Royal Geographical Society with IBG
Advancing geography and geographical learning

WILEY

British Survey on the Western Front
Author(s): H. S. L. Winterbotham
Source: *The Geographical Journal*, Vol. 53, No. 4 (Apr., 1919), pp. 253-271
Published by: geographicalj
Stable URL: http://www.jstor.org/stable/1779286
Accessed: 27-06-2016 02:47 UTC

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at
http://about.jstor.org/terms

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.

The Royal Geographical Society (with the Institute of British Geographers), *Wiley* are collaborating with JSTOR to digitize, preserve and extend access to *The Geographical Journal*

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

From the Assam Valley and up the Lohit Brahmaputra (which is an affluent of the Brahmaputra from the north-east), a route passes through from India to Burma and from Burma to Tachienlu and China. That is, no doubt, the one route which geography points out as the natural highway from India to China. Why should not that route be opened? I only know one traveller who has been successful in getting through that route from the side of China to India—the adventurous young discoverer Captain Bailey. I cannot quite see why, if we are now on good terms with China, we should not decide that this plain and straight route up the Brahmaputra, by the Lohit Brahmaputra into Burma and China, should be open to us. It is one of the highways of the future, and the sooner that connection between China and India can be established the better. I will ask you to join with me in a very hearty vote of thanks to Mr. Coales, not only for what he has told us but for what he has shown us. It has been as good an illustration of the domestic life of that part of Tibet as ever we have seen.

BRITISH SURVEY ON THE WESTERN FRONT

Lieut.-Col. H. S. L. Winterbotham, C.M.G., D.S.O., R.E.

Read at the Afternoon Meeting of the Society, 20 January 1919.

THE work which fell to the lot of the surveyor in this war has been extraordinarily interesting, and I hope to be able to show you wherein that interest lay. If it is not evident it will be no fault of the subject. I propose to divide the lecture into four main sections: (1) The new and unexpected demands made on the surveyor; (2) the material available on which to build; (3) the main tasks of the surveyor in detail; (4) some other activities of the Field Survey Battalions.

In the first section I propose to outline the general ideas prevalent before the war as to the probable requirements of our Expeditionary Force in a European war, and to show how and for what reasons the demand for an accurate survey grew. The main tasks which confronted us can then be defined. In the second section I will endeavour to describe the material on which we had to build. In the third we will take the main tasks in detail, and I will try to describe how they were carried out. The fourth section will deal generally with some other aspects of our work, and it is unfortunately in this category that we must leave the most interesting questions of all—the location of hostile batteries—of which no precise details may be given.

I. The New and Unexpected Demands made on the Surveyor.

Geography has always had a great and sometimes even a decisive influence in war, and a correspondingly important place in military education. The topography of the theatre of operations, the physical obstacles to be overcome, the defiles to be passed, the roads, railways, and rivers available for transport, and even the very character of the soil are all matters of strategical importance. Tactics, even those of the smallest

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

unit, are affected in precisely the same way. It is a mere matter of scale. The exact position of an underfeature whose height above the surrounding plain does not exceed 5 metres may be as important to the success of some minor operation as a mountain chain is to the success of the whole campaign.

Important, therefore, as a good topographical map is to the industrial development of a country, it is the soldier rather than the engineer who has been responsible for the topographical maps of the civilized world. In our own country, extensive mapping operations began with the rising of 1745, and we have the long line of soldier surveyors who have controlled the Ordnance Survey of Great Britain—from General Mudge, the first Director-General, down to Colonel Sir Charles Close, who is Director-General to-day. In France there is General Bourgeois, Artilleryman and Geodesist, as head of the *Service Géographique*; and in the *Istituto Geografico* in Italy is General Gliamas, whose influence upon the excellent coloured maps of Italy has been so marked. Military Topography has been taught in all military schools and included in examinations for promotion.

In the main, however, the soldier has concentrated on the type and scale of map suitable for a war of movement. France, for example, possessed an excellent map on the scale of 1/80,000, which shows topography in enough detail for the wars of the past, except in the case of formal sieges. It does not publish a general map of sufficiently large scale for the needs of to-day. In fact, continental large-scale maps are cadastral rather than topographical, and are made for revenue purposes rather than for tactical ends.

When therefore the Expeditionary Force embarked for France in August 1914 it was comparatively well found in small-scale maps, and foreseeing the calls which would be made in the future, the Ordnance Survey added many new printing machines and placed large orders for printing paper. The supply of these existing maps appeared to be amply secured therefore, and foreseeing no necessity for original survey, the War Office decided that the three survey sections maintained for service abroad by the Ordnance Survey would not be required.

The supply of maps to the troops comes amongst the duties of the Intelligence Branch of the Staff, and a special officer deals exclusively with this question. Colonel E. M. Jack, C.M.G., D.S.O. (then Major), was the officer who sailed with the original Expeditionary Force in this capacity, and it was under his leadership that all our subsequent growth took place. He had at first a staff of one additional officer and two clerks.

During the first battles, the retreat from Mons and the earlier stages of the battle of the Marne, it was all he could do, and more, to distribute sheets of the French 1/80,000 or smaller scales. In those days such a map was the most highly valued of all articles. During the swift changes of scene of those earlier battles it would have been impracticable to pro-

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

vide larger-scale maps. It would have been impossible to issue them fast enough. From this time onwards until the mobile warfare of 1918, however, the small-scale topographical had to give place to the larger-scale map, and this in spite of the excellent 1/100,000 produced by the Geographical Section, General Staff, which for strategical purposes was by far the best map issued.

We now come to the pause on the Aisne; and with that pause came the first demand for something at once more accurate and larger in scale than the French 1/80,000. No new survey could be undertaken, for there were no trained surveyors available for the purpose; but the Ordnance Survey set to work at once to enlarge and redraw the area of operations on the scale of 1/20,000 (roughly 3 inches to a mile). No sooner were these prepared than the race for the coast began, and the British Expeditionary Force moving northwards became engaged in the first battle of Ypres. After that battle the line steadied down again, and renewed demands were made for better and larger maps; and again the Ordnance Survey enlarged and redrew the area in question. These sheets were most valuable and continued in use for several months.

In both these cases, however, on the Aisne, and later in Flanders, the enlargements supplied were exact enlargements of the originals. They had therefore no advantages, except in size, over the original, and reproduced faithfully its errors. They are of great value to the Staffs, for they provide space on which to mark up disposition and make notes, but are valueless for the gunner.

And now it is time to explain why an accurate large-scale map is so essential to a war of positions. In the first place each side develops a highly intricate system of trenches. Now the defence of a sector involves a good deal of organization; the different lines of resistance, the direction of traffic, the machine gun and trench mortar positions, the stores of bombs, tools, ammunition, etc., must all be known and mapped, in order to hand on a knowledge of conditions and of what has been done to each succeeding unit as it takes over the sector. The distance of the German trenches, the position of his wire, the different lines of defence, must also be known and mapped, in order to organize an attack. The machine and trench mortar gunners, also, want a map of their targets.

