

PROVISIONAL

(Winterbotham's preliminary report. This was consulted and largely used in preparing the official report. E.M.J.)

SURVEY ON THE

WESTERN FRONT

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MAPS  
General Headquarters  
20 December 1918

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General Headquarters  
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| <u>Index</u>    |   | Page |
|-----------------|---|------|
| <u>PART I.</u>  | <u>INTRODUCTION.</u>                                    | 1    |
| <u>PART II.</u> | <u>LARGE SCALE MAPS</u>                                 |      |
| 1.              | (i) <u>MATERIAL EXISTING BEFORE THE WAR</u>             |      |
|                 | (a) The National Triangulation of France.               | 3    |
|                 | (b) Cadastral Plans.                                    | 3    |
|                 | (c) Railway Plans, Canal Plans and<br>Road Plans.       | 4    |
|                 | (d) Mining Area Maps.                                   | 4    |
|                 | (e) Fortress Plan Directeurs.                           | 4    |
|                 | (f) Bench Marks & Spot heights.                         | 5    |
| 2.              | (ii) <u>FIRST DEMANDS FOR LARGE SCALE MAPS</u>          | 5    |
|                 | (iii) <u>THE FIRST TOPOGRAPHICAL SURVEYS</u>            |      |
| 3.              | The Ranging Section.                                    | 5    |
| 4.              | Resurvey or Revision.                                   | 6    |
| 5.              | The new Survey of Flanders.                             | 6    |
| 6.              | Remarks upon the Second Edition.                        | 7    |
| 7.              | Extending Southwards & Westwards.                       | 7    |
| 8.              | The Ranging & Survey Section.                           | 7    |
| 9.              | The Survey of Calais.                                   | 8    |
| 10.             | The Revision of Sheet 19.                               | 8    |
| 11.             | Revisions of Portions of the First Survey.              | 8    |
| 12.             | Divided Responsibility.                                 | 8    |
| 13.             | Maps of our own Trenches.                               | 9    |
|                 | (iv) <u>FRENCH EXPERIENCE IN MAPPING UP TO MAY 1915</u> |      |
| 14.             | New Survey.   | 9    |
| 15.             | New Organisation to meet new requirements.              | 9    |
| 16.             | Special needs of the Artillery.                         | 9    |
| 17.             | Map Squares.  | 10   |
|                 | (v) <u>THE TOPOGRAPHICAL SECTIONS</u>                   |      |
| 18.             | Topographic Sections.                                   | 10   |
| 19.             | Map Situation in August 1915.                           | 10   |
| 20.             | New Compilation Maps.                                   | 11   |
| 21.             | Plotting from Air Photographs.                          | 11   |
| 22.             | Area Mapped.  | 11   |
|                 | (vi) <u>MAPPING IN THE FIELD SURVEY COMPANY</u>         |      |
| 23.             | Field Survey Companies.                                 | 11   |
| 24.             | Remapping of the Arras Sector.                          | 11   |
| 25.             | Maps on the Scale of 1/5000.                            | 12   |
| 26.             | Formation of the 5th Field Survey Company.              | 12   |

|     |  |    |
|-----|--|----|
| 27. | Battle of the Somme.                       | 12 |
| 28. | German Retreat on the Somme.               | 12 |
| 29. | Wide Angle, Short Focal Length Photographs | 12 |
| 30. | Formation of Corps Topographical Sections. | 13 |
| 31. | Counter Battery Work.                      | 13 |
| 32. | The Battle of Arras.                       | 13 |
| 33. | Forward Areas.                             | 13 |
| 34. | Photo Reduction Maps.                      | 14 |

(vii) MAPPING IN THE MOBILE CONDITIONS OF 1915

|     |                                    |    |
|-----|------------------------------------|----|
| 35. | The British Retreat in March 1915. | 14 |
| 36. | Back Area Surveys.                 | 14 |
| 37. | Conventional Signs.                | 14 |
| 38. | Secret Maps.                       | 15 |
| 39. | Distribution of Maps.              | 15 |

PART III. THE TRIGONOMETRICAL FRAMEWORK

|     |                           |    |
|-----|---------------------------|----|
| 40. | Original data.            | 16 |
| 41. | Retriangulation.          | 16 |
| 42. | Single & Divided Control. | 17 |
| 43. | Coordinates.              | 17 |
| 44. | The Retreat in 1915.      | 17 |
| 45. | General Lessons.          | 18 |
| 46. | Grid.                     | 18 |

PART IV. BATTERY SURVEY

|     |  |    |
|-----|--|----|
| 47. | Earlier History.                         | 19 |
| 48. | Map Shooting on Original Enlargements.   | 19 |
| 49. | The Battle of Neuve Chapelle.            | 19 |
| 50. | Battery Boards.                          | 19 |
| 51. | The Second Edition Map.                  | 19 |
| 52. | A Battery Commanders View.               | 20 |
| 53. | Third Army Battery Boards.               | 21 |
| 54. | The Preparation for Loos.                | 21 |
| 55. | The First Field Artillery Boards.        | 21 |
| 56. | Insertion of Maps on Battery Boards.     | 21 |
| 57. | The Somme Battle.                        | 21 |
| 58. | Survey Pickets.                          | 22 |
| 59. | The Battles of Arras and Messines.       | 22 |
| 60. | Battery fixation during operations.      | 22 |
| 61. | The Battle of Cambrai & Bearing Pickets. | 22 |
| 62. | The Preparation for Operations in 1918.  | 22 |
| 63. | The German Offensive.                    | 23 |
| 64. | The Counter Offensive.                   | 23 |
| 65. | The Final Advance.                       | 23 |

PART V. THE OBSERVATION GROUP

|     |                                  |    |
|-----|----------------------------------|----|
| 66. | Early History.                   | 24 |
| 67. | French Early History.            | 24 |
| 68. | German Early History.            | 24 |
| 69. | The Artillery Survey Detachment. | 24 |
| 70. | Breakdown of dual control.       | 25 |
| 71. | Synchronisation.                 | 25 |

|     |  |    |
|-----|--|----|
| 72. | Second Army Flash Spotting.                | 25 |
| 73. | First Army Flash Spotting.                 | 26 |
| 74. | Fourth and Fifth Armies.                   | 26 |
| 75. | The Battle of the Somme.                   | 26 |
| 76. | The Observation School.                    | 26 |
| 77. | Observation for ranging.                   | 27 |
| 78. | Training in Mobile Warfare.                | 27 |
| 79. | The Battles of 1917.                       | 27 |
| 80. | G.H.Q. School.                             | 27 |
| 81. | Autumn of 1917.                            | 28 |
| 82. | The Work of an Observation Group in a Day. | 28 |
| 83. | The Operations in March & April.           | 29 |
| 84. | Operations from May to July.               | 30 |
| 85. | Mobility.                                  | 30 |
| 86. | The Last Offensive.                        | 30 |
| 87. | The role of the Observation Group.         | 30 |
| 88. | The Officers and Personnel.                | 31 |
| 89. | Questions not yet solved.                  | 31 |

#### PART VI. SOUND RANGING

|      |  |    |
|------|--|----|
| 90.  | Early History.   | 32 |
| 91.  | Early British History.   | 32 |
| 92.  | Experimental Section.  | 33 |
| 93.  | New Sections.  | 33 |
| 94.  | French & British Stopwatch Sections &<br>the "Claude" Orthophone.          | 33 |
| 95.  | Battle of the Somme.   | 34 |
| 96.  | The end of 1916.   | 34 |
| 97.  | The Tucker Microphone and the Regular Base.                                | 34 |
| 98.  | The Retreat to the Hindenburg Line.  | 35 |
| 99.  | Locating the bursts of our own shell.                                      | 35 |
| 100. | Additional Sections, The Experimental<br>Section and Sound Ranging School. | 35 |
| 101. | The Battles of Arras and of Messines Ridge.                                | 36 |
| 102. | Wind Sections.   | 36 |
| 103. | Passchendaele.   | 36 |
| 104. | The Automatic Developer and the<br>Cambridge Scientific Co.                | 37 |
| 105. | Characteristic Breaks & Standard Containers.                               | 37 |
| 106. | Tactical Lessons of 1917.  | 37 |
| 107. | Extension of the line southwards.  | 37 |
| 108. | Application of wireless to S.R.  | 38 |
| 109. | Mobile and Survey Courses at G.H.Q.  | 38 |
| 110. | Sound Ranging Sections in the retreat of<br>the Spring, 1918.              | 38 |
| 111. | Meteorological Data.   | 39 |
| 112. | A Sound Rangers Day in 1918.   | 39 |
| 113. | The Attack opposite Amiens in August.                                      | 39 |
| 114. | The LYS Salient.   | 39 |
| 115. | The Final Advance.   | 39 |
| 116. | Location by earth tremors.   | 41 |
| 117. | The composition of a Section.  | 41 |

#### PART VII. THE COMPILATION SECTION

|      |                          |    |
|------|--------------------------|----|
| 118. | Its origin.              | 42 |
| 119. | The Compilation Section. | 42 |

|      |  |    |
|------|--|----|
| 120. | Enemy Organisation.                          | 42 |
| 121. | Positions Determined.                        | 43 |
| 122. | Field Survey Companies.                      | 43 |
| 123. | Elimination of R.F.C. Lists.                 | 43 |
| 124. | Hostile batteries.                           | 43 |
| 125. | Conferences.                                 | 44 |
| 126. | Counter Battery Target Maps.                 | 44 |
| 127. | Compilation Sections in other Armies.        | 44 |
| 128. | The Somme Battle.                            | 45 |
| 129. | Progress in 1st and 2nd Armies.              | 45 |
| 130. | Growth of Compilation Offices.               | 45 |
| 131. | The compilation offices & the R.A.H.Q.       | 46 |
| 132. | The final estimate of position.              | 46 |
| 133. | Strength and Duties of a Compilation Office. | 47 |
| 134. | Lessons for the future.                      | 47 |

#### PART VIII. CORPS TOPOGRAPHICAL SECTIONS

|      |  |    |
|------|--|----|
| 135. | The Battle of the Somme.                 | 48 |
| 136. | First Proposals.                         | 48 |
| 137. | Reproduction.                            | 48 |
| 138. | Raising of the 1st Corps Topo Section.   | 49 |
| 139. | Field Battery Survey.                    | 49 |
| 140. | Organisation - Internal & External.      | 49 |
| 141. | The work done.                           | 50 |
| 142. | The manuscript work for the Corps Staff. | 50 |
| 143. | Faults of the organisation.              | 51 |
| 144. | Lessons for the future.                  | 51 |

#### PART IX. SCREEN CALIBRATION

|      |  |    |
|------|--|----|
| 145. | First trial on Salisbury Plain.                                | 52 |
| 146. | Early history in the B.E.F. France.                            | 52 |
| 147. | Experiments on the Coast near Dunkirk.                         | 52 |
| 148. | Allowance for Jump and Droop.                                  | 53 |
| 149. | Captain Chapman's report in October.                           | 53 |
| 150. | Movement of the Calibration Section.                           | 53 |
| 151. | Sections in 1st & 3rd Armies and<br>difficulties of personnel. | 54 |
| 152. | Need for further experiment.                                   | 54 |
| 153. | Natures of Guns calibrated and value<br>of results.            | 54 |
| 154. | The "Jolly" Apparatus.   | 54 |
| 155. | Experiments on Salisbury Plain.                                | 54 |
| 156. | Present position of Screen Calibration.                        | 55 |
| 157. | Screen calibration compared with<br>calibration in the line.   | 55 |

## SURVEY ON THE WESTERN FRONT

### PART I - INTRODUCTION

At the outbreak of the war none of the Armies which took the field were equipped for the geographical work which a war of positions subsequently made necessary.

The British Expeditionary Force included a Mapping Section under I (c) and a Printing Company at G.H.Q. There was no staff of surveyors neither was there any thought of having to re-map on a large scale any portion of an already mapped civilized country.

There was a Survey Section fore-shadowed in British War Establishments but it had been considered that such a Section would not be wanted in Europe and although three such Sections were ready at the beginning of the War the Ordnance Survey (which was to provide these) was informed that they would not be required.

In the German Army arrangements had been made for a staff of surveyors and the special needs of the Artillery had been well thought out. They were thus probably the first to put into the field Sections able to compile large scale maps, but they do not seem to have issued any such in 1914.

In the French Army special arrangements had been made to survey the area around fortresses and to provide units known as Brigades Geodesiques to assist the artillery in the location of targets in siege warfare.

The Mapping Section (Ic) has remained in being throughout the War. The special duty of providing sheets of the existing national surveys has been carried out as was foreseen. The following notes do not, therefore, make mention of this work nor do they refer to Topographical maps of a scale of 1/80,000 or smaller. The Printing Company has continued its special functions and still retains its original title. No mention is made of it, therefore, in the following notes.

To the Ordnance Survey has fallen the bulk of the work of reproduction. The quantities of maps it has had to print have been very greatly in excess of anything that could have been foreseen, but this work - efficiently as it has been carried out, and invaluable as it has been to the Army at large - presents no novel features and is not, therefore, touched upon.

Mapping and Printing Sections modelled on the lines of the Mapping Section and Printing Company at G.H.Q. were formed for the 1st, 2nd, and 3rd. Armies. These small units were quickly swallowed up by the remarkable expansion of the Field Survey Battalions and existed under their original title, and for their original purpose, for so small a time that subsequent mention of them would serve no purpose.

