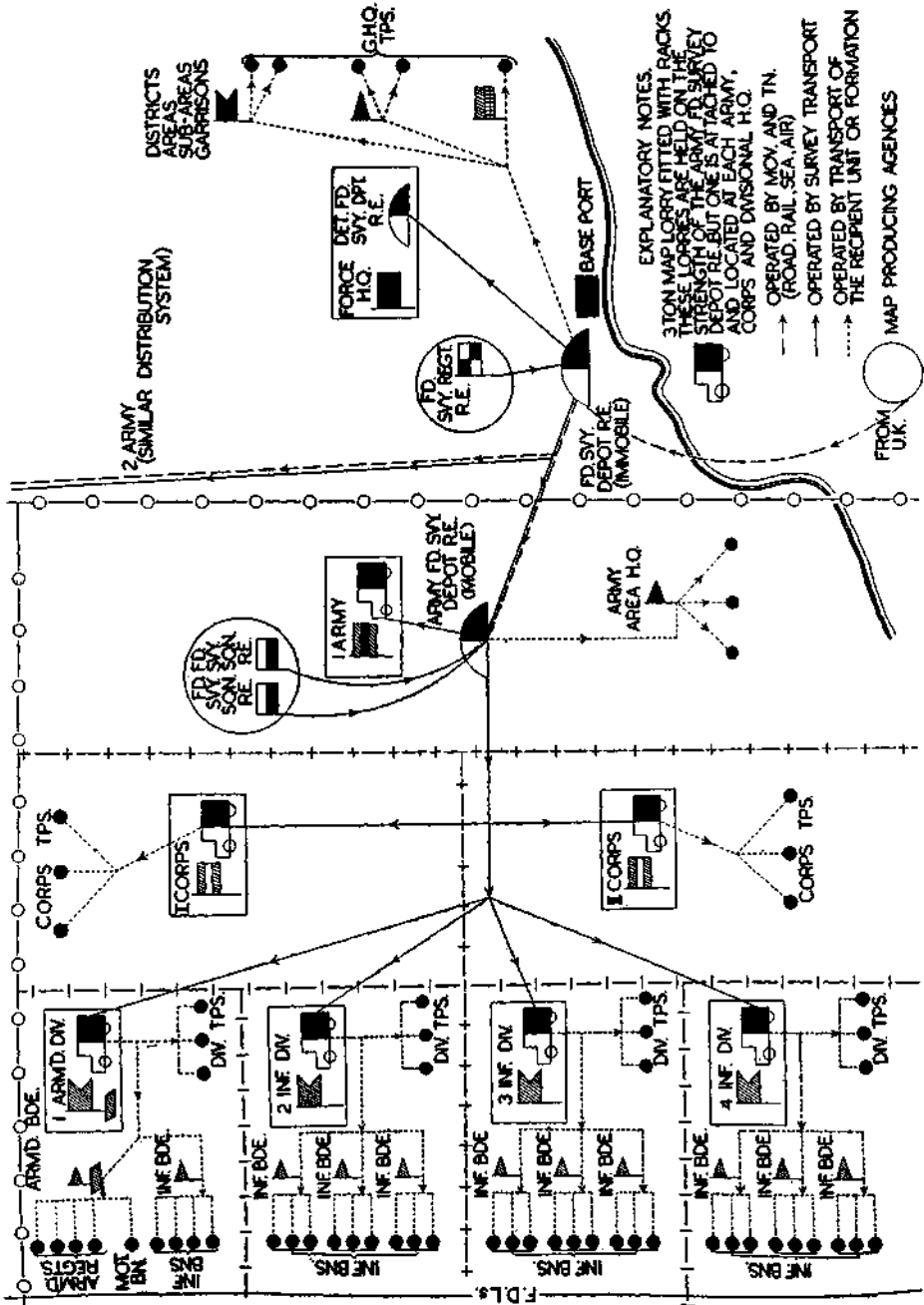
Any future plans for the organization of field survey depots will have to take into account the purpose which the depot is destined to fulfil, such as whether it will be operating with an army in the field, at an army group H.Q., or at the base; whether in a friendly or hostile country, and what quantities 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-



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:—

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|--|-----------------------|
| 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:—

Scale	Corps H.Q.		British Airborne Div.	Total Initial Issue	Reserve
	U.S.	U.S. Airborne Div.			
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 I (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.