Now the trenches are comparatively close to each other; and so narrow and intricate in pattern that they cannot be shown with accuracy on any scale smaller than 1/20,000. The 1/80,000, like all small-scale maps, suffers from an unavoidable generalization. Errors of well over 100 yards are common, and sometimes rise to over 200 yards, and on an enlargement of this map it is impossible, with the best will in the world, to do anything more than show a very distorted and faulty representation of the trenches. This fact is as important to the surveyor as to the man who has to use the maps, for no work is more difficult or more disheartening than to correct and add to a thoroughly distorted map.

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

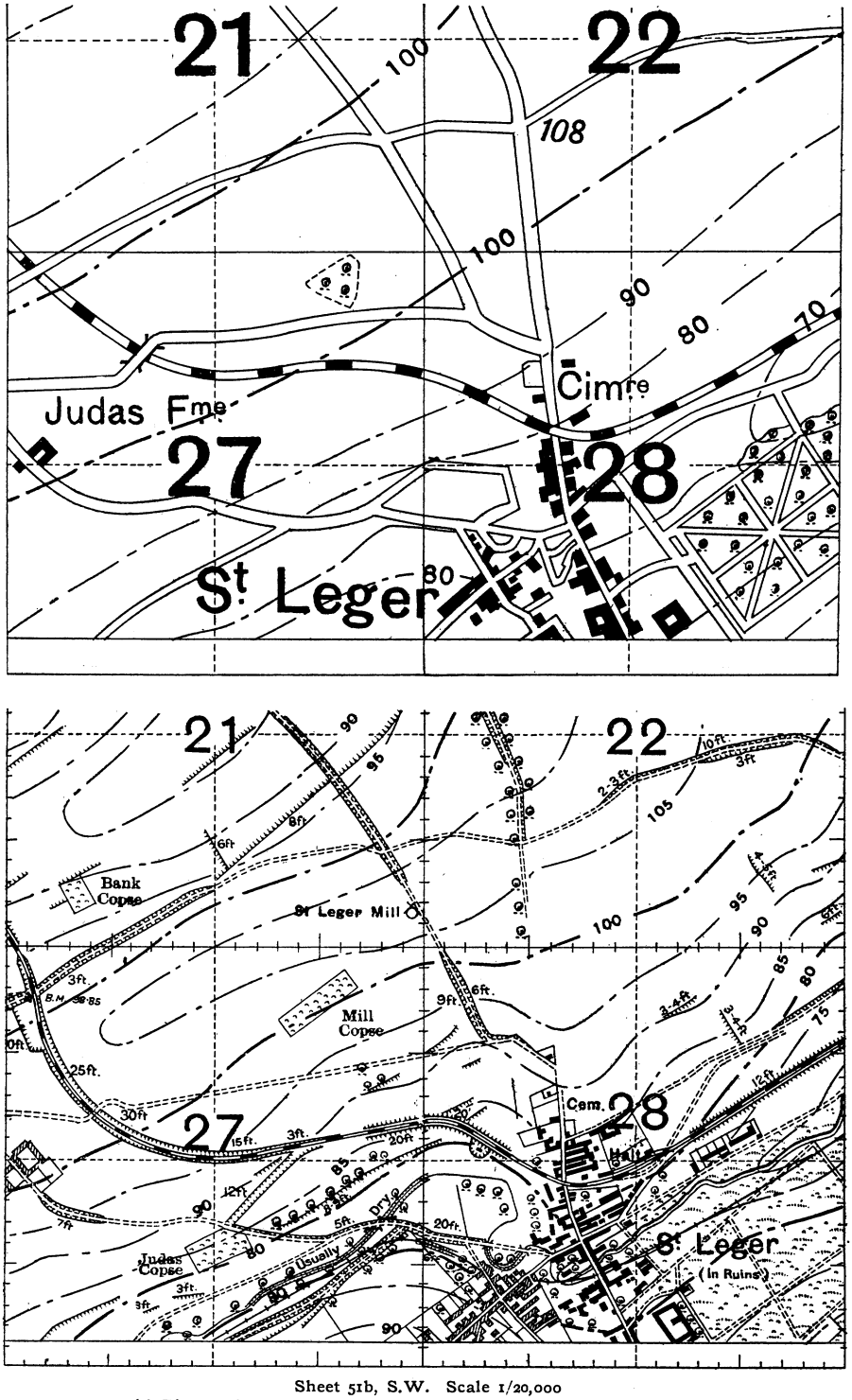
So far no mention has been made of the Artillery, but they are the people for whom by far the largest proportion of our Survey work has been done. This will be dealt with later at greater length. Although they require much else besides, they must have a good accurate map. The intricate trench system, the strength of the enemy's artillery, the introduction of trench mortars, the wide bands of protective wire, all called for an increase in the number and calibre of our batteries and for more scientific gunnery. Providing that the gunner has a map of such accuracy, and so detailed that he can find the position of his gun and of his targets readily upon it, and can measure ranges and bearings to these targets with an accuracy corresponding to that of his gun, a great stride has been made. Accuracy of this class is a luxury to other arms, but it is an absolute necessity to the gunner in a war of positions, for the greater proportion of fire must be based on elements taken directly from the map, and it implies that errors of more than 20 yards in position should not be made on that map.

Yet another arm which is vitally interested in the accuracy of the map is the Royal Air Force. It is their duty to locate the exact position of any gun they may see in action, of any body of troops which may be engaged by our own artillery, and in fact any target of importance. To say where this target is, however, they must have a map on which all natural and artificial features are shown accurately, and so shown as to resemble the actual appearance of the landscape from the air. Enough has been said to show the necessity for a good large-scale map.

There soon arose, however, other demands upon the surveyor, all in connection with the Artillery. A gun can be laid upon a line with an accuracy of within five minutes, and is laid at the required bearing from some clearly visible aiming point. Now the target is practically never visible from the gun sight, and it is not possible to measure the required angle from the map sufficiently exactly with a protractor. The map is often torn or folded or affected by the humidity, and even when new cannot be used for such measurement. But if gun, aiming point, and target are all attached to that rigid trigonometrical framework on which the map is built up, this angle can be calculated; or better still, if a correct bearing is known between two points, one of which is close by, the artilleryman can carry this bearing by traverse to his gun and lay on any required bearing.