These notes, therefore, confine themselves to the growth of original survey work and to the expansion in personnel and stores necessary to carry it out.

Before beginning, however, on the special work of the Field Survey Battalion, it is necessary to add a word on topographical maps in general.

All ranks must be supplied with these topographical maps and must be able to read from them without difficulty the special points in which they are particularly interested.

Invaluable as these small scale maps are, their use is common to all kinds of warfare and they give neither the space nor the precision of outline necessary to the more detailed information required in position warfare.

This war has been fought practically entirely on maps of 1/50,000 or larger scales and it is to the preparation of these that the energies of the Field Survey Battalion have been directed whilst the small scale maps remain practically unaltered copies of pre-war survey.

For the more precise work of the Artillery however even carefully compiled large scale maps fail to give the requisite accuracy and recourse must be made to the positions of trigonometrically determined points.



## PART II - LARGE SCALE MAPS

### i. MATERIAL EXISTING BEFORE THE WAR

#### (a) The National Triangulation of France

1. A triangulation complete over the area of operations and consistent in itself is a necessity to a war of positions.

Fortunately we possessed full data as to the French and Belgian National Systems.

The Belgian results are given in Volume 3 of the "Triangulation du Royaume de Belgique" and those of the French Triangulation were supplied, in the earlier days of the war, on manuscript lists from the Service Geographique, and more recently in printed pamphlets.

No descriptions of stations were available however and, in the course of time, many of the original points had been destroyed.

In an extraordinary large number of cases church spires had been so destroyed and reconstructed so near to their original position that the change was not immediately apparent.

In several cases compilation maps were distorted from this cause, for the existing position of a church spire, conspicuous on an air photo proved in these cases not to be the position of the original trig point.

The positions of those points were given in a variety of ways. As latitudes and longitudes: as rectangular coordinates on the Bonne Projections of France and Belgium: and as rectangular coordinates on the French Lambert.

All Belgian positions were referred to that figure of the Earth known as the "Ellipsoide de la Carte de France". French results showed a generous indifference to figure and were on the "Carte de France", on the "Plessis" (a diminished Carte de France) or on Clarke's 1880, spheroids.

The different systems which affected our work were the original national trigonometrical survey, the new 1900 arcs and cadastral triangulations, and the Coast Surveys of the Admiralty.

The life of a trigonometrical computer may at times degenerate into a full routine. Not so however if his labours lie in the North Eastern provinces of France.

#### (b) Cadastral Plans

The whole of France was mapped for revenue purposes at the scale of 1/2,500. Each commune represented a separate survey, and was completed in a number of separate parts (from two to eight) corresponding to the size of the commune. Three manuscript copies of these original surveys exist and these copies are to be found at the Mairie of the Commune in question and at the Revenue Office in the capital of the Department.

Their survey value varies much from place to place. Some have been found exceedingly accurate whilst others show considerable errors.

For purposes of reference, a diagram to the scale of 1/10,000 was made of each commune, showing the relative positions of the various portions which were surveyed at the larger scale. These indexes were made from hand reductions of the originals, and are, therefore, neither so accurate nor so detailed.

In 1899 it was decided to begin a new cadastral survey of France, but little was done before the scheme was abandoned, and the number of modern cadastral plans is so small that no further mention is made of them.

Most of the topographical maps of France ultimately rest on these cadastral plans. Thus the skeleton of the 1/80,000 Carte de l'Etat Major is compiled from them although much new survey had to be done in order to complete the map.

The other plans and maps which are mentioned subsequently are almost invariably based upon the 1/10,000 indexes to the Communal Surveys.

(c) Railway Plans, Canal Plans and Road Plans.

Railway and Canal Plans are available practically everywhere. They are, however, mere compilations as mentioned above and this compilation is often not above reproach. They appear also, generally, to represent the engineers plans for construction rather than a survey of the finished article, and cases are frequent in which the actual trace of railway or canal is found to differ materially from that given in the official plans.

As material for accurate large scale mapping, therefore, little was to be got from these plans and it was best to neglect them altogether if air photos were available of the area in question.

In the majority of cases, however, the plan is accompanied by a profile which adds considerably to the data available for contouring. In one or two cases plans had been contoured in the field.

(d) Mining Area Maps.

In the coalfields of Flanders and Artois the various mine concessions had produced maps based on the original cadastral surveys, and amplified by additional work on the ground. Some of these plans were of great assistance but difficulties arose occasionally from the inclusion of projected villages, railways etc. which had never been constructed.

(e) Fortress Plan Directeurs.

Fortress Plan Directeurs were surveyed on the scale of 1/10,000. They were carried out in no regular pattern but were extended apparently to cover all the ground which might become of importance during a siege of the fortress in question. These Plan Directeurs were revised at irregular intervals and were really good topographical maps. They were printed in black at the scale of 1/20,000. The contouring on them was excellent but certain cases of errors due to the faulty plotting of trig. points have been found and in certain other cases it has been evident that the initial survey, done with the theodolite and chain, has been good, but that hedges, ditches etc. have been joined up wrongly. Such errors should have been found out during a revision on the ground, and were at once apparent on comparison with air photos or on plane table revision. These maps were occasionally of the greatest value but cover relatively a very small area.

(f) Bench Marks and Spothights.

The Nivellement General de la France has covered the whole country with a network of 1st. 2nd. 3rd. 4th. and sometimes 5th. order heights which materially assist in contouring.

The "Bourdaloue" system which preceded the Nivellement General provides another set of benchmarks. A correction is necessary to bring the Bourdaloue values into sympathy with those of the Nivellement General.

Lastly the heights of Churches and of the majority of the points of the old French Triangulation were fixed trigonometrically. A special comparison was necessary in each area to establish a general correction to these trig heights.

It is impossible, however, to compile good contours at a small vertical angle on a large scale map from lines and levels, and the only original evidence available as to shape is the hachuring of the 1/80,000 map and the profiles published for each railway plan.

ii. FIRST DEMANDS FOR LARGE SCALE MAPS

2. During the retreat from Mons there was no opportunity for the use of any maps other than those on small scales, and a supply of these was a matter of the greatest difficulty. The first demand for anything larger and more accurate came immediately following on the battle of the Aisne when the line became more or less stable. There was, however, no possibility of fresh survey at the moment neither was there any trained staff of surveyors available.

The 1/80,000 was therefore enlarged and redrawn at the Ordnance Survey Office Southampton. Almost immediately afterwards the British Expeditionary Force moved Northwards, and was engaged in the battle of Flanders. As soon as the line became more or less stable again, renewed demands were made for enlargements. These were supplied as before and the regular redrawn sheets from Southampton were preceded by a temporary map issued by the Printing Co. G.H.Q. These enlargements were in every way unsatisfactory. Reproducing the errors of the original, they made them the more conspicuous by reason of their additional size, and, as artillery work developed, so did the demand increase for a more accurate map.

iii. THE FIRST TOPOGRAPHICAL SURVEYS

The Ranging Section.

3. On 7th November 1914 the first Ranging Section R.E.\* arrived as part of the Divisional Troops of the 8th Division. During the retreat and in the earlier stages of the war, it had been obvious that the German Air Service was ranging German Artillery on to suitable targets by dropping a smoke bomb or other conspicuous signal over the target it wished to indicate. No doubt German surveyors fixed the position of these signals and reported them to their artillery. It was to inaugurate such a system in the British Army that the first Ranging Section was formed.

November and December 1914 were, however, two of the most unpleasant months that the climate of Flanders could produce. During the whole of this period there were three occasions on which a signal from an aeroplane could be picked up and no occasion presented itself therefore to familiarise the Royal Flying Corps and the Artillery with the procedure nor to train pilots to drop a signal vertically over any desired spot. This latter is a matter requiring not only

\* Original copy bears a pencilled note "Asked for by Rawlinson - Trained on Salisbury Plain and embarked with 8th Division".

special apparatus but considerable skill. Moreover at this period wireless telegraphy from the planes themselves developed into a reliable procedure which fulfilled the desired purpose much better than could the necessarily inaccurate determination by vertical signal.

The ranks of the first Ranging Section R.E. (1 officer and 1 other rank) were however, expert surveyors and were thus immediately available for the commencement of a new survey.

#### Resurvey or Revision

4. It was decided on, then, to issue a new series of maps of a more accurate order. It was at first thought that the old map might be revised in the same manner as is the 1" to 1 mile map of Great Britain. The magnitude of the errors and the difficulty of selecting any points, which might be regarded as accurate, made such methods impossible. A traverse was run, closing on itself, and covering about 10 miles of road, from which attempts were made to revise the whole country in the neighbourhood but it was found that this practically amounted to a resurvey. Finally an entirely new map on the scale of 1 in 20,000 was decided upon. It is curious that the first surveyor to start work with the theodolite in the British Army was arrested as a spy on the grounds that no-one except a German would be likely to use an instrument such as a theodolite in our area.

#### The new Survey of Flanders

5. The British Area was from North of Ypres to Bethune. The Northern most portion was however in Belgium and the Belgian maps were considered to be of sufficient accuracy.

Joining up to the Belgian map, the fortress Plan Directeur of Lille embraced an area (shown on Diagram 1) which covered another portion of our front. On subsequent examination of this Plan Directeur many omissions and some inaccuracies were found, but in the second edition (which incorporated the new survey) the original plan Directeur material was reproduced without revision.

The responsibility of the 1st Ranging Section ceased at our own front line. Beyond that mapping was carried out by G.S. Intelligence.

It had already been decided that the size, shape and scheme of the Belgian 1/40,000 series was to be adopted. Full records of Belgian mapping and triangulation existed and the adoption of the Belgian projection and sheet lines promised a consecutive series of maps stretching as far as the German Frontier.

The first step was to secure the latitude and longitude of the points of the French Triangulation and to calculate the rectangular coordinates in the Belgian Bonne which corresponded to these geographical coordinates.

Meanwhile application was made for 12 plane tablers. An attempt was made to profit as far as possible from the old survey by working on "blues" of the enlargement to 1/20,000. Their use was given up almost immediately however.

The value of the old cadastral survey was not understood at this period and it was made no use of.

No-one anticipated at that time that the war would last for many years. The survey was therefore undertaken with a view to providing a more accurate map than had been available formerly in as short a period of time as possible, and did not aim at that accuracy of outline which became necessary afterwards.

Work in the field started on the 25th of January. Each plane tabler was given an area of 20.6 square miles or 207 square inches to complete. On the 28th of February the material was complete and all field sheets were forwarded to the Ordnance Survey for reproduction.

Meanwhile the H.Q. of the Ranging Section remained with the 8th Divisional Artillery, and 3 men were kept busy in layering maps for the various staffs and in supplying lists of trig points and heights to the R.A.

#### Remarks upon Second Edition

6. It has been found on the average that about 5% of the geographical coordinates supplied from Paris have been wrongly copied. Unfortunately one such case occurred at the Southern end of our line and caused an error of about 150 yards. Moreover quite close to this point, another, which has a Church Tower built close to but not on the site of the original trig point, was 50 yards in error. Other cases are known to have existed also. The new survey was, therefore, not above reproach neither was the detailed survey carried out with that care which subsequently proved necessary. The detail inside towns and villages was blocked in from the old maps and many of the minor ditches and hedges were omitted. In fact the whole survey corresponded to an average error in position of 20 yards with outside errors of 50 except in cases as mentioned above, where the trig skeleton was at fault.

The second edition was however a very great advance on the first. Its effect on artillery methods was at once apparent and its comparative accuracy gave rise to renewed demands for a more accurate map of the territory in German Occupation.

The drawing, the conventional signs and the lettering were arranged to correspond to the hasty nature of the survey. On comparing one of these sheets with one of the later Field Survey Battalion maps, their relative coarseness is at once apparent.

#### Extending Southwards and Westwards

7. Whilst the first resurvey was in progress our line was lengthened towards the South. Additional area was taken up therefore and at the same time the series was extended Westwards back to G.H.Q. in order to include training grounds etc. For these subsequent sheets time was not so important a factor and the survey was carried out with greater care and with a higher order of accuracy. During the survey of the original area which lay almost entirely in exceptional flat country no contouring was done in the Field. During the extension contours were surveyed at the same time as the detail. Of this latter portion the original field sheets hold extremely well in comparison with work done still more thoroughly in 1918.

#### The Ranging and Survey Section

8. During the first months of the war many of the best and most experienced plane tablers from the Ordnance Survey had been sent out in Field Companies, on the understanding that they would not be wanted for mapping. These plane tablers began now to apply for survey work and to be called in from their original units.

Moreover a few extra draughtsmen and topographers were applied for from England. It became evident that the bulk of the work could not continue under the nominal control of the 8th Division and the First Ranging Section was therefore transferred, as 1st Ranging and Survey Section, to G.H.Q. where it came under the administrative control of the Commandant G.H.Q. Troops.

#### The Survey of Calais

9. This additional personnel made it possible to start at once on a map of Calais. Calais had already been mapped in one of the Fortress Plan Directeur Series but new camps, railway construction etc. made it imperative to have a good and up to date map. The originals of the Fortress Plan Directeur (drawn at a scale of 1/10,000) were secured from Paris and in April work was started on the revision of those. Curious errors were found, some of which appeared to be due to a discordance in the trig points, and to a subsequent equation of intervening detail. The map of Calais was completed in 3 1/10,000 sheets, based not upon the Belgian Bonne but on a Casini Projection whose origin was Notre Dame in Calais. The town portion of the work was subsequently enlarged to 1/5000.

#### The Revision of Sheet 19

10. It was decided next to revise sheet 19 lying to the North of our area and to fit it to the Belgian Sheets which lay upon its Eastern edge. The Fortress Plan Directeur of Dunkerque was found to be exceedingly accurate on the whole. Areas of inundation, new railway construction and a good deal of recent detail around Dunkerque were added, not without a considerable amount of opposition. This work was completed in May.

#### Revisions of Portions of the First Survey

11. The Headquarters of the 1st Ranging and Survey Section was now shifted to Ste. Marie Capelle immediately S.E. of Cass 1. The battle of Neuve Chapelle had meanwhile advanced our line to some small extent in sheet 36 S.W., and due to this fact, and the original error mentioned in paragraph 6, it was decided to revise that portion of the original survey which stretched from Bethune to Laventie. A portion of the personnel was employed on this task therefore while the remainder were employed on battery fixation, which had started in the meanwhile, and which will be dealt with in a separate section.

#### Divided Responsibility

12. It has been previously mentioned that the responsibility for the maps of forward areas lay with GENERAL STAFF (Intelligence). These maps had been produced without any general scheme of sheet lines, without recourse to the trig: skeleton, and without much technical skill. Indeed the work of map making is not so intrinsically simple that it can be pursued with success at a moment's notice by one unacquainted with the guiding principles. Numerous cases occurred which deserve mention. For example one town appeared as copied from the report of a girl who had been repatriated. A marsh was inserted on the evidence of a refugee, where all the topographical data available gave evidence to the contrary. In one enlargement contours were drawn based on the bench marks of systems whose datums differed considerably. It had indeed become obvious that mapping should be taken up by the expert, and that compilation where actual survey was impossible called for expert handling even more than maps of the area behind our own line. These facts led to the formation in July 1915 of the Topographical Sections for each Army.

## Maps of our own Trenches

13. Air photographs began now to make it possible to produce a good trench map by plotting from them.

In late 1914 and early 1915 our own trenches were largely unmapped. Two Royal Engineer Officers lost their lives in surveying with the compass. Some points were fixed by the Ranging Sections in the trenches however and lists of trig points were issued to Royal Engineer units in the hopes that local surveys might be facilitated and might be good enough to incorporate upon maps. None such ever materialized however and although many large scale trench maps have been produced by Royal Engineer Units, few if any have been done in collaboration with survey units and few have found their way into print.

### (iv). FRENCH EXPERIENCE IN MAPPING UP TO MAY 1915

The following paragraphs are extracts taken from a report made in May 1915.

#### New Survey

14. The need for something larger, more detailed and more accurate began to make itself felt after the battle of the Marne, and from about the beginning of October Armies began to organise a service of Topographical information for themselves, with the inevitable over-lapping of work, and inefficiency of dissemination of information. Indeed the information from the various sources was never properly collated and not referred to the already fixed and available framework.

#### New Organisation to meet new requirements

15. In November, the Service Geographique received instructions to organise the work of these Army Sections, and the present organisation of the Groupe de Canevas de Tir is the result, which however was not attained without opposition, or until it had proved its value in an increasing supply of valuable information.

From the beginning of the new regime it was recognised that many sources of topographical information could be utilised, but that the value of the information so obtained depended principally upon its correct compilation with, and upon, the correct skeleton, and that the issue of any large scale sketch maps correct in detail, distorted (probably) in outline, position and azimuth, added confusion, distrust of the official map, and divided council without any corresponding advantage. An immediate deduction from the above is that all information should be collated upon the known outline, and that air photos, information from inhabitants, communal and other plans etc. should all pass through the same hands and be shown on the periodical revisions of the Group.

This conclusion is remarkably in accordance with our own, more limited, experience.

#### Special needs of the Artillery

16. The error of any map yet issued appreciably exceeds that of the actual plotting, and results partly from faults of survey and partly from generalisation necessary to the scale in question.

Consequent on above the combined error of gun position, aiming points, and target as placed relatively to surrounding detail may be such as to increase the consumption of "registration" rounds and decrease the effect of fire opened on new targets without previous registration.

Moreover a skeleton of all fixed points and targets has been found by the French more helpful to the battery commander than a topographical map.

Consequently the introduction on the "Canevas de Tir", issued to each Battery, and having on it the positions of guns, aiming points, church spires, and enemy targets. The whole of the above information is revised as new information is received.

#### Map Squares

17. The Map Square System in use is not, as with us, a grid of a size convenient for ranging purposes and available for reference only in one sheet or group of sheets, but is a grid departing from one origin for the whole Army and therefore affording a ready reference in coordinates for the whole series of maps and for every Canevas de Tir".

#### (v) THE TOPOGRAPHICAL SECTIONS

##### Topographic Sections

18. Following upon our own experience, confirmed as it was by the French, and upon the continual expansion of our front it was decided to form topographical sections in each Army.

The officer commanding was made responsible for the topographical work of the Army, for all mapping and reproduction, (including the supervision of trench mapping from air photographs), for examining and assigning its proper value to all topographical information received from any source and for the embodiment of such information on the map.

The personnel of the Ranging and Survey Section was divided into 3 to correspond to the number of Armies then in being, and the 3rd Topographical Section (the first to start work) joined the 3rd Army on the 30th of July 1915.

A Map Section and a Printing Company Section arrived at the same time and were incorporated.

##### Map Situation in August 1915

19. The situation with regard to large scale maps at this time was that the second edition was available in Flanders, that a few special General Staff Intelligence trench maps existed in the 1st and 2nd Army areas, and that in the new 3rd Army area there were French Plan Directeurs which had been prepared by the French Army previously holding this portion of the line.

In order to introduce regular sheet lines and continuity of Map Policy, Maps General Headquarters had started a new 1/10,000 series in the 1st Army area, compiled partly from French Plan Directeur and partly from mine concession maps. A few draughtsmen were instructed in plotting from air photographs and a good first issue was on the point of completion.

Meanwhile in 3rd Army area a Topographical Survey at 1 in 20,000 behind our own front line was begun.



## New Compilation Maps

20. The first good compilation map was begun at this time. The cadastral plans (1:2500) of the Somme department were copied at Amiens and were then compiled on a trigonometrical framework. Air photographs were now available in considerable numbers and were used for the mapping of new detail and of trenches.

The first sheet to appear - Ovillers - was published in October 1915.

### Plotting from Air Photographs

21. In all mapping work at the close of the war geographical draughtsmen are using prolongations, alignments, and cuttings, on the photograph in preference to the Camera Lucida.

At the outset the Camera Lucida was tried but it has not yet reached a stage of perfection that allows of accurate work. During the earlier stages the French Groupe de Canevas de Tir used them considerably.

French Army Maps are not however of the same high standard as our own and a perfection of small detail characterises them rather than a general level of accuracy in relative position. The British Army has of course been fortunate in the services of a number of very highly trained N.C.O's whose topographical experience combined with an Ordnance Survey training in revision methods made them immediately suitable for plotting from air photographs.

In later times much has been done in rephotographing to scale and thereby eliminating distortion due to non verticality, but in the earlier days cameras for this purpose were not available.

### Area Mapped

22. At the beginning of 1915 there was available throughout the British line trench maps on the scale of 1/10,000 either one or two deep. On our side of the line the 1/20,000 sheet in which the line lay was completed by topography in the field. It is obvious that the time these maps took to produce was far too long to guarantee any large areas being ready for a movement in advance or in a retreat. The drawing establishment constantly grew therefore and was almost invariably much in excess of establishment. The 2nd Topographical Section had been trained by the 3rd and had started work in August and had grown as quickly whilst the first, started much later, was gradually assuming the same dimensions. Even so, however, the numbers employed were entirely insufficient to map the necessary area.

## (vi) MAPPING IN THE FIELD SURVEY COMPANY

### Field Survey Companies

23. Field Survey Companies were therefore formed with a more liberal allowance of draughtsmen and topographers and inclusive of Observation Groups and Sound Ranging Sections. Early in 1915 the 4th Field Survey Company was formed in the 3rd Army area and trained by the 3rd Field Survey Company. Immediately afterwards the 3rd Army moved up to take over the area previously occupied by the 10th French Army and the British Line was now complete from the North of Ypres to the Somme.

### Remapping of the Arras Sector

24. The difference of grids and sheet lines between ourselves and the French made it necessary to remap this sector of the line. Moreover the French maps covered very little area in rear of the actual fighting line and a topographical survey was taken up at once in back areas. The 1st Field Survey Company pushed its topographical surveys down South to meet the new work. It was during this topographical survey that the cadastrals were made use of for the first time as a

basis for planetabling. The plans, which were copied and reduced to 1/20,000, were compiled on a plane table and sent out for revision. The consequence was a topographical survey not more accurate in the open rolling downs but considerably more accurate in very close intersected valleys and in the interior of towns and villages.

#### Maps on the Scale of 1/5,000

25. About February and March 1916 the first British 1/5,000 plans were issued. In the French Army the 1/5,000 issue has always had a fairly large place. There is no doubt that something bigger even than the 1/10,000 is wanted for infantry work in an intricate system of entrenchments and during stationary warfare but British mapping units had been unable to cope with this demand except in a few cases of special importance.

#### Formation of the 5th Field Survey Company

26. During the early summer of 1916 the 5th Field Survey Company was formed and the addition of the number of draughtsmen and topographers began to make itself felt in the extension of the compilation maps Eastwards.

#### Battle of the Somme

27. The battle of the Somme put the first severe test on the capabilities of the Field Survey Company in mapping. The frequent attacks and small advances, the number of new trenches which appeared in the course of the fighting, the frequent cry for new editions, began to make it apparent that the system hitherto in force of relying on the Ordnance Survey in England for the reproduction of trench maps was not sound. In many cases in this battle Corps produced duplicator sheets of their own, and there is no doubt that operations suffered from the lack of rapidly produced topographical and trench information. It also led to the demand for special overprints dealing with counter battery information and with special administrative organisation. The hand presses of the Printing Section with each Army were quite unable to cope with the numbers and speed required.

#### German Retreat on the Somme

28. The German Retreat on the Somme took them back to the Hindenburg line which lay partly on maps which had previously been compiled and partly beyond the limits of anything but the original 1/80,000. During the earlier periods of the war, before the troops had become accustomed to a large scale map it was possible to devote the necessary time to the preparation of a good map before issuing anything more than mere enlargements. At this period, however, it was not possible and temporary maps had to be produced, with very little information, and proved to be more or less inaccurate. Moreover opposite St. Quentin and indeed almost as far North as Arras the cadastral plans were not available and such copies of the 1/10,000 Communal Indexes as could be procured in Paris were the sole available information.

#### Wide Angle, Short Focal Length Photographs

29. In the Autumn of 1915, the immense value of photographs covering so large an area that several fixed points would appear on one photograph had already been pointed out to the Royal Flying Corps. For a long time however such cameras were not available. They came into use first in early 1917 and then in very small numbers only. Had they been available during the retreat on the Somme a great deal of most important work could have been done and the initial issue would have been sufficiently accurate to have served as a basis for subsequent editions.

### Formation of Corps Topographical Sections

30. The experience of the fighting of 1916 had shown very markedly the need for some small map organisation in each Corps which could provide an immediate representation of the situation upon already existing backgrounds. The Field Survey Company was necessarily too far from the line for it to produce and distribute maps with the necessary speed. Prior to this, Corps had already produced many temporary maps but these maps were of the same order of accuracy and showed the same faults as those prepared by the Army Staffs in the early portion of the War. It was necessary then to train the officers for these Corps Topographical Sections in good mapping methods, and to equip them with a few draughtsmen who had been specially trained in plotting from air photos. For reproduction an Ellams duplicator was given in preference to a hand press on account of its greater rapidity. These Corps Topographical Sections were raised in the autumn of 1916.

### Counter Battery Work

31. In the early days of 1916 a good deal of progress was made in the graphical representation of counter battery data and of targets of all sorts. The 5th Field Survey Company were the first to produce a counter battery map in its existing form embodying zone call areas. Target maps and counter battery maps were produced at something like monthly intervals.

### The Battle of Arras

32. With the experience of the previous fighting to go on the staff of draughtsmen in the Field Survey Company continued to expand and attempts were made to secure printing machinery. Orders issued by the 3rd Army at this period laid down that a map was to be produced daily showing the situation at on the day before. It was obvious that this could not be produced in the requisite number, nor with the necessary speed on hand presses and a printing machine was brought out and installed prior to the battle. The daily issue of situation maps was thus rendered possible, and it was also possible to keep up special sheets and issue them in the requisite quantity. During battles of the type of that of Arras or of the Somme in which local objective succeeds local objective it is not possible to continue overprinting on sheets of the regular series. In fact from that time onwards until the final campaign of 1918 it became necessary everywhere to have special editions differing in sheet line from the regular series, and designed to cover on one sheet the front of each separate Corps.

### Forward Areas

33. In the meanwhile the compilation of forward areas was pushed steadily ahead and by midsummer had joined up in most places to the original Fortress Plan Directeurs or to the Belgian Maps, except opposite the 4th Army Front, where a wide gap existed, and where even the front line trench maps had not yet been satisfactorily made.