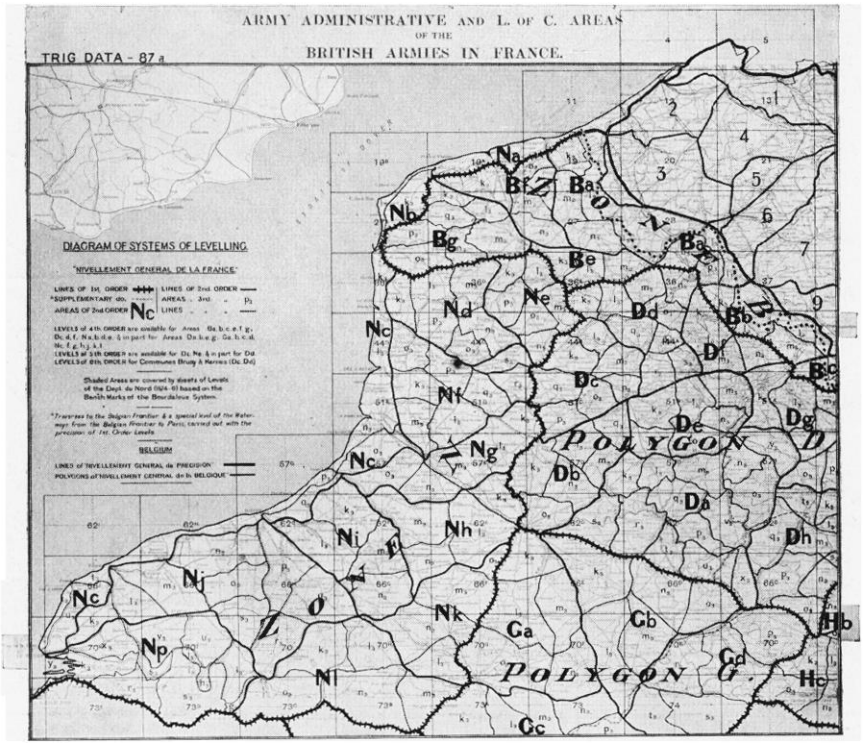
Now the gun can be directed on any target whose position is known. This target, however, may be some point defined only on the map, and not, as the gun position is, connected to the triangulation. To make it easy to use the map to the best advantage, the inevitable paper errors of the map can be eliminated by supplying zinc boards on which the map is pasted bit by bit into its correct position. The board is covered with a grid of squares which is plotted on the zinc. The map is now cut up into squares which are pasted down into the correct positions. Upon this

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms



Sheet 51b, S.W. Scale 1/20,000
(1) First Edition, B Series. Printed by O.S. 1915
(2) Eighth (Final) Outline Edition. Printed by O.B.O.S., June 1918

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms



SYSTEMS OF FRENCH AND BELGIAN LEVELLING

AMERICAN PLANE-TABLING

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

"artillery board" the trigonometrically fixed positions can now be plotted, and ranges and bearings to trench junctions, etc., can be more accurately measured. An arc divided to 10′, or reading to 2′ by estimation, is pasted on the board with the gun position as centre.

It stands to reason that the gunner cannot always wait for these refinements. The situation at the moment decides what can be done; but before any "set piece"—any big attack or artillery surprise—the surveyor must provide the accurate groundwork which will enable the gunner to do the utmost damage with the means at his disposal.

It is only half the work, however, to fix the positions of the guns. Targets must be fixed also, as must the datum points on which the gunner tests his atmospheric corrections for the day.

To fix the positions occupied by the enemy's artillery, or, as they are called, counter-battery targets, various methods have been evolved. The most notable of these are flash-spotting (or fixing by bearings the position of the flash of discharge) and sound ranging. Full details of these methods cannot be divulged, but all armies make use of them, and the principles involved are the same. I will say a few more words on this subject later.

They fix a position which is independent of the map, because observations are taken from points along measured bases which are connected to the trigonometrical framework just as are the positions of gun and aiming point. All therefore may conflict with the position as shown on even the best of maps, *e.g.* guns may appear to be on the wrong side of the roads.

In the survey of the gun and its target, heights must be fixed as well as horizontal distances, for in each instance the gunner must know the angle of elevation or depression (or, as he calls it, the angle of sight) as well as the range.

The principal duties of the surveyor in war are therefore: (*a*) the construction of the map; (*b*) battery survey, inclusive of gun, aiming point, datum points, etc.; and (*c*) the survey of sound ranging and flash spotting bases. Of this two-thirds are entirely and one-third largely for the artillery.

II. The Material available on which to build.

Now to deal with the trigonometrical and topographical data available in the theatre of operations.

There was no lack of trigonometrical information; the trouble was to secure it in such a form that it was immediately usable, and to reconcile the conflicting systems which were no less than *five* in number.

These were: I. The old French National Triangulation, begun in 1818 and finished in 1855, which is known as the *Triangulation des Ingenieurs Géographes*.

By far the most important triangulation to us, it covers the whole

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

countryside with a network of fixed points, defined almost entirely by church spires, steeples, or towers. There are practically no marked ground stations. The framework of this triangulation in the area of our operations is the meridian of Paris (associated with the names of Delambre and Mechain) and the Amiens parallel. The base which defined the standard length is that of Melun, south-east of Paris. The initial latitude and azimuth used for calculation were those measured at the Panthéon.

Unfortunately many of the original points have been destroyed, and in some cases new spires or towers built close to their original sites add considerable doubt and confusion to one's results; while sometimes the old spires have acquired a severe tilt. There are no descriptions of stations available, and the sheep can be separated from the goats only by bitter experience.

At first there were no printed lists of the positions of points, and everything had to be copied in manuscript.

Owing partly to the date of this triangulation and to the instruments used, partly to the system of completing the third-order triangulation by sheets, and partly to errors of copying, a very careful check was necessary before one felt safe. Relative errors were very large, often of the order of 1/500.

II. The results of the Belgian triangulation are given in the published national records. Perhaps a better and more systematic triangulation than the old French, it resembles it in the absence of ground stations, and in the number of points which have been destroyed.

I. and II. provide comparative values of common points, from which to find the correction to be applied to the latitude and to the tabular difference of longitude between Brussels and Paris, for naturally the two systems do not fit exactly. The *Service Géographique* published a scale of corrections in longitude which were applied to the Belgian results in bands or strips running north and south. These corrections amounted in all to 20 metres, and when plotted against longitude showed a markedly "bellied" curve. The scanty evidence hardly seemed to warrant this, and we shall return to this point.