During the fighting on Passchendaele Ridge in the Summer of 1917 most of the draughtsmen available were concentrated in the North. The compilation in the South therefore went on very slowly and had not reached the Fortress Plan Directeur of Birson before the British Retreat in March 1918.

## Photo Reduction Maps

34. No further developments in method are noticeable during this period except a growing reaction against the "photo reduction type" of 1/20,000. For the sake of economy the original 1/10,000 trench maps produced by the Field Survey Battalion were directly reduced and compiled into the 1/20,000 series. This led to a minuteness of detail and a smallness of writing which often proved troublesome to the troops actually in the line, and brings out rather strongly the fact that each scale should, if possible, be drawn for itself without reference to reduction or enlargement.

### (vii) MAPPING IN THE MOBILE CONDITIONS OF 1918

#### The British Retreat in March 1918

35. During this period the rapid movement made the question of continuous map issue on a large scale almost impossible to deal with. A large amount of the actual fighting was done on the 1/10,000. Hitherto very few attempts had been made to produce a trench map on this scale. There is no real reason against it but it implies printing in grey instead of colour as had been the usual practice. The line finally steadied in such a position that for the most part it remained on well mapped country, but in the 5th Army it had been pushed beyond it. Immediate steps were taken to extend the topographical survey well backwards to provide for any further eventualities.

#### Back Area Surveys

36. All back area surveys were carried out like other previous topographical surveys on the 1/20,000. During their execution various ways of using the cadastrals were tried. It was found in the end that the following procedure was the best:

- (a) A rapid test of the triangulation in the sheet and the addition of a number of subsidiary points and heights.
- (b) The addition on a plane table and by a topographer of a number of cross roads and points of detail readily observable on air photographs. In fact a sort of fourth order triangulation.
- (c) Compilation of cadastral plans on this framework.
- (d) Revision in the field for such parts as were not well covered by air photographs.
- (e) Detail plotting from air photographs on the framework so secured.
- (f) Contouring in the field.

#### Conventional Signs

37. During 1918 an attempt was made to secure complete unanimity of grid and of conventional signs along the whole of the Western Front. This led to the adoption by us of a good many signs which made for clearness and for lightening the map. An example is the question of trees. The British conventional sign for a tree has always remained a symbol representing a vertical section rather than a horizontal section. The French sign of small circles and dots is at once clearer and lighter than our own and was therefore adopted.

## Secret Maps

38. Throughout this campaign a good deal of misconception has arisen on the subject of secret maps. In the Autumn of 1915, a French Commandant Commanding a Groupe de Canevas de Tir informed his General Staff that he had no good maps of his trenches up to date because no German maps had been captured for the last month. This is an illustration of the fact that our maps of the German trenches were more complete than their own, and the German maps were more complete as regards our own trenches. There has never been therefore any call for secrecy in showing the trace of our own trench system providing that no really secret details are inserted on them. Such secret details obviously include battery positions, trench mortar positions, command posts, telephone routes etc and indeed may be classified as anything which cannot be readily located and plotted from air photographs. A small secret edition of the trench map at 1/10,000 was allowed for but in such small numbers that the troops in the trenches made their own diagrams and sketches, which were freely distributed, and which from the information of all sorts inserted upon them, were much more dangerous than a regular issue properly controlled would have been. There was also an objection to a secret issue made on the 1/20,000. The refusal to introduce a much more liberal issue of secret maps has led to a waste of labour and of personnel which might otherwise have been saved. Monthly defence schemes, reports on defence lines etc necessitated the production of large numbers of these secret maps, and as no official issue was made the detail had to be drawn in by hand.

### Distribution of Maps

39. The distribution of maps has already been arranged on a liberal enough scale by higher formations but has not always been carried out by the lower formations in a sensible way. A map is a peculiarly perishable article and in bad weather must be renewed extremely often. It is, however, the commonest thing to find that troops have gone short. On investigation this generally proves to have been due to the idea of some subordinate that once an officer has been issued with a certain map he is responsible for its maintenance and has no right to call for another.

Transport difficulties are of course very acute and no transport at all has been authorised for the issue of maps from a Corps. Theoretically the issue of maps throughout the Corps should be made by and through that Corps. Practically it has never been possible to do it, neither has there been any officer with the necessary time or experience to see that the distribution is carried out.

Map distribution is one of the duties which had been foreseen for GENERAL STAFF (Intelligence). As a matter of fact the distribution down to Divisions has been done throughout by the Field Survey Battalions and this has made such calls on the transport as seriously to affect the work of other branches of the Battalion.

A very useful means of ensuring that each officer has the necessary maps, is the provision of Map Depots near the line. These Depots were fairly common during the period of position warfare and at them an officer was allowed to procure up to ten copies without reference to higher authority.

It is very doubtful however if map distribution has reached its economical point yet. In some Brigades special maps have been produced for every soldier taking part in an attack and if it is true that a graphical representation is worth much more than detailed written instructions, then it follows that for any operation from a raid up to a general attack special maps should be distributed at least down to Platoon Sergeants.

## PART III. THE TRIGONOMETRICAL FRAMEWORK

### Original Data

40. The form in which the values of the French and Belgian Triangulations originally reached us has been mentioned already in Section II, and in the same section mention made of the adoption of the Bonne Projection with origin at Brussels Observatory.

A further note is necessary however on the triangulations of France.

The ruling factor in N.E. France is the Paris arc of meridian and the parallel of Amiens. Now each of these has two editions, the 1800 and the 1900. The 1800 is the backbone of the triangulation reaching over the whole country: the 1900 is not but has attached a largish area of cadastral triangulation centring at Doullens and extending Westwards to the coast, and eastwards to Hebuterne. The first, calculated on the Ellipsoide de la Carte de France, starts from a different standard of length, base, latitude and azimuth, from the second. The results of the two can be used in common, only after a laborious research, and for this reason the original French Lists dealt with the 1st and complete triangulation leaving the second without mention. In the first however the subsidiary orders are of poor value and include many lost or altered points, whilst the second, a really good triangulation is still more or less intact, and includes many ground stations which the first does not.

The Admiralty triangulation is good of its kind but is calculated on Clarkes Spheroid, is given in coordinates on a special projection, and has few connections to the triangulations of the Service Geographique.

The coordinates of the Belgian Triangulation are taken direct from the Belgian records. Now these coordinates were calculated from the original latitudes and longitudes by interpolation from a table. The table, in itself correct, gave the coordinates corresponding to the intersection of certain meridians and parallels. Inasmuch, however, as the parallels are curves by so much are results, got by interpolation, in error. Negligible for plotting purposes this error is most serious to the trig work for it may bring in angular distortions foreign to the original work, and to the projection, of over a minute.

In 1915 the Ordnance Survey calculated the coordinates of the French National Points on the Belgian Bonne from a similar table, and this class of error therefore burdened all the data available. On beginning the resurvey the difficulties of calculating the coordinates on the Belgian Bonne were almost insuperable. One computer alone was available and even with officers help (which could ill be spared) it was impossible to do anything further than to make a local Cassini Projection for the area of resurvey, such that, on its extreme edges, it showed a divergence from the Bonne which was not plottable.

In the light of subsequent events, this approximation had disastrous effects, for the area occupied by the British Army grew far too large for such treatment, and an effort had to be made to get back to the original projection.

### Retriangulation

41. In May 1915 the growth of Artillery Survey work, meaning as it did, constant recourse to resection, led to a retriangulation of the front from Ypres to Bethune. The results of this work, hasty as it was, were excellent and may be classed as given an order of precision of 1/30,000.

## Single & Divided Control

42. So far, however, the trig work was done under one head. The errors of each portion were known and the past history of the national triangulations understood. With the advent of topographical sections the troubles began again at the beginning.

Each Army started to bring all its points into sympathy within its own boundaries and without regard to its neighbours.

Thus, in the 2nd Army, Capt Simms, whose great zeal and high technical qualifications did so much for survey methods in France, instituted a new system on Bessels figure, thereby adding fuel to the flames, and made a portion of Belgium and a portion of France agree in a set of rectangular spherical coordinates which left the 1st Army 18 metres out of adjustment on the edge.

Captain Matthews, also a surveyor of great parts, adopting an arbitrary azimuth, and also working on rectangular spheroidals, did the like in 1st Army area and failed to touch on to the 3rd.

The latter adopting the maxim that the points immediately within the German lines must be referred to as the arbiters of position, continued to fit their triangulation locally to them, and the 4th and 5th following up the German retreat, carried a system of rectangular coordinates across the gap, only to find that these chains were out of touch with the values of points within German territory. These latter must remain the important factor for they define the position of German batteries on the map.

The above appears to indicate a general and disastrous muddle. Such a muddle really existed but fortunately was not large enough to disturb the work of the Artillery. It did however mean mistakes in the survey of Sound Ranging Bases, and much unnecessary trouble in dealing with undigested and often irreconcilable material.

## Coordinates

43. The obvious lesson is that

1. Some projection should be selected in advance such that
  - (a) Angular accuracy is safeguarded as far as possible.
  - (b) Systems of plane rectangular coordinates can be used on it without appreciable error, if controlled by ruling points.
  - (c) Corrections due to Projection are small and simple in calculation.
2. That some good real geodesist with a staff of Computers should control the triangulation of the whole area and insist on certain ruling coordinates being retained.

## The Retreat in 1915

44. The retreat in 1915 brought the 3rd and 5th (later 4th) Armies well into the area of the 2nd or 1900 French Triangulation. It was of immediate and practical utility, and as, by this time, a central office was available at G.H.Q. full information was ready to hand. All points of the old triangulation were quickly

put in sympathy with the new, whilst the growth of knowledge in the various Armies made it possible to understand and to adhere to the projection.

Steps were taken to extend the new values over the whole of N.E. France and were nearing completion when the final victorious offensive took us back on to the old values just too soon, and would no doubt have added much subsequent difficulty had the line become stationary for any length of time.

#### General Lessons

45. Wisdom comes tardily after the event and in spite of the undoubted fact that British trig work served its main purpose, and ranks higher than French or German, one must acknowledge that the former have evolved the best projection and grid whilst the latter have assigned a staff much more commensurate with the real importance of the subject.

More than all however does the choice of trig officers affect the question. All the work of survey in the field depends upon this choice. For years we have had in this most important position some whose zeal far outran their knowledge, and whose work had to be redone. None but the most expert surveyors should be chosen and their knowledge must include a grasp of projections and of coordinate survey which is not common to the bulk of English and Colonial surveyors.

#### Grid

46. Finally on the subject of grids. The grid must naturally allow a system of easy and natural referencing. To this end it must consist of squares. The referencing must be such that it can be abbreviated for general, or lay, use and amplified for the trig hand and the gunner. It must therefore be continuous over the whole area and not confined to a sheet. It must define lines of equal value in the coordinate system of the projection adopted, and for the sake of the observer and computer should be orthomorphic.

With our existing grid there are few who can give a correct reference in "Noman's Land" between 1/40,000 sheets, and few care to tackle the work of computing bearing between the points as defined in our system.



## PART IV. BATTERY SURVEY

### Earlier History

47. In February 1915 a 15" Howitzer came to take up position in the 8th Divisional area. The arc of fire was to include both Fromelles and Aubers and the Ranging Section R.E. was asked to lay out the platform and centre line. In the subsequent report ranges and bearings to all prominent points in German area were given.

The 9.2 Howitzer Batteries which arrived shortly afterwards were dealt with similarly and the practice became popular so quickly, that by the end of February most heavy and siege batteries were fixed and the Battery Commanders had been supplied with information concerning all fixed points.

Working from a Headquarters in La Gorgue, two or three trig observers were able, at this time, to deal with all heavy and siege batteries on the front.

### Map Shooting on Original Enlargements

48. The issue of this information marked an immediate advance in map shooting, for it showed up areas which were particularly in error on the map, and allowed of a rapid estimation of good line. Aiming points were always included in the survey.

### The Battle of Neuve Chapelle

49. Before the Battle of Neuve Chapelle, a quantity of siege and heavy batteries were concentrated for the preliminary preparation. All these were fixed and line given to aiming points. In the case of batteries which came in at the last moment, the field in which they were to take up position was surveyed and bearings were given from a central place in the field.

### Battery Boards

50. A general demand soon became apparent for the provision of this information in graphic form. In June 1915 many new batteries appeared and our line was lengthened to the Southwards. A special small Section was sent to Bethune to deal with the battery fixation.

Some of these batteries which were in the extreme South of the new area came in touch with the "Groupe de Canévas de Tir" of the 10th French Army and were given 'planchettes' or battery boards by them. This naturally increased the demands for such boards.

### The Second Edition Map

51. The second edition appeared at this time and in all those cases in which the arc of fire fell on French Fortress Plan Directeur material, the combined effect of a good map and an initial well fixed position and line was much commented on. In the South end of our front however the territory in German occupation was still shown on enlargement or local General Staff (Intelligence) Maps and in these cases the position of targets had to be referred to the nearest trig point.

## A Battery Commanders View

52. The following is a letter received from a Battery Commander at that time. It shows the progress which had been made both in the introduction of the idea and the use of it by the Gunner.

"Value of information received from the Survey Section and recommendations for the future.

1. The exact location of battery positions irrespective of the detail of the map (which may be, and is often, wrong) and of certain points trigonometrically fixed in the enemys lines is useful.

At present a battery coming into action fixes its position from the detail on the map and proceeds to register some point in the centre of its zone which is easily recognisable.

In this area in 9 cases out of 10, either the battery position or the target is wrongly marked on the map.

In consequence the initial line must be bad and there is an unnecessary wastage of time and ammunition even with visual observation. Without visual observation the advantage of having accurately fixed lines and ranges becomes more apparent. It follows that the error of the initial line will apply equally to all subsequent registrations.

2. The Officer Commanding Ranging and Survey Section has supplied this Brigade with positions of batteries and targets relative to the triangulation system. I have therefore consulted him with a view to ascertaining how best to make use of the information at his disposal.

3. From our conversation I have arrived at the following conclusions:

- (i) To have all battery positions trigonometrically fixed.
- (ii) To have all observation stations similarly fixed, in so far as this is possible, without giving away their positions.
- (iii) To have a list of all trigonometrically fixed points in our area.
- (iv) To have this information both in tabular and in graphical form, such as a tracing or skeleton map.
- (v) To fix in advance such alternative battery positions as have been prepared or reconnoitred for occupation.
- (vi) To secure information as to any points which are known to be out of position on the map.

4. In the identification of targets by aeroplane the following difficulty occurs. A target located by an aeroplane from the detail on the map is described by the square reference shown on the map as corresponding to that position. The detail is, however, often displaced in the square owing to the inaccuracy of the map.

Providing that I knew from trigonometrically fixed points in the neighbourhood, how much the detail is swung I can readjust my lines of fire

accordingly. For this reason it is desirable that the trigonometrical information should be given graphically, as mentioned in paragraph 3 (iv), on a tracing which should be superimposed on the existing map."

#### Third Army Battery Boards

53. The 3rd Topographical Section started life in July 1915 and immediately began to prepare and issue battery boards. These were made locally and covered with zinc sheets. The grid, the trig points, and the position of the battery or directing gun were shown, but no map was added, and indeed no decent map was available.

In one or two cases the trenches were plotted as correctly as possible and hand drawn on the board. This was done for the 6" Howitzers only.

#### The Preparation for Loos

54. Batteries were now congregating for the battle of Loos. A party from the old Ranging and Survey Section took up its Headquarters in Bethune to fix positions and line.

From Laventie in Lorette all Heavy and Siege batteries were fixed and provided with battery boards, whilst the field guns and light howitzers were fixed graphically (for the first time) and given tracings (to put over the map) showing all fixed points.

The French 10th Army also helped in the work and supplied some of the batteries in the extreme South with "planchettes".

#### The First Field Artillery Boards

55. Directly the first good 1/10,000 trench maps had appeared one or two field artillery boards, showing the particular trench sectors affected, were made up for selected batteries. Comment was very enthusiastic. In many cases observation on trench targets is very difficult and a good battery board is of great assistance.

#### Insertion of Maps on Battery Boards

56. Although in theory the skeleton of fixed points is all that Battery Commanders really require, the addition of squares of the map pasted back into place was asked for so frequently that battery boards constructed on this principle were issued as soon as the forward maps were of the necessary accuracy.

#### The Somme Battle

57. The battle of the Somme put the same severe test on battery survey as it did on the map supply. Transport again became the guiding factor. It was impossible to continue work from Company Headquarters, and plane tablers or trig observers were attached to Corps Heavy Artilleries. Moreover as every conspicuous trig point was flattened out the difficulties of survey were enormously increased.

The experience which led to the formation of Corps Topographical Sections led also therefore to the decentralisation of battery survey for the field artillery to the Corps Topographical Sections. Unfortunately this step which might have been advisable had sufficient staff or supervision been available, has resulted in almost completely stopping the application of survey principles to the work of field artillery. The Officer i/c has so much office work to do that the proper supervision of his plane tablers is impossible.

## Survey Pickets

58. During 1915 an enormous number of points were fixed in connection with battery survey. Reserve and alternative positions, aiming points, etc. were continually being surveyed.

To prevent duplication of work in the Somme neighbourhood it became obvious that permanent marks of iron must be used. In the autumn of 1917 1916 therefore the 3rd Field Survey Company was using these pickets everywhere and lists referring to the numbers marked on the tabs tied to each picket were distributed to all gunners concerned. In several cases such pickets were expressly inserted for the convenience, in finding line, of the battery commander concerned.

This was the origin of the present day bearing picket, though their general use did not follow for some time.

## The Battles of Arras and Messines

59. A new departure before the battle of Arras was the survey of forward positions, in or close to, our own trenches. The regular progression of the barrage is obviously a most vital matter and the survey of forward positions together with some provision for finding line is a natural corollary. The advanced positions for the 9th Divisional Artillery were so surveyed and this previous preparation proved its value in the gain of speed and accuracy.

The same general procedure was followed at the battle of Messines.

## Battery fixation during operations

60. It is, however, during the course of such battles that the real difficulties begin.

The necessity for pushing forward the trig skeleton, and the congestion on the roads and the heavy reaction from the enemy's artillery are all contributory causes, whilst perhaps the greatest trouble of all is the difficulty of getting information as to the movements of batteries. The battle of Passchendael introduced extraordinary difficulties in all these directions.

## The Battle of Cambrai and Bearing Pickets

61. The battle of Cambrai began a new era. The tendency to rely for success on a complete artillery surprise was of course natural and inevitable. A complete surprise means however map shooting and no previous registration. This in turn implies the most careful preparation for line and to a slightly lesser extent for position. The survey preparations for this battle were therefore most thorough and included the insertion of a "bearing picket" sufficiently close to each battery to allow of easy reference. Every battery, heavy or siege, which took part was visited by an officer of the Field Survey Battalion.

From this time onwards bearing pickets became a most recognised feature of the preparation for attacks and lists of them and of bearings from them have been distributed to all gunners concerned.

## The Preparation for Operations in 1918

62. Naturally the survey preparations for a defensive battle are more extensive than those for an attack. The number of alternative and reserve positions is much larger and a considerable area in depth has to be allowed for. Trig points and bearing pickets were fixed and marked throughout the zones in which fighting was anticipated.

### The German Offensive

63. During the movement little could be done to help batteries. The impossibility of finding them and the frequent change of position made any attempt worthless, but it is also doubtful if survey can help at all under these circumstances. There is little counter battery work and targets are mostly under direct observation.

### The Counter Offensive

64. During the preliminary battles of the counter offensive the bearing picket resumed its importance. It had now become a general practice throughout the length of the line to provide these pickets and short courses were held at each Battalion to explain their use.

The Canadian and Australian attack in front of Arras owed a large measure of its success to the complete artillery surprise, and an examination of the German battery positions after the attack showed how successful and accurate the shooting had been. A considerable part was played by screen calibration but much is due to the proper use of survey methods in obtaining line.

Before the attack the position of many of our own batteries was taken from air photographs. Line was found however invariably by some direct survey method. Sun Azimuths were observed in cases where more simple methods were impossible.

### The Final Advance

65. The survey was carried up with the advance until the last stages. Naturally however as conditions became more and more mobile transport difficulties intervened and the necessity for survey diminished. Positions were fixed up to the last but bearing pickets and battery boards were not always available.

In one Army a return was made to the practice of earlier days in issuing boards with a skeleton grid and the trigs plotted on it. The Battery Commander himself inserted his position on his board, and used a protractor, in place of a paper arc.

The overlap between the 1/10,000 sheets naturally makes it impossible to issue a board for universal use but in this case an overlap series of squares was plotted at one third of the breadth and the battery had therefore to be plotted in its correct relation to the overlap.

## PART V - THE OBSERVATION SECTION

### Early History

66. Flash Spotting has always been a recognised method of locating hostile batteries. Before the War Siege Observers were particularly well trained in this duty, but no attempt had been made to constitute any separate unit entirely devoted to this end nor had the difficulties of flash spotting during times of great artillery activity been foreseen.

It is impossible to locate batteries in this way unless arrangements have been made to ensure that all observers look at, and record the bearing to, the same flash at the same time.

In the Autumn of 1914 much unorganised flash spotting was done along the whole front line from YPRES to BETHUNE. Locations were numerous, but most inaccurate, for the positions of the O.Ps were never properly fixed, even on the, then, extremely inaccurate map. Bearings were referred to magnetic or true north, without proper R.Os and it was impossible to be certain which rays were taken on the same battery.

In the early days of 1915, an attempt was made to combine the results from FOSSE 9 and LAVENTIE CHURCH, and a certain measure of success was obtained.

### Early French History

67. The French were in the same position as we were ourselves in the earlier periods of the War. By April 1915 they had however one or two flash spotting organisations well arranged. One particularly worthy of note was that organised by the Groupe de Canévas de Tir of the 7th French Army in the VOSGES. The bearings from the different O.Ps (which were well fixed) were taken with good instruments and referred to known R.Os. Careful stopwatch flash to report intervals were measured and the resulting locations were compared with the reports from Airmen and from Balloons.

### German Early History

68. The German Army had gone more thoroughly into the question in peace time and had an organisation - the "MESSPLAN ABTEILUNG" - which supplied a Section for the siege of ANTWERP. A description of this unit was captured at the battle of LOOS.

### The Artillery Survey Detachment

69. The compilation of the first large scale (1/10,000) maps on the new Third Army Front made it possible to fix accurately many of the German Battery positions which appeared on photographs. It was found that these positions differed markedly from the counter battery lists of the day and that many batteries were supposed to exist of which no trace could be found.

This fact combined with the growing desire to secure a more accurate knowledge of enemy movements led to the formation in October 1915 of the Artillery Survey Detachment.

Manned by a mixture of gunner observers and trained scouts it was officered by R.A. Subalterns and the control was divided into Administration and Tactics under the R.A. and technical method under the Officer Commanding Topographical Section.

The O.Ps originally seven in number were spaced too widely along the front, and the only form of concentration on one single battery was by accurately timing the flashes observed upon.

The Officers went through a short course at the Headquarters of the Topographical Section.

The establishment of this Artillery Survey Detachment included One Officer, 6 Observers and Telephonists, and 1 cook for each post. The Topographical Section of the Army remained the collecting centre for information from the posts.

#### Breakdown of dual control

70. Meanwhile much trouble was caused by the dual control. It was found that orders received, on the one hand from the R.A. and on the other from the O.C. Topographical Section were not always reconcilable, and made demands on the time of the small staff employed which could not be met.

The M.G.R.A. of the Third Army decided therefore to leave all matters Administrative, Tactical, and Technical, in the hands of the O.C. Topographical Section. This decision was approved of by the Army, and from that date the O.C. Topographical Section, or Survey Company, has acted in the 3rd Army as the Officer responsible to the M.G.R.A. for the efficiency of flash spotting, and for the best employment of the personnel available.

#### Synchronisation

71. For the first month very few good locations were obtained. The posts were too far apart, telephonic communication was bad, and the Topographical Section was too far away to intervene successfully. An advanced Headquarters to which all posts were connected, was soon added, and the team work improved considerably.

Early in 1916 arrangements were made to split the Section up into Groups of from three to four posts, each Group under an Officer.

At the same time a "drop shutter", ringing bell, exchange was tried as a method of making sure of the coincidence of observation from the posts. Unfortunately the drop shutter proved too slow.

Meanwhile the 3rd Army moved Northwards to take over the Arras Front and in taking over secured an excellent Artillery Command telephone system, part of which was handed over to the Observation Section, and at the same time secured many valuable ideas from a French Flash Spotting Group which was in the process of formation.

The personnel at each post was raised to 10, the "flash and buzzer" board, a great stride in synchronisation, was introduced, and by May 1916 the Group assumed what proved to be more or less the final form.

#### Second Army Flash Spotting

72. Meanwhile a good system was gradually being built up by the R.A. in the Second Army Area.

The IInd Corps R.A. took a leading part in its formation and a Section of particular merit was installed on the front from Hill 63 to the Southern Outskirts of ARMENTIERES. This Section was commanded by Lt Col Pottinger and was manned by R.F.A. The instruments used at the post were Sectors with alidades, but "Instruments, Observation of Fire" were introduced in December 1915.

In November the 2nd Army decided to make flash spotting an Army, as opposed to a Corps, Formation because of the frequent changes of Corps Areas.

Throughout its history this 2nd Army Flash Spotting organisation was thoroughly sound and in close touch with counter battery work, suffering only from poor accuracy of position and R.O., and poor accuracy of plotting. Observation for ranging was begun also.

The formation of the Field Survey Companies by G.H.Q. in February 1916 brought this Flash Spotting Section under the command of the 2nd Field Survey Company.

#### First Army Flash Spotting

73. Shortly after the formation of the Artillery Survey Detachment and following on a Conference held by the D.M.I. the 1st Army formed a Flash Spotting Section.

The men were in no case gunners, and the instruments were theodolites reading to 10 seconds. In fact neither the end in view, nor the means to that end, were properly appreciated.

To make matters worse, each post was ordered to report individual flashes to the R.A. thereby destroying the chance of securing a location.

In spite, therefore, of the fact that at the close of the War the First Army Sections were some of the best, it took a year and a half for flash spotting to live down its early mistakes in this Army.

#### Fourth & Fifth Armies

74. In 1916 the Fourth & Fifth Armies came into being, each in turn taking over the original Artillery Survey Detachment Headquarters at Bouzincourt.