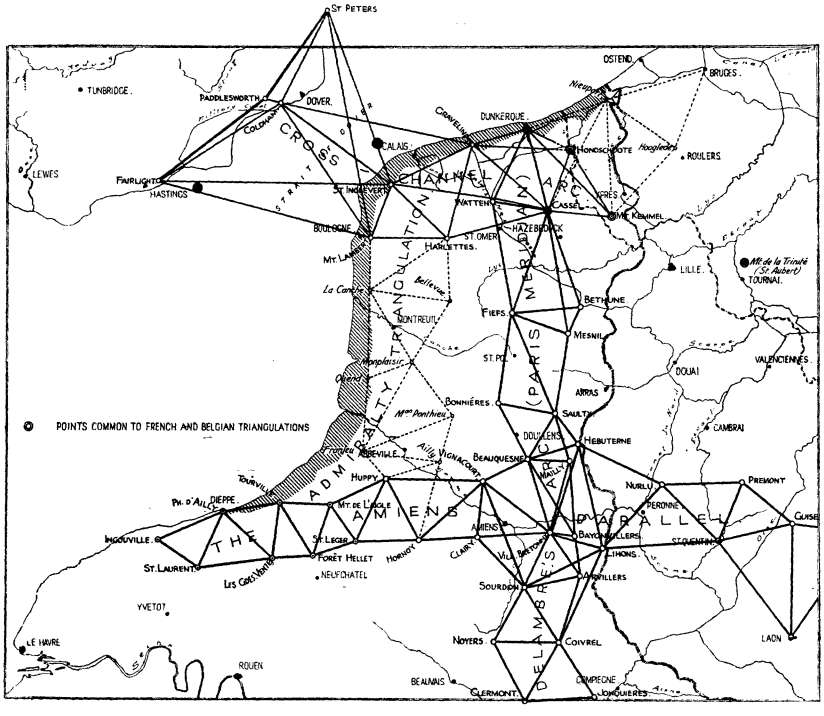
III. A chain runs across the north end of our area, which starts with the cross-Channel connection (finished in 1860) and which forms part of the great European arc of parallel, used by Clarke in his later figures of the Earth, and studied by Helmert in his *Europäische Längengradmessung*. It is interesting to think that English surveyors observed from these stations some sixty years before their descendants used them again in this war. Cassel and Kemmel, two famous and most useful points, were included in this chain.

IV. The French Admiralty Survey provides a close network of well-fixed points around the coast, but is calculated on a different figure of the Earth, and plotted on a projection different from that of the old French triangulation.

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

V. In 1890 the French Government decided upon a new cadastral survey. As a preliminary to the new topography they undertook to remeasure the arcs, and to extend from them a new and reliable triangulation of the second and third orders. In our area the new arcs consisted of a part of the new meridian of France (associated with General Bourgeois' name); and a new but unfinished parallel of Amiens.

The new triangulation starts from a new base, depends upon new astronomical determinations of latitude and azimuth, and is calculated on a different figure of the Earth; it is no easy task to combine it with



The French Geodetic Triangulation

the old. At the beginning of the war, the French decided to refer the points of the new triangulation to corresponding positions on the old spheroid. This they did by André's formula, but took no account of the change of scale due to the new base, or to the change of azimuth due to the new determination from the Panthéon. These two factors were to be dealt with as local corrections based on comparisons, which could be done only where many common points existed. Moreover the new triangulation covers a relatively small area, and could not be utilized at all without introducing serious troubles and discrepancies at the edges of the area covered. In 1918 after the March retreat, it became imperative to adopt this new triangulation at the southern end of our line,

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

because the old points were largely destroyed, and the new provided many ground stations from which to work. These ground stations are marked by a square brick pedestal, or in the case of important points by a chimney about 10 m. high. Unfortunately they are already being destroyed in numbers, partly by farmers, and partly by camps and aerodromes.

The material outlined above was not collected without much difficulty. Even the existence of some of it was unknown to us in the field for some time, and the perpetual expansion of the field work and the calls on our energies in other directions made it impossible to digest it all thoroughly until nearly the end of the war. A visit to the *Service Géographique* always gave one a delightful feeling of anticipation of something fresh—like a dip in a lucky bag.

If the material varied, so also did the guise under which it was given. There were three different figures of the Earth and four projections involved. I will not enter into details of these here, for it appears to me to form a most effective part of the French System of National Defence—whether by design or accident—and I suspect the German surveyors of having spent many a cross and wasted day in their efforts at comprehension.

It is interesting to note, however, that as the work for the surveyor grew naturally upon our comprehension, and we realized how valuable a consistent triangulation was in war, we turned to the existing national triangulation and used it as a comprehensive whole. The Germans, who had foreseen much of the necessity of the future, had evolved a system of triangulation in the field by armies. As the area occupied by these armies changed, so did they get into ever greater trouble between those army systems, which were entirely independent of each other and defined by rectangular co-ordinates from different origins. In one captured document a gentleman known as the *Stoverm* (Staff officer for survey) of one of the German armies complains bitterly of having three separate systems of co-ordinates to deal with, and they published two sheets at least with three separate grids upon them.

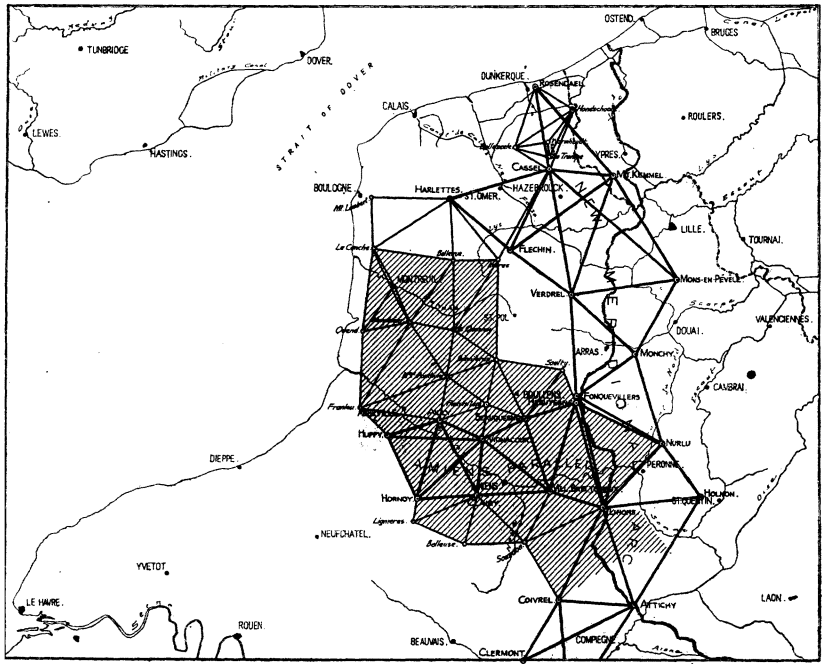
Even as it was, however, we had our own troubles in joining up the French and Belgian triangulations, and on the borders between armies; and we determined later in the campaign on a step which would have been of international importance had it ever been completed. Starting from the new meridian of Paris, working along the new or partially finished Amiens and Paris parallels, and using the old observed angles on the Sedan meridian where the new work had not been completed, a new and better connection was made with Belgium. This new connection did much to reduce former discrepancies, *e.g.* from 20 metres to 12, and made it possible to obtain a much smoother and more consistent junction. In fact, a consistent triangulation from the line as it existed in July 1918 to the Rhine was within our grasp. The field work necessary in our area had been completed, and many of the calculations done, when the last victorious offensive carried us forward so fast that we could not keep pace

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

with it. Nevertheless had Captain McCaw, to whose capable hands the matter was entrusted, been able to finish off the work, it would have been a most valuable contribution to modern geodesy.