Flash Spotting was organised throughout the line under the Field Survey Companies and in close touch with the Sound Ranging Sections which were then coming into being.

#### The Battle of the Somme

75. The battle of the Somme was the first test on the ability of all geographical methods to meet mobile conditions. It was, naturally, impossible to arrive at a sound tactical programme without such experience. The two extremes became apparent, however, at once. On the one hand, under the orders of an old regular gunner everything was sacrificed to mobility and the Group became a mere collection of individual posts (or F.O.s) whilst on the other overcaution and delay meant few results and loss of the confidence of the artillery.

The style of this battle with its succession of local objections lent itself to an advance of post by post rather than to a general move forward of the Group.

#### The Observation School

78. Meanwhile a School for Observers had started at Beaumetz (in March 1916), was then moved to Dainville (in April) and had become the regular training ground for observers in the 3rd Army. Training was also done for other Armies. In August 1916 larger quarters were taken in Beaumetz Chateau and a School large enough to train systematically for all Armies was started.



The dummy ranges, the O.P. with its actual view over the trenches, the growing experience of the O.C. and his instructors, combined to make it an efficient and useful accessory.

#### Observation for ranging

77. Observation for calibration and ranging had been one of the duties foreseen in both 2nd and 3rd Armies. It did not make much headway however until the middle of 1916.

By this time all Groups of the 3rd Army, and some others, had graphs ready for a number of datum points and targets. At this period German Artillery Tactics included the construction of a number of clearly defined heavily protected positions, which were very visible on air photographs and which continued active for months. Shoots upon these could be undertaken at any moment providing they were visible from the posts.

It is curious that these graphs (at a scale of 1/2500) are still the recognised method of plotting the fall of rounds in the French Observation Group of today.

#### Training in Mobile Warfare

78. With the lessons of the battle of the Somme in mind, courses of instruction in mobile warfare were held in preparation for the battle of Arras.

A Group of three mobile posts with forward and a rear Headquarters was the organisation chosen. Speed of construction of lines, of fixing positions graphically and of subsequent computation, organisation of transport and packing were all practised. These courses were most valuable and taught many lessons.

#### The Battles of 1917

79. The battles of 1917 were not responsible for any marked advance in methods or tactics. Advances were too small to give much practice in mobility and the change in German Artillery Tactics - the introduction of alternative positions, wandering guns and the value given to concealment at the expense of protection - brought many new difficulties.

The obvious lesson, however, lay in getting into more intimate touch with the R.A. generally: counter battery office and battery alike. Many Group Officers, who were not usually gunners as these latter could not be spared from their batteries, were attached to batteries for a period. Courses of instruction in flash spotting were given to R.A. Officers and men. Lectures were started at Artillery Schools and Observation was freely done for calibration and ranging. It was, in fact, realised that intimate cooperation is quite as vital as intensive technical training.

#### G.H.Q. School

80. In the Spring of 1917 the 3rd Army School was taken over by Maps G.H.Q. and was removed, in stages, to its final position. Throughout its career its instruction has remained exceedingly practical and sound, and the value of its recruits and advanced courses has been most marked.

81. Three points of considerable interest arose in this period. Firstly the value of work on daylight flashes was much emphasized by the excellent results secured in the coast area East of Dunkerque. In the rolling downs South of Notre Dame de Lorette, with which the earlier progress of flash spotting was associated, little had been done on daylight flashes, and from lack of practice and opportunity the point was largely overlooked. Secondly the introduction of Report Centres by the 1st and 2nd Armies marked a great advance for purely stationary conditions. These Report Centres were instituted with the idea of warning all location units of whatever sort at the first hint of activity in any particular locality. The 1st Army system was considerably the more efficient, and the general introduction of these report centres would have added greatly to the efficiency of both Observation Groups and Sound Ranging Sections during trench warfare. Unfortunately the other Armies were apathetic and the point was not pressed by G.H.Q.

The third novel feature was ranging on a shrapnel or high air burst. This method, simple enough from an observation point of view, but bringing in certain difficulties in ballistics had already become common in the French and German Armies. The British Artillery lacked the necessary time fuses for H.E., but in spite of this fact, this form of observation grew gradually into favour. Considerable impetus was given to it by the excellent arrangement and the extraordinarily quick reporting introduced by Captain Cockburn during his period of duty at the Overseas Artillery School.

#### The work of an Observation Group in a Day

82. Early in 1918 the Observation Group was at its most efficient period for a war of position. None were up to strength however for it became increasingly difficult to procure, train, and send up reinforcements. The average strength allowing for casualties and leave may be taken as 2 officers and 44 other ranks.

We will now take a typical group and run through the sort of programme of work common on a typically busy day of good visibility.

Starting at 9 a.m. the first thing is to investigate the list of calibration or other sheets which are pending. The list would include some ten items or so. The first item, a calibration for a heavy railway gun from a back position is started on with posts 1 - 2, and 4. No 3 is "dis" and linemen are repairing the lines. One officer meanwhile sets out to fix and height a new alternative No 4 post. The computer is busy working out interpolations for some reserve posts which were reconnoitred the day before.

At 9.45 an imprudent German Balloon ascends rather too close to our line. The "long guns are quite ready to cooperate, and a shoot is begun at once upon it running for a few minutes concurrently with the calibration.

At 11 a.m. the Germans fire a "crash" on a village in rear and one trisection on a muzzle flash, two intersections on "puffs" and one "ray and time interval" result. By lunch time three calibration shoots have been finished, and at 2 p.m. the Report Centre gets an indication from a neighbouring S.R. Section which secures another good trisection. At 2 p.m. an observer spots a column of some thirty Germans just within 60 pdr. range. After urgent appeals and a ten minute wait, fire is opened just too late: the opportunity is gone.

Meanwhile the O.C. has gone to see Nos 1 and 2 posts and the Second-in-Command has just received some sketches of datum points for an incoming battery whose O.C. arrives to fetch them. The sites suitable for observation in a certain

sector are discussed and panoramas looked over. Meanwhile the C.R.A. of a Division new to the sector has arrived at No. 3 post and has found there an observer specially warned for the purpose who has been long on the front and knows it thoroughly. Panoramas are available and the inspection goes on whilst the post takes part in a ranging shoot. An old friend, shall we say VA 23 is spotted in action. The Counter Battery Staff Officer is stirred to activity. The Group observes - Fire for effect follows on a good M.P.I. from a 9.2 battery and tea is sweetened by the sense of having got on with the war.

At 6 p.m. however retribution overtakes No. 1 post which is heavily shelled. It is cut off at once and whilst 2, 3 and 4 hunt for the offender the personnel of No. 1, minus one man wounded, remove instruments to a safe distance. The offender is caught by the Sound Ranging Section who ranges back on it, the wind being favourable. The lines to No. 3 are repaired and the post is reoccupied. From now on to 8 p.m. the firing is continuous and ten good locations are made.

At 10 p.m. a sudden bombardment heralds a British raid. The Counter Battery Staff Officer having called up six times running in half as many minutes is now given locations on two of the reacting batteries, and the opinion of the O.C. of the Group as to the probable position of four others.

The O.C. is now writing his "General Report", the graphs for the calibration shoots of the day are just finished and the N.C.O. on the Group Board is exhorting No.2 in which a new observer is peculiarly slow in getting on to a battery.

The Second-in-Command wrestles with returns.

A final conference on the new plotter which the O.C. hopes will revolutionise flash spotting is the last item in his day.

The Second-in-Command goes to see No. 3 post.

Throughout the night a few H.V. Guns "harass" our back areas and several more locations are made.

One of our harassing batteries is ranged, by air bursts, on a dump of ammunition. At 7 a.m. in the growing light the Germans show increased activity and by 9 a.m. the total bag is 20 locations by three or four line observation and 10 intersections of which 4 are checked by a good "flash to report" time interval.

#### The operations in March and April

83. On the extreme South of our line the retreat was too pronounced and continuous to allow of much flash spotting. Indeed Artillery work generally was on visible targets or on cross roads and communications. Locations would not have been of great value. Groups were assembled in rear and formed part of "Careys Force" for the defence of AMIENS, suffering fairly heavy casualties.

On the 3rd Army front however movement was more methodical and much less rapid. Groups were able to keep in action, changing bases every day and keeping touch with the nearest heavy battery or Brigade.

Here, as always in mobile operations, the chief difficulty lay in keeping in touch with someone who could exploit the information gathered.

On the LYS front the experience of the German Offensive followed very much on the same lines with added difficulties of topography: for the country, flat, heavily timbered, and closely intersected with hedges, affords extremely few good observation posts. Touch was completely lost with C.B.S.Os as it had been in the South.

## Operations from May to July

84. As the line steadied observation groups took up their ordinary duties again. The numerous and accurate locations in the LYS salient and from the VIMY RIDGE were perhaps the most noticeable feature in location whilst calibration and observation for all sorts of shoots continued to a greater extent in the South where muzzle flashes are rarely visible by day.

## Mobility

85. In the meanwhile much thought was devoted to the mobility of the Group. The original 3rd Army Course early in 1917 and subsequent mobile courses at the School were on sound lines. In them an effort was made to make all affairs of detail into a routine or drill which should follow automatically whilst educating N.C.Os i/c Posts to select and fix their own posts and generally to use intelligence and initiative. These ideas were not accepted everywhere. No opportunity had ever been given for real "team" training because the number of Groups had never allowed for more than an occasional reserve group, whilst most Groups had remained continuously in the line since their formation.

Moreover the official transport was ridiculously inadequate and the help given by Corps and Armies in this respect varied in proportion to the standing of the Field Survey Battalion concerned. It was admitted that a Group could come into action on a front of from 2 to 4 Kilometres, in 3 to 4 hours after arriving at a point on the base. It was not clear, however, what exact role it should fulfil in Artillery tactics nor to whom it should report, and ideas varied from place to place.

## The Last Offensive

86. On the Northern half of the line from VIMY to YPRES no fresh experience was gained and no new deductions can be drawn, for the advance was too rapid and far reaching to allow of counter battery work on any large scale.

The one thing evident was that every Group must be so trained in survey methods as to be entirely independent of outside help, whilst it must advance along some already chosen signal route in order to report the information it has secured.

From AMIENS to ARRAS however the advance, occasionally in bounds of ten miles at intervals of several days, occasionally in bites of two to three thousand yards, daily, for a week or so, gave ample opportunity for experience and deduction.

At the end of the period Groups were thoroughly efficient. Advancing along a signal route, in close touch with some heavy Brigade R.A. occupying a small base (3000 to 5000 yards) continually studying the topography ahead and sufficiently served by transport, they averaged as many locations as in quiet times, and showed that the Observation Group is not a purely siege warfare unit but is a necessary and indispensable adjunct to the artillery work of a large army.

## The role of the Observation Group

87. The real duty of the Observation Group is to provide accurate 3 or 4 line observation for both location and observation of fire.

It should be capable of advancing 10 miles a day and coming into action in 6 or 7 hours from the start.

It must move and keep in touch with some artillery formation.

The above implies a highly organised skilled body however whose value lies in team work. It is obviously absurd to split it up into independent posts on the Lovat Scout principle (as was proposed in one place) and it is equally unsound to leave it behind for some days during an advance and thereby lose its services just as hostile batteries began to come into their new positions.

#### The Officers & Personnel

88. It was most unfortunate that owing to the call for R.A. Officers none were allowed to join Observation Groups after May 1916. A good grounding in gunnery is an essential qualification for a Group Officer.

Every officer must also be thoroughly trained in survey. Map reading is of course important, but far more is needed. The ordinary simple methods, intersection, resection, traverse and plane tabling must be familiar to him. The simple calculations involved must also be so familiar that he can direct and check the Group Computer even if he does little computation himself.

The third essential is a practical knowledge of signal work and a thorough grasp of the electrical connections and instruments necessary to the running of his Group. A large proportion of the rank and file must be skilled observers. It takes fully 3 weeks to give the new observer the necessary knowledge and understanding of his instrument. Quick and accurate reading combined with skill in observing on flashes come only after long practice. The H.Q. Staff must include a surveyor, a computer, and skilled "board" N.C.Os who plot results as they come in from posts.

#### Questions not yet solved

89. There are several questions which affect flash spotting which have not yet been solved. The first of these is the automatic record of all flashes. In the earlier days of sound ranging the human observer was used. His duty was to tap a key when he heard the report of a gun. The human observer soon gave way to the microphone.

Similarly in flash spotting the time will come when the human observer will give way to a photographic record. So far the difficulties of finding a plate sensitive enough for the purpose have proved insuperable. To be of value the camera must be able to record the glow or reflection of a flash from a gun defiladed from direct view. Most location by flash spotting is done, after all, upon the glow and not upon the muzzle flash. Should the camera succeed in ousting the observer the personnel could be much cut down and the length of the base could be very much reduced because of the great accuracy of plotting which can be obtained on a plate.

The second point is that of communications. It is one of the hardest problems to get information back from the Group or Section H.Q. to the gunner. This difficulty should be largely solved by the introduction of wireless. Either C.W.W. or Sparking Sets could be used but whichever type is employed must be such as is used by the batteries themselves.

Wireless will also solve the problem of warning all other location units of the area in which activity is suspected, so that confirmatory evidence may be got at once. It may also do away altogether with the necessity of laying internal communications in the Section itself.