In dealing with trigonometrically fixed points it is usual for the surveyor to define their positions on the Earth's surface by co-ordinates —geographical or rectangular—while the cartographer defines them by the rectangular co-ordinates on that projection he desires to use for his map.

In war it is essential that co-ordinates should be rectangular, and that they should be the same for both purposes, for no sooner is a point fixed than it has to appear on a new edition of the map or be put to some immediate purpose, and there is no time to repeat calculation. Our



New British Surveys and connection between French and Belgian Triangulations

maps were, however, on Bonne's projection, which introduces considerable angular distortion. Fortunately we were not so far from the origin that the co-ordinates on this projection were unusable for field work, but they did mean distortions of as much as a minute. Such small distortions are undiscoverable on the map, but are a distinct drawback to the field work, and it was mainly for this reason that the French adopted the Lambert orthomorphic in which angular distortions are much reduced, and linear distortions anywhere within the area of operations are negligible. We were on the point of adopting this projection when the last offensive began.

The importance of the projection adopted for the map throws a curious light upon the value which attaches to the surveyor's work in

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

a modern war. It arises from the fact that the gunner is perpetually having to measure the range and bearing from one point to another, and the surveyor is equally busy in providing the respective positions. Both must talk the same language, and it must be simple, hence all points must be defined by rectangular co-ordinates on the map; the projection should introduce as little angular distortion as possible, that is, it should be orthomorphic; the sheets should be rectangular, to simplify questions of bearing and measurement; co-ordinates must run consecutively throughout the theatre of operations.

Now, in order that the position of each spot may be described correctly and rapidly, the map is covered with a grid. In designing our grid we considered only the ease of reference, and not the question of deducing from the references of two points the distance and bearing between those two points. The French, working from their co-ordinates, adopted a system which could be used with just as much ease for simple reference as ours, with the additional advantage that the relative position of two points could be immediately deduced.

As before explained, an accurate knowledge of heights and contours is almost as important to the gunner as is the triangulation. Here also we had much difficulty in reconciling different sources of information. The contours as shown on the 1/80,000 map of France are form lines only, even at that scale. When enlarged to 1/20,000 they appear in places to bear very little resemblance to the ground. Under features are scarcely noticed, and occasional large errors are apparent. They are based upon trigonometric heights which are in very poor agreement with the national levelling of France.

The latter excellent system, called the *Système Lallemand* after the *Directeur du Nivellement général de la France*, covers the whole of our area of operations with a network of lines, and from the benchmarks of this system we recontoured all such areas as we could work in. There are also many benchmarks of the *Système Bourdaloue* which immediately preceded the *Nivellement général*. There is a difference of about a metre between these two systems. As one crosses the frontier into Belgium one finds contours based on the *Nivellement général* of Belgium, which are referred to a datum 2·3 metres lower than that of the *Nivellement Général de la France* (see Plate).

The following table shows the relation of various systems of levels to the *Nivellement Général de la France:*

Datum of Belgian Ponts et Chaussées	2·47 metres
Belgian Nivellement général	2·30 ,,
Système Bourdaloue (Northern France)	0·93 ,,
Belgian Nivellement de précision	0·29 ,,

all below datum of the *Système Lallemand*, so that heights are greater by corresponding amounts.

Just at the close of the campaign we captured a German diagram of

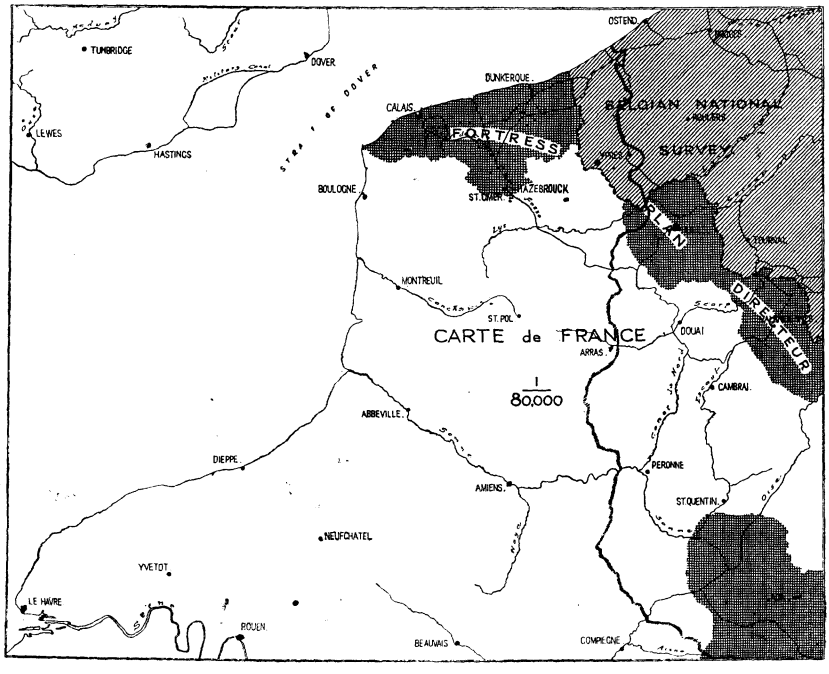
This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

levelling systems which showed that he had got most but not quite all of the information concerning the *Nivellement général.*

As for map material, we had, first of all, the existing survey of Belgium drawn on the scale of 1/10,000 for reduction to 1/20,000. This is an excellent map on the whole and well contoured, but certain errors of plotting had been made, and the amount of detail shown by conventional signs, such as grass and meadow land, made it necessary to redraw.

France had published the 1/80,000 throughout, and there are the 1/20,000 *Plans directeurs* round fortresses.

Fortunately however there existed a general survey on the scale of



The French and Belgian Surveys

1/2500, made for revenue purposes in the beginning of the nineteenth century, which provided a reliable basis for the compilation of new maps. This cadastral survey was never published, but remained in manuscript at the capital of each province. Each commune was surveyed in a series of about four to eight of these plans. A communal index on the scale of 1/10,000 showed where the various plans lay.

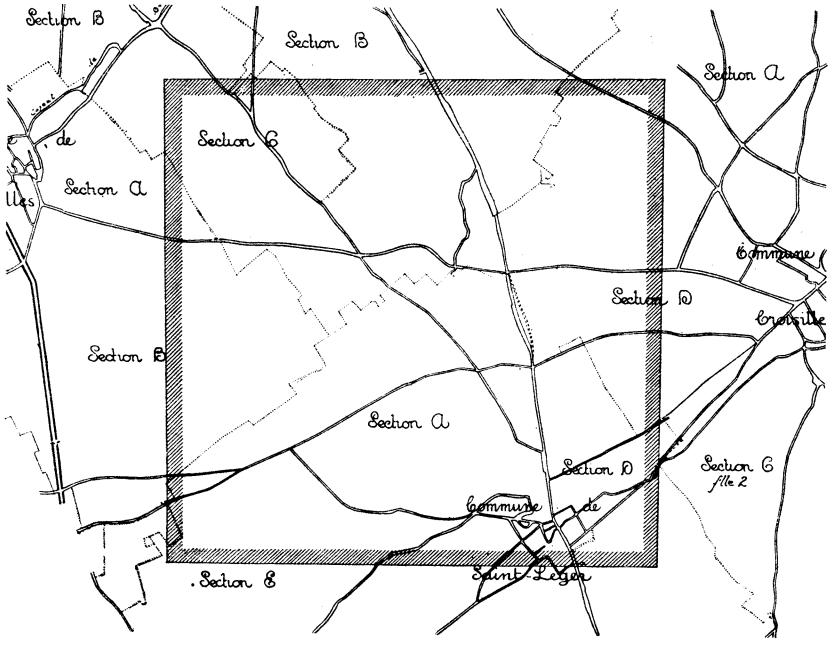
The Germans captured the cadastral plans of the *Département du Nord* in Lille and others further south. In such cases we had to rely on the communal indexes, copies of which had been collected in Paris.

There existed also large-scale plans of railways, canals, and mine concessions; but these mixed up contemplated construction so much with existing fact that little reliance could be placed on them. For

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

example, the railway apparently departed fairly frequently from the surveyor's idea of where it ought to go, and mining plans showed nicely designed garden towns for their employees which had evidently remained in the category of pious hopes.

Lastly we received from the R.A.F. quantities of excellent photographs taken vertically from aeroplanes. Such photographs open a new page in mapping. Naturally they do often show distortion due to the tilting of the camera; but there were almost invariably several photographs for the same region, and in any case it is not a difficult task to



Combination of French Cadastral Plans

rephotograph the original in such a way as to correct both for distortion and for scale.

III. The Main Tasks of the Surveyor.

Now we will take the various duties which fell to the surveyor in detail, and foremost among them the making of a map. We will consider a map on the scale of 1/20,000, through which the line ran, and which was therefore only partly accessible for field work.

The first step is to test the triangulation, eliminate any points which appear inaccurate, and add as many new ones as can be fixed. Meanwhile the cadastral plans of the area are being reduced to the correct scale and the R.A.F. have been asked for photographs.

In the area in which survey is possible, plane-tablers are out fixing

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

a sort of fourth-order triangulation of road junctions, corners of woods, hedges, etc. The sheet lines of the sheet (probably distributed among four draughtsmen) are now laid down, trig. points are plotted, the plane-tablers' additional points being included, and the cadastrals are fitted upon this skeleton. The fit was generally good, but not always. Doubtful points in our own area can be verified at once on the ground, but doubtful cases forward can be checked only by plotting from air photographs. This is never a very satisfactory and often a rather lengthy operation.

The next step is to transfer to each plane-tabler's board the outline of roads, villages, etc., from the compilation, to add the bench marks and spot heights, and to send out this skeleton for contouring and for the clearing up of any doubtful points in the compilation.

Meanwhile the draughtsman with his air photographs added to the map all the alteration and addition in the country since the cadastrals were made.

It is worthy of special remark that our experience proved it to be a great saving of labour to use the plane-table for fixing ruling points only, and to plot the detail from photographs, which had been rephotographed to fit these points. In all cases, however, a final check on the ground is necessary.

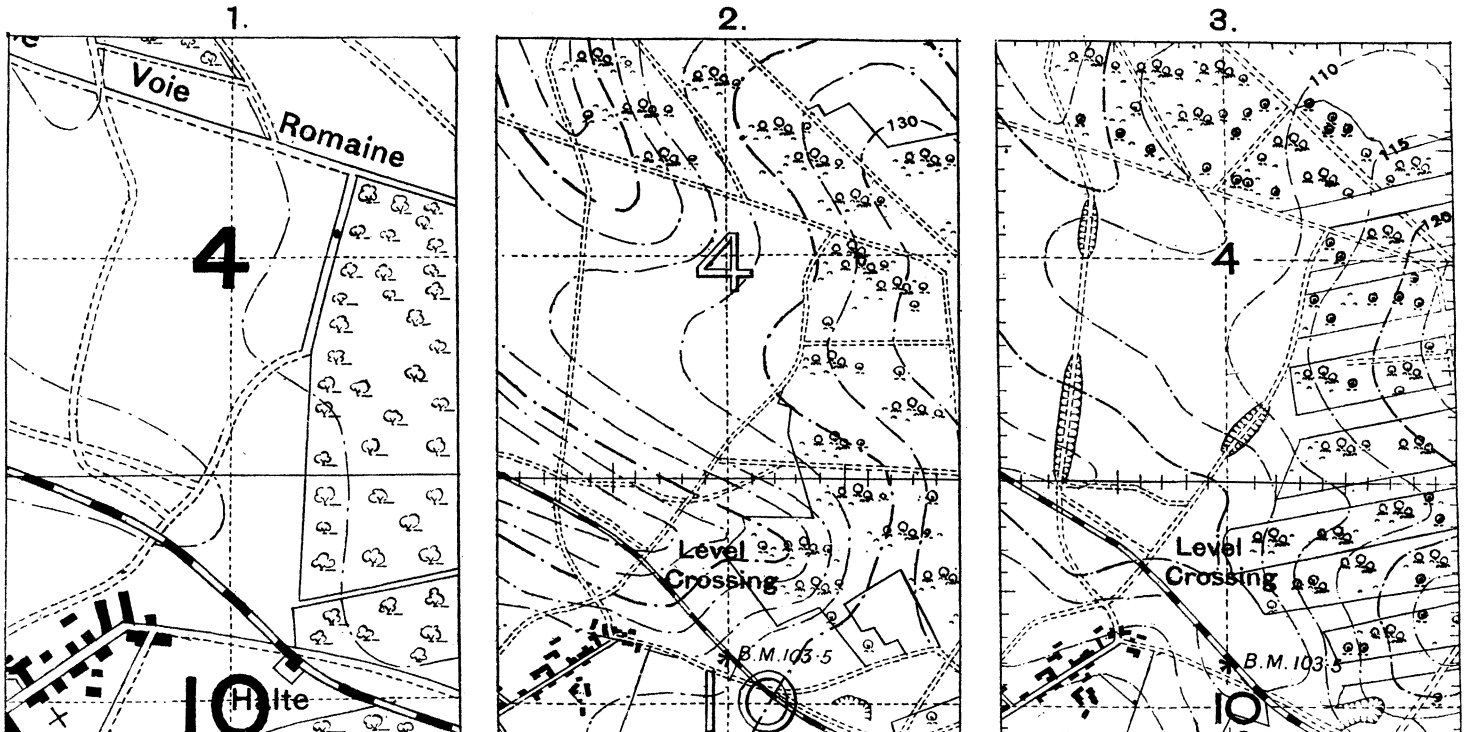
Next comes the preparation of the contour plate. In our own lines we have the survey of the contours by the plane-tablers. For the area occupied by the enemy we must draw the contours in the office from such information as level books, profiles of railways and canals, vertical angles from the trig. officer or from the flash spotters, air photographs, and captured German maps. Now the net result of this forward contouring is not of course ideal. Many instances have occurred where it was actually bad. One can say with confidence that it was always an improvement on the old 1/80,000 contours, and that sometimes it was very good, but there must exist a great danger where one allows a topographer, who understands and loves his work, the license to make an intricate contoured map from scanty evidence.