## PART VI - SOUND RANGING

### Early History

90. The possibility of locating a gun, from a record of the respective times at which its report reached fixed positions, appears to have been discussed many years ago in Austria. No arrangements had been made prior to the outbreak of this war, however, for the actual application of "sound ranging".

It was Professor Nordman (Astronomer at the Paris Observatory) who first gave it practical shape. His first idea was to work on a measured base with three men, each with a stopwatch, who could record the instant the sound reached them. He had foreseen the use of microphones which should register the sound graphically, however, if the human ear and stopwatch method failed.

He was sent to Paris to experiment and by September 1914 had enlisted the advice and assistance of Mr Bull (who later produced the system we now use) and was working at various forms of recording and registering devices.

In the middle of November successful trials were held which converted into enthusiasts the three French Generals who were detailed to investigate the possibilities of Sound Ranging. As a result Nordmann was sent to the front with a Section.

Meanwhile Mr Bull perfected his apparatus, and a Section with an automatic registration took the field in January 1915.

This Section was unfortunate enough to encounter a period of unfavourable wind which prevented the sound of the report reaching the microphones at all. It managed however to locate French guns near by and the bursts of German shells and in fact thoroughly established its possibilities.

In February at least three other methods of registering the report graphically were evolved in Paris and Sound Ranging literature grew correspondingly.

It was at this period that the phenomenon of the shell wave, due to the excess of the speed of a shell from a high velocity gun over that of sound in air, was first properly appreciated.

Whether it was in consequence of Professor Nordman's experiments or whether it was entirely due to original thought a Section working with stopwatches was installed on the Arras Front in January 1915 by Captain Bourcier of the French Engineers whilst a similar Section sprang up on our left North of YPRES.

### Early British History

91. The idea of sound ranging was fairly commonly met with in the British Army late in 1914. General Phillips R.A. was one who was discussing its possibilities at that time. The doings of the French Sections on either flank soon attracted notice. Colonel Blandy R.E. (Signals) wrote a report on sound ranging as he had seen it in Paris, in March. In April, Colonel Hedley (M.I.4 - Geographical) saw the progress of sound ranging had made, whilst on a trip to Paris, and it was directly due to his report that a Committee of three - a gunner, a surveyor, and a representative of Signals - was sent to Paris to investigate and report on sound ranging in general and on the type best suited to the British Army in particular.

The Committee reached Paris early in May and after investigating the results of French experiments reported that

- (i) The system of sound ranging might give valuable results.
- (ii) The Bull System was the best.

Authority was asked for the construction of two sets. On receipt of this report the General Staff at once arranged a further visit to enable the members of the Committee to study the work at the front. A Section working on the VOSGES was visited and the subsequent (second) report confirmed the first.

The experiments Committee dealt with these reports. At first they put some obstacles in the way of ordering sets, but after much correspondence, gave way and authorised the purchase of one experimental set. This set, made in Paris, was ordered in June and delivered in October 1915.

Meanwhile as a result of special demands for the best expert procurable, Lieutenant (now Major) Bragg R.H.A. was detailed to command the first section and took up his duties in the 2nd Army Area in November 1915 with the absurdly inadequate staff of six officers and men. In spite of many troubles, partly due to lack of staff and partly due to faulty survey, the results obtained showed much promise, and in December 1915 it was decided to order seven more sets, allowing two each per Army in the field.

#### Experimental Section

92. The first section was the original school of British Sound Ranging but an Experimental Section was soon added to it and the officers and some of the men for the new sections were trained there.

#### New Sections

93. In April 1916 these new sections were ready to take the field with the new sets built in Paris.

#### French & British Stopwatch Sections & the "Claude" Orthophone

94. Meanwhile the French Sections which had been working on the Arras Front had given many good results and had created a belief in the possibilities of sound ranging which stood the new sections on the southern end of the line in good stead.

These French Sections were of the stopwatch, personal observer type. The personnel was excellently trained however and the officers of the Sections shrewd knowledgeable men who were not above drawing bold (and generally justifiable) conclusions on scanty evidence. Subsequent experience with such Sections raised in the British Army to fill gaps between the few automatic sets we had, showed that long training and experience are necessary before any reliable results can be obtained.

Another French device - the orthophone - was also working on the Arras Front. It consists of two ears at either end of a long (10') horizontal tube. From the centre of this tube two smaller internal tubes, connected to the ears, turn downwards, still inside a covering tube, through the top of a dugout, and end in a stethoscope headpiece which is worn by an observer. The whole can be rotated so that the ears (and the ear base) are at right angles to the direction from which the sound comes. A pointer reading on an arc completes the outfit. This instrument was soon given up both by the French and by ourselves. The "shell wave"

with its conical shape introduces insuperable difficulties in locating guns (tho' not howitzers) by this method and the results obtained suffer much in comparison with those obtained by our regular system. The Germans continued to use it however and appear to have been satisfied with the locations so obtained.

#### Battle of the Somme

95. As sound ranging developed it became more and more evident that the staff necessary to the due working of a Section had been consistently underestimated. Even when enough personnel had been provided for a stationary and fairly quiet front these sections which started on the Somme front, about the same time as operations began, were helpless in face of the exceptional difficulties then met with for the first time. A Section had something of the order of twenty miles of cable to maintain. This is not a formidable task on a quiet sector but on the Somme front the shelling caused an enormous quantity of breaks, and maintenance was quite beyond the powers of the Sections. Moreover the perpetual bombardment resulted in so large a number of "records" that they could not be disentangled.

The microphone in use at this period was most unsatisfactory. A rifle shot, the rustling of the leaves of a tree, a man talking etc would all set the strings vibrating.

One may say that, throughout the earlier stages of the battle of the Somme sound ranging was of no assistance, but the experience gained was invaluable.

#### The end of 1916

96. Meanwhile much progress was made on quieter fronts. At first a certain amount of incredulity, quite natural under the circumstances, prevented the results obtained from exerting their proper influence. It happened at this time, however, that German Battery Positions on the quieter fronts were very conspicuous and the accuracy of the sound ranging locations was therefore readily checked.

It became apparent too that sound ranging was the only accurate method of location in times of bad visibility. Lectures were given and visits invited and by December 1916 Counter Battery Staff Officers were mostly convinced.

#### The Tucker Microphone & the Regular Base

97. Towards the close of June 1916 a new form of microphone or recorder was invented by Lieut Tucker. Undisturbed by casual noises this recorder answers only to the long period waves distinctive of gun reports or bursts. The invention of this microphone was in fact the most important stride made by sound ranging since the introduction of Bulls and Dufours graphic registering apparatuses.

It is a curious fact that the introduction of the Tucker Microphone came just at the moment when numbers of German high velocity guns made their first appearance. Previous to this the bulk of the enemy's artillery had consisted of howitzers. Now the Tucker microphone records the sound of the "report" as well as of the shell wave whereas the previous microphone rarely picked up the "report".

At the same time the lesson of the battle of the Somme led to the introduction of the "regular" base. It is curious how little influence topography has in comparative flat country on audibility. So far it had been taken more or less as an axiom that it was desirable to place microphones fairly high and to choose their positions with this in view. The "regular" base however depends on the fact that you can place your recording microphone almost anywhere, with equally good results. Now by spacing your microphones on a regular curve at equal distances from each other you secure an equally regular register of "breaks" on the film - and enable a computer to pick out these "breaks" which refer to the same gun with comparatively little trouble.



## The Retreat to the Hindenburg Line

98. The Sections working on the Somme Front now began to procure valuable results, in number, and during the German retreat the old German Battery Positions were compared with the locations which had been made previously. The comparison proved without doubt the real value of sound ranging, a fact which was endorsed by every Counter Battery Staff Officer in that neighbourhood.

## Locating the bursts of our own shell

99. Late in 1916 "observation" of our own destructive shoots was began by locating the bursts of the shell. A perfectly feasible method of observation, it is of the greatest value when visibility is poor, or by night. From this time onwards many shoots have been carried out in co-operation with a sound ranging section, but even now ideas as to when and under what conditions to employ sound ranging are far from clear.

In the first instance it should not be employed when the target can be seen. It cannot be employed at all if the wind is unfavourable and it should never be used for calibration.

It is most accurate in shooting at a battery whose position has just been fixed by that same sound ranging section which is to carry out the observation. In this case any errors inherent to the location are repeated in the observation of fire (providing our retaliation follows at once).

It can be used, if the wind is favourable, with great advantage in engaging targets in a wood, village, or other thick cover.

Single sections using our usual length of base should not be called upon to locate bursts further off than 9000x from the line.

On many occasions batteries have been told off to shoot with sound ranging when good opportunities occur. One such case, opposite Bethune, resulted in stopping a German 8" Howitzer which had been brought close up to the line in a fog for harassing fire on billets, after the second round, and in compelling it to move at once.

Another on the YPRES front in July 1918, resulted in a lucky, but welcome O.K. on an 8" German Howitzer after its third round.

On one occasion two sections were employed to locate the fall of our own rounds in a shoot on the famous Courrieres Gun. Each of these Sections gave 'line' and the intersection of the two lines was used as the location. This shoot, at a distance of 20,000x from the front line, was eminently successful.

## Additional Sections, The Experimental Section and Sound Ranging School

100. In August 1916 it had been decided to form enough additional sections to provide one per Corps. These new sections were raised and trained during the Autumn and Winter and took the field early in 1917. Meanwhile the School and Experimental Section were shifted into G.H.Q. detaching a small nucleus for the formation of another experimental section at Salisbury Plain to work with the Overseas Artillery School. The construction of apparatus in England was also begun at this period.

## The Battles of Arras and of Messines Ridge

101. The locations obtained prior to these battles were exceedingly valuable and accurate. Subsequent investigation on the ground proved that some 90% of German Battery Positions had been accurately located and were therefore successfully neutralised and unable to take their part in the German Defence.

The advance after the battles afforded some new lessons. Up to that time the guiding factor in the speed of getting into action was the time taken in laying the lines. This was done either by Army Signal Units or by the Corps Heavy Artillery. In both cases it took far too long. In order to get going quickly Sections took up too short a base and if the infantry advance continued were out of action much sooner than need have been the case.

Some of the Sections in the 4th and 5th Army Areas had peculiarly short bases for the above reason and because of special difficulties of transport and personnel.

### Wind Sections

102. The accuracy of sound ranging location depends very largely upon the accuracy of the knowledge of the speed and direction of the wind and upon other meteorological data. Each section had a wind gauge as part of its equipment and received periodical reports from "Meteor" but the information so obtained was not sufficiently reliable. In order to get better values the introduction of Wind Sections was decided upon and the first to be installed was sent to the 3rd Army in August 1917.

The idea of a wind section is to produce an explosion or report, at a known or surveyed spot and to register the time of the arrival of this report at each of a series of microphones, arranged in semi-circles of varying radii. The positions of the microphones relative to the origin of the sound are accurately known. The origin of the sound and the microphones were so placed as to reproduce more or less the relative position of a German Gun and the microphones of British Sections. It is easy to deduce therefrom the influence of wind and temperature on sound. Five wind sections were contemplated and the experience gained in the 3rd Army was so promising and added so much to the value of locations that the remaining four sections were pushed ahead as fast as possible.

### Passchendaele

103. The battle of Passchendaele ridge coincided with one of the worst periods for sound ranging which has been known during the whole war. A persistent S.W. Wind prevented sound from travelling from the German Guns to the microphone. In such cases the sound, working against the wind, rises steeply and leaves a "sound shadow" below which is analogous to a thick fog to the flash spotter. Moreover there were many and serious difficulties of survey and transport.

Practically no results were obtained therefore during the battle. Harassing fire on our back areas had been growing more and more noticeably a feature of German Artillery tactics. During this battle the harassing fire caused so many breaks in the lines that a section experienced less trouble when close up to the line than when at ranges of 4000 - 6000 yards from it. On the other hand the number of linesmen with each section rose through borrowing unofficially from other units, and sections gradually assumed the responsibility for constructing as well as maintaining their lines and saved much time thereby in coming into action.

In the past airline had been used fairly frequently. Experience had proved by now however that admirable as air line is, in times of comparative quiet, the number of breaks which always occur when activity recommences are far greater than is the case with cable. S.11 cable laid on the ground became therefore the standard pattern of communication.

#### The Automatic Developer & the Cambridge Scientific Co

104. In July 1917 the introduction of the automatic developer helped to simplify and quicken the work in the office. In earlier times films had been developed by hand.

Constant small improvements were added to the apparatus from time to time and Cambridge Scientific Instrument Co. who constructed those of our new instruments which were made in England spared no trouble to make their work a success.

#### Characteristic Breaks and Standard Containers

105. One very strong point of sound ranging is the accuracy and certainty with which the calibre of the gun or howitzer can be determined. Generally speaking this follows from the time of flight between the discharge of the gun and the explosion of the shell, the exact position of each having been determined by sound ranging.

It would be a great advantage if calibre could also be deduced from the sort of break apparent on the film. As the shape and size of these breaks largely depend upon the container in which the microphone is placed standard containers were supplied to all sections.

Subsequent experiments have established a distinct relation between types of breaks and definite calibres but there are reasons why this method will never be entirely reliable.