Curiously enough much can be done from air photographs. Shadow, banks and cuttings, evidences of standing and running water, all help. It was one of the pleasantest relaxations after a day's grind to spend an hour or two at this most fascinating study.

This map was used as a background for a map of the trench systems; as the most accurate guide possible to map range and bearing for the artillery (the enemy batteries being specially marked); as a reference on which the R.A.F. observer described the position of the things he saw (woods are shown in green to help him to recognize the country); as a background for an intelligence map showing the organization of the enemy's defence, which also helps the gunner responsible for harassing fire to pick his targets, and to measure line and range; and as a background for a secret map showing the organization of our own defence.

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

THE GRADUAL IMPROVEMENT OF CONTOURS. SHEET 62c S.E.



First Edition, 1915

Edition 2A, February 1917

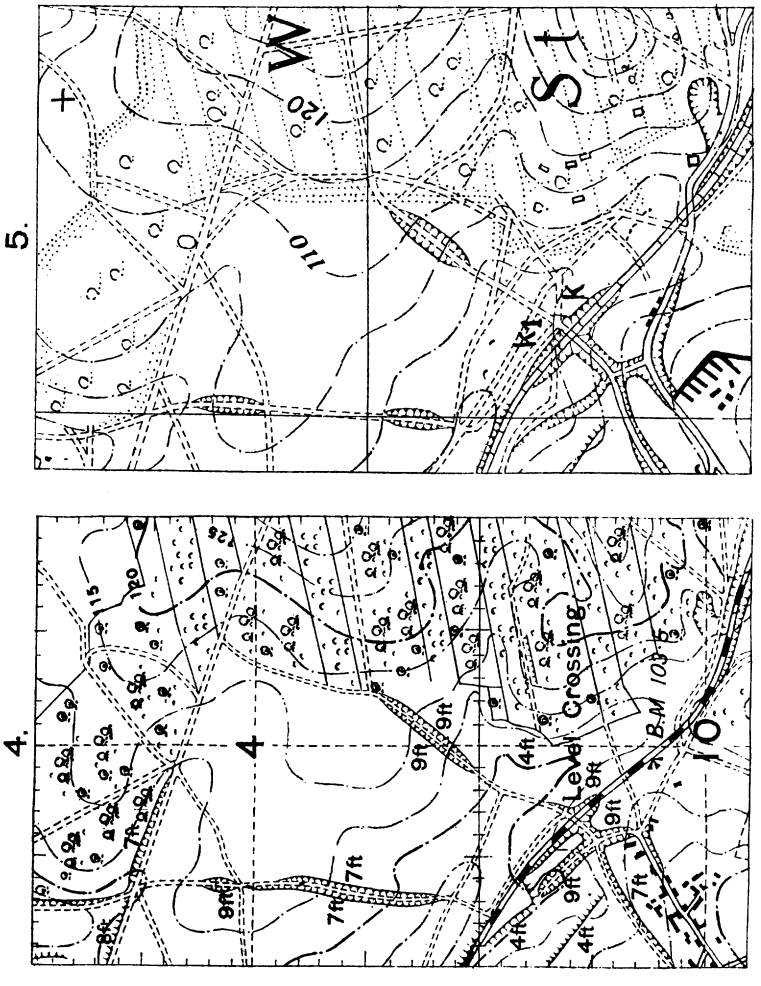
Edition 4B (local) 18 August 1918

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

Now let us take another aspect of the work. We will imagine that an attack is decided upon and is to take place in four days' time. This is following upon a slight advance which has made it necessary to move all our batteries forward, and has had the contrary effect on the German batteries. We may take it that we have some forty heavy and siege batteries detailed for the attack.

Probably many of these batteries will remain concealed until the attack opens. For a successful artillery surprise all armies have adopted the principle of opening a heavy artillery fire without previous registration. That in turn means that there must be no doubt as to the accurate survey of the positions of both gun and target.

The survey operations are useless unless they can be finished in three days, and there are three officers and three men available for the task.



This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

Whatever the weather may be, the new positions of these batteries and a bearing near each of them must be fixed and battery boards made and issued.

Now taking one typical case, we find the battery in an orchard in a little valley. From a point 400 yards away one can see three trig. points, one of which is within a quarter of a mile. Measuring a 200-yard base, and observing three points from one end and two, including the nearest trig. point, from the other, we get a good determination of bearing and position and a check on both. A mark is left at each end of the base. The position of the directing gun is fixed from the base, and the survey of that battery is finished.

The next case is much worse. In the yard of a demolished homestead with hedges, old buildings, and thick country all round there is no hope for a trigonometrically fixed position without a full day's work. A gleam of sun, however, gives a chance of an azimuth; and recording the position from which the azimuth was taken, with an iron pin as before, the site of the directing gun is plotted from an air photograph.

To complete the survey of the forty batteries will mean working day and night. But the survey was always finished somehow, and a day before zero each battery will have its battery board and its bearing properly prepared.

Now suppose this attack to have been a success, like that of the battles of Arras or Amiens, an advance over absolutely destroyed country follows; and this means that the triangulation has to be restored and pushed forward to the new line. It may be that by interpolation from points still standing in the territory occupied by the Germans we can provide enough points in our own area for the next call on battery survey; or it may be that triangulation has to be brought up from behind with the help of those excellent signals which the Germans leave behind them.

It is however absolutely essential in either case that the trig. points in German territory should be the arbiters of position. It has happened on several occasions that chains of triangulation brought up from behind have joined up very badly to the trig. points in the area in which the targets lie. In such a case previous work must be scrapped. The position of the target is decisive, and it is obviously of no manner of use to have recourse to methods of precision if they include a weak link at the most vital part of the chain. In either case the bad and crowded roads, insufficient transport, and dust add to the difficulties which one must experience to appreciate.

Supposing the triangulation well forward, the next task is the survey of sound ranging and flash spotting bases. The officer who is responsible for the Army triangulation is too busy a man to be able to undertake this work, so each unit has to survey for itself. Courses have therefore been held to train officers of each unit. The survey is not a very difficult

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

affair, granted good visibility. It is sufficient to fix posts for either the sound ranger or flash spotter within two metres, and here interpolation is the usual solution. Nevertheless everything has to be carefully checked, and it is often impossible to do any methodical and quick work in these areas. Unfortunately the surveyor generally wants to get on some under-feature, where his presence is generally objected to. It is safer, therefore, to proceed by intersecting poles on or near the required position, and finishing up with a short traverse.

We have recently learned from the Germans the simple device of firing rockets vertically upwards from the required position and intersecting these rockets from places at a safe distance. It is not a difficult matter to produce such rockets, and their value will be just as great in surveying forests or thick and inaccessible country, as it is in war.

It is noteworthy, however, how very large a part interpolation or resection plays in war-time survey. In recent times Captain McCaw read a paper before this Society on that subject. Since then three other pamphlets have been published in France on the same question. As a legitimate and useful method in survey it had not hitherto received sufficient attention.

IV. Some other Activities of the Field Survey Battalions.

The magnetic compass is an instrument which should be used as little as possible where accurate results are wanted. In the area of operations there is so much old iron lying about that one can never use a compass with confidence. Nevertheless there are occasions, and many of them, when the gunner is compelled to fall back upon its use, and for that reason Field Survey Battalions have made special arrangements throughout the campaign for testing and reporting on individual compasses.

The information from which the magnetic data for the area of operations had been compiled was very scanty and out of date, however, and early in 1918 it became evident that we had been relying on a figure for the yearly variation which was too small. A magnetometer was borrowed from Kew Observatory and a magnetic survey carried out at eighty-eight stations. On completing the field work, Lieut. Mitchell, who was in charge, was sent to Kew Observatory, where with Dr. Chree's kind permission the corrections for diurnal inequalities and the reduction of the readings to January 1, 1918, were made. These corrections were obtained from a simple comparison between the mean value of the magnetic declination from true north at Kew on January 1, and the mean value of the magnetic declination as given by the Kew magnetographs for the day and time of the observations taken in the field. The results of this survey were most valuable, for they proved that in certain areas we had been relying on a figure for the magnetic declination too large by 30′.

The bulk of our personnel were engaged in the location of hostile artillery. Their methods I am not at liberty to divulge. Whenever the

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

results they have reported have been checked by examining the remains or traces of the German batteries in a conquered area it has been proved that we have known some 90 per cent. or so of his positions.

There is, as a matter of fact, an astonishing similarity of method in flash spotting among the principal armies engaged. This is the more curious since we have never had until recently full knowledge of German methods, and it appears likely that they had the same scanty knowledge of our doings. Nevertheless there has been general progress, the important steps in which seem to have been pretty well contemporaneous. Our location was however undoubtedly better than theirs, and I fancy this fact is due to our better survey methods and better maps, without which location labours under great difficulties.

In sound ranging there was little comparison; they were, until quite lately, years behind. Just recently they had brought out an improved apparatus, but I have no details yet as to its type and design.

The making of maps would be of little use unless the printer intervenes and reproduces them in large numbers. No apology is needed therefore for a word or two on the printing which has been done.

The output of the Ordnance Survey has been a wonderful record. From 4 August 1914 to 31 March 1915 no less than 2,300,000 maps were printed for war purposes, of which we received 1,400,000 in France. In the financial year starting on 1 April 1917 and ending on 31 March 1918, 8,800,000 were printed there, of which we received 7,200,000 in France. Altogether over 32,000,000 maps have been printed for military purposes at Southampton alone.

In 1918 an Overseas Branch of the Ordnance Survey was established in France, to undertake the printing of the more urgent work. In spite of many initial difficulties, and of an enforced shift from the first place chosen, during the German attack on the Lys in April, this Overseas Branch has already turned out millions of maps.

Printing establishments had necessarily to be raised in each army also, as part of the Field Survey Battalions. There are many maps of such urgency that no delay is permissible, and printing must be done on the spot.

The following figures will illustrate their activities and the distribution of maps which followed:

BATTLE OF CAMBRAI, NOVEMBER 1917.

(1) **Printing done by Field Survey Battalion:**

	Army special sheets.	Outlines for Corps Topo. Sections, etc.	Totals.
Number of runs	306,560	153,100	459,660
Number of sheets	108,260	73,600	181,860
Average runs per sheet ...	3	2	$2\frac{1}{2}$

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms

Special Printing done by Ordnance Survey.

10,000 of each of 2 Army Sheets. Plates left ALBERT on Thursday and were received back on the following Wednesday (2½ days at O.S.O.).

(2) Maps issued by Field Survey Battalion:

	Regular series printed in England.	Special sheets printed at Army H.Q.	Totals.
Issued November 1—10 ...	64,859	15,694	80,553
,, ,, 10—20 ...	91,694	56,982	148,676
,, ,, 20—30 ...	65,501	36,956	102,457
Total for month	222,054	109,632	331,686
Average per day	7,400	3,700	11,100

Additional Corps Topo. Outlines 68,000.

Information.

Trench maps ...
Organization ...
Positions ...
Layered (for Staffs)
} 1 : 20,000

Rear Organization ...
Situation ... ...
Roads, banks, hedges, etc.
} 1 : 40,000 for tanks and cavalry.

Before closing I would like to add a word on the very close and cordial co-operation which existed between the Geographical Staffs of the various Allied Armies. I think we all regard General Bourgeois as an elder brother, and with more affection than that relationship necessarily implies. It was immaterial, too, whether it were a French, American, Italian, or Belgian mapping unit that one visited, one found throughout not acquaintances but friends, and a helpfulness which was rather astonishing, that augurs well for the future of any international geodetic association.

In conclusion we must own that to us has fallen one of the most interesting problems of the war. Throughout the four and half years it has been for us a succession of interesting problems and developments. The war has brought together in the Field Survey Battalions a body of young scientific men, surveyors, and engineers of the new army, whose talents, zeal, and energy have kept us abreast of—if not ahead of—our friends and enemies, and whose company we shall miss badly when we are all demobilized.

The Chairman (Sir Aubrey Strahan, F.R.S.) having introduced the lecturer, Colonel Winterbotham read the paper printed above, and a discussion followed.

Colonel Sir CHARLES CLOSE: I think Colonel Winterbotham has given us a remarkable exposition of a very troublesome and intricate subject. Personally, I should like to express my very deep admiration for the work which has been carried out by Colonels Jack, Winterbotham, MacLeod, Reid, Keeling, Salmon, and the other officers of the Field Survey Battalions, all of whom have done work which cannot be too highly praised in regard to its value to the Army. One has sometimes seen in despatches, especially recently, remarks on the fine work done by our Artillery; that they have done fine work is undoubtedly true. Much has been rightly said as to the accuracy

This content downloaded from 128.197.26.12 on Mon, 27 Jun 2016 02:47:32 UTC
All use subject to http://about.jstor.org/terms