#### Tactical Lessons of 1917

106. The experiences of 1917 showed that Sound Ranging Sections still had much to learn in adapting themselves to mobile conditions. Two conferences of Commanding Officers of Battalions were held under the presidency of GENERAL STAFF (Intelligence and some French Sections were visited to see if they had found the same difficulties. It was decided at these conferences that each Army should instruct its own Sections in "team" work whilst G.H.Q. was to inaugurate a course in mobile warfare. It was decided also that delays due to survey were now more common, and more to be feared, than delays due to constructing lines. The natural inference was to train officers of the Sections themselves to carry out their own survey so as to be quite independent of the trig: section which is always so busy during the progress of operations. These courses were not begun however till the Spring of 1918. The French Sections were found to have suffered under the same difficulties and to have been out of action at the same time as our own.

In order to save the time in preparation of the plotting boards standard types were drawn, printed at Southampton, and issued by G.H.Q. on demand.

#### Extension of the line southwards

107. During the late Autumn of 1917 and early Spring of 1918 the line was extended to the South. The area thus taken over had included sundry Sound Ranging Sections. It was found that they were working on much longer bases than we were and also in some cases with earth returns instead of metallic circuits, as had been our invariable custom. Experiments were carried out with these earth returns and with transformers but were not successful.

## Application of wireless to sound ranging

108. For some months in 1917 experiments were carried out with a view to determining whether the impulse from the recording microphone could not be transmitted to the registering apparatus by wireless. Were that possible the construction and maintenance of lines would be comparatively trivial and much time would be saved. Unfortunately it turned out that wireless is still unable to solve the problem without large and cumbersome installations at each microphone. Undoubtedly wireless will, one day, replace cable, but it is not able to at the moment. The Signal Officers who investigated the problem did very valuable and efficient work, however, and succeeded in doing actual good sound ranging with wireless - a new and noteworthy fact. The drawbacks lie in the size and weight of the installations at each post and the staff necessary to maintain them.

## Mobile and Survey Courses at G.H.Q.

109. The mobile course was instituted in order to afford practice in the speedy and efficient installation of a section on a new base. It aimed at practising NCOs and men to carry out intelligently and quietly the wishes of the O.C. rather than at laying down a hard and fast routine.

Nevertheless a certain amount of standardised routine in matters of detail is an essential point of good organisation and has been too much neglected in the past.

The survey courses begun early in 1918 aimed at teaching the usual simple methods of survey and computation with particular reference to their relative speed and errors. No effort has been made to turn out a finished surveyor. Experience alone can do that. Sound Ranging Officers are generally particularly well qualified to learn and understand survey methods at short notice and the courses have been an unqualified success. In future every Section should have at least two officers sufficiently trained to conduct the survey of their own microphones with despatch, under ordinary circumstances.

## Sound Ranging Sections in the retreat of the Spring '18

110. The retreat of the 5th Army was too fast and continuous to offer any possibility of getting into action after leaving the bases which has been occupied. All stores, instruments and documents were got away safely however and no information of any value left to fall into German hands. Together with the flash spotters, Sections formed a considerable part of "Careys Force" in front of Amiens and suffered severe casualties.

In the 3rd Army area Sections were withdrawn during the German Offensive but came into action again directly the line steadied.

There were no particular tactical lessons to be gathered from these operations but it was easy to see that sections had been carrying too many stores and had gone in for far too many "gadgets" which caused confusion and delay both in getting out of, and into, action.

It was partly due to having learnt the above lesson and partly to the presence of reserve Sections that moves were made with such efficiency on the YPRES salient during the German Offensive of April. In one case a section was only out of action for 5 hours whilst shifting backwards 7000x from a forward position to a base which had been prepared and wired up for it behind. In another case a section was in action till 12 noon when it received orders to reel up wire and return to a reserve position. At 4.30 pm, the section reported all ready and packed for the move.

## Meteorological Data

111. Unfortunately the German Offensive had succeeded in putting every Wind Section out of action. Moreover the expenditure of cable had been so heavy that little was available for new bases and the amount necessary for a wind section is so comparatively large that it was decided not to continue wind sections in the future. The results which had come in from wind sections in the past had been so important and so many that it was possible to see much more clearly what was wanted and to arrange with Meteor to supply it.

One officer and a few computers were lent therefore to the Meteor of each Army who were thus enabled to extend and amplify their experiments and to send out information more of the desired form and in much greater volume. It is doubtful if "wind" sections will ever appear again as such but it is clear that much was gained from their brief experience.

## A Scound Rangers Day in 1918

112. The front was soon fairly stable again and sound ranging sections were everywhere installed. As this was the last quiet period and as sections were now at the top of their form it will be interesting to summarise a typical days work.

A section is, of course, never off duty. Results continue to come in throughout the 24 hours. Assuming that the wind is favourable, and the German busy, the locations made in this period would be on the average 100. Of these 80 would be about the number of "identifications" or fresh locations of old friends. 20 would refer to new positions. In the majority of cases both the calibre of the offender and the target at which it fired would have been given accurately.

On two or three occasions the section would "observe" for a shoot on one of the batteries fixed.

One of the officers with a couple of men would be out surveying a reserve base. The O.C. would have gone to see the Counter Battery Staff Officer or the O.C. Battalion. A third officer would have been busy on apparatus or lines.

## The Attack opposite Amiens in August

113. The successful attack of the Australian and Canadian Corps opposite Arras was a triumph for the Field Survey Battalion.

German batteries had been shifted back some 8 days before due to a minor Australian attack. The weather in the interval was extremely thick and no locations were made except by sound. These proved most reliable in every case and many direct hits were obtained in consequence.

## The LYS Salient

114. Meanwhile counter battery work was costing the German Army dear in the Lys Salient. Location was excellently carried out both by sound ranging and flash spotting and a special feature of these locations was the number and accuracy of determination of calibre made by sound ranging.

## The Final Advance

115. A great deal of experience in mobile warfare has been gathered from the last offensive. Prior to the beginning of the movement none was very clear as to whether sound ranging could be carried out in such times or whether it would not be wiser to park sections in rear and send them forward only when the enemy had prepared a stubborn resistance on a well entrenched line.

The question was complicated by the tactical control which was vested in the G.O.C., R.A. of the Army and which resulted in so many different solutions.

These divergencies of thought led to three solutions which may be condemned at once:

- (a) To call in all sections and park them in a central place.

To do this implies long and unnecessary marches both in the concentration and in the getting into action again and offers no corresponding advantages.

- (b) To leave Sound Ranging Sections behind and to move them up after the line had stiffened.

Delay again. By the time the Sections had got into action movement was just recommencing and the valuable information which might have been got in the first day or two was lost.

- (c) To use part of the personnel of one section to reinforce another section or Group.

It was found that a section once split up loses its identity and suffered much if and when it was reassembled.

In the Northern half of the front the consecutive large German withdrawals made sound ranging next to impossible. It was impossible to get up even the bulk of heavy artillery quickly and there was insufficient transport to tackle the shift of sound ranging sections until some time after the line had steadied.

Some sections got into action very quickly and efficiently however when they eventually received permission to advance.

At the South end of the line conditions were much more interesting and provided much more experience. It gradually appeared certain that sections could be in action 48 hours or less after receiving orders to move and that, like the Groups of the Observation Section, they are real tactical units capable of accompanying the movements of any large Army and able to come into action whenever counter battery work is called for:

The above is only true however when:

- (a) The Officer in immediate tactical control (in the past the O.C. Field Survey Battalion or the O.C. Artillery Section) is closely in touch with the tactical situation and can gauge accurately the time at which to put in the section.
- (b) Sufficient transport is available for the stores, men, and cable.
- (c) The Section is entirely self sufficient and can survey its own base and construct its own lines.

Throughout the advance of the 3rd and 4th Armies the above conditions were gradually fulfilled. Sections continued therefore to play a real and important role and the future utility of sound ranging in any war, in which powerful artilleries take part, is assured.

### Location by earth tremors

116. In 1917 and 1918 the possibilities of locations from earth tremors has been discussed. Experiments have been carried out both in England and in France. By the beginning of 1918 it became apparent that the inconsistencies of soil and rock were such as to put accurate location out of the question.

It appeared possible, however, that if the position of the gun were established our own artillery could be ranged back upon it by re-establishing the same record or sequence of tremors as had been characteristic of the gun. Here, however, one is met with the following difficulties:

1. The shock of recoil is taken up largely in the mounting and is not communicated sufficiently through the spade or trail to the ground.
2. Extraneous noises (eg. a cart going along a road) are often larger and more apparent.

It may be that in the future these difficulties will be overcome - one can only add that hitherto they have proved insurmountable.

### The composition of a Section

117. It has often been thought that sound ranging is a peculiarly difficult art, beyond the comprehension of the average man and exacting a knowledge of pure science and mathematics common only to the senior wrangler or a science master. This is absolutely erroneous. The practical side, the organisation, the efficiency of the apparatus, and the care of the transport, are all as important as a knowledge of physics. Scientific control and experiment are essential but can be done behind and so long as the officers of the sections are able to understand their instruments and the value of the results they obtain it is unnecessary to specify a university degree. Of the officers it is as well that one should be specially interested in physics and one in electrical engineering. Two should be well trained in simple survey methods and the O.C. should be rather of the organising and directive type than an expert in any one line.

## PART VII - THE COMPILATION SECTION

### Its origin

118. Before the start of the Artillery Survey Detachment in the 3rd Army in October 1915 a good deal of thought was given to the use which should be made of the results and locations which it was hoped to get.

To quote from a report which was written in September 1915

"There is little difficulty in arranging survey posts and in training the staff, but the important and rather difficult point then arises of the proper collation of all results, ie, air photographs, R.F.C. reports, Corps Intelligence Summaries, R.A. Observation Reports, as well as such locations and reports as may result from the work of the Artillery Survey Detachment".

The solution of this difficulty was aimed at none the less.

Information concerning the movements and organisation of the enemy had always been dealt with by GENERAL STAFF (Intelligence), but the location of German Batteries had been the subject of a number of periodical lists emanating from R.A., R.F.C. and General Staff (Intelligence). These lists, differing widely from each other, and in no case getting very close to the truth, had resulted in a distrust of any and all lists and a reliance on the necessarily crude and insufficient knowledge of the gunner concerned. To compare, to sift, and to analyse into a really reliable list was therefore regarded as the function of the central office of the Artillery Survey Detachment.

For some time this work was carried out by two specially chosen NCOs under the personal supervision of the O.C. Topographical Section, but the work grew so quickly and assumed such dimensions that a special section "The Compilation Section" was started in December 1915.

### The Compilation Section

119. A special officer was allowed for each Army Staff for the study of air photographs and the officer chosen for the work in the 3rd Army, Lieutenant Goldsmith, was attached to the 3rd Topographical Section. His duties were defined in the following terms:-

"To extract from reports and summaries all evidence as to position, whether of batteries, dumps, observation posts, railways, earthworks, obstacles etc. To file the same in a logical and handy way for reference.

To study the interpretation of air photographs, and to that end, the system and types of enemy works. To issue the Intelligence Summaries of the Survey Posts and to provide them with lists of points to be cleared up".

### Enemy Organisation

120. Whilst GENERAL STAFF (Intelligence) was, and is, responsible for information concerning the strength and dispositions of the enemy a mass of topographical evidence connected with this subject has to be plotted accurately on the map.



In the first of the new and good large scale maps the enemies tracks, light railways, machine gun emplacements etc appeared on the trench plates. The bulk of the air photograph work was done, and is done, at the Topographical Section, or its descendants, the Field Survey Company and Field Survey Battalion, - cases of doubt being referred to GENERAL STAFF (Intelligence).

The Compilation dealt therefore with all those cases of air photograph interpretation which affected maps as well as with battery location. A skilled topographer plotted positions on the map.

At this period photographs were beginning to come in, in considerable numbers. An average number on a good day might be taken as 50 for the Army Front.

#### Positions Determined

121. During the early surveys and the plotting of the first good maps many features of interest were fixed. Such features were prominent trees, houses etc and all well defined earthworks inclusive of prepared artillery emplacements. Lists were printed for each shoot giving the coordinates and map square locations, of all such fixed points. These lists were called "Positions Determined" and gradually became a statement of the known and plotted battery positions in each shoot irrespective of whether these were or were not active.

#### Field Survey Companies

122. In February 1916, G.H.Q. authorised the establishment of Field Survey Companies and modelled on the existing organisation of the 3rd Topographical Section.

A compiling officer was included on this organisation. The 1st and 2nd Armies therefore raised their own compilation sections.

#### Elimination of R.F.C. Lists

123. In order to reduce the number of competing lists and to ensure the loyal cooperation of all units, conversations had been taking place between the General Staff (Intelligence) Royal Flying Corps and the Topographical Section.

Towards the end of February the final arrangements were made for a list, issued by the Major General General Staff, entitled the "Active Hostile Battery" List, embodying all location reports and prepared by the Field Survey Company.

The counter battery information was, therefore, provided as explained (below) in a circular dated 23/2/16.

#### "Hostile Batteries

124. It is proposed to introduce the following system of indicating to all concerned the position and nature of Hostile Guns, Batteries & Emplacements:

- (1) A weekly list of Active Hostile Batteries - inclusive of Royal Flying Corps, and Field Survey Company locations.

This list will be the authorised current one, will be issued each Sunday (starting from March 5th) and will automatically cancel:

- (a) All previous lists.
- (b) All previous reports from the R.F.C.
- (c) All previous reports from Observation Section.

(2) Intermediate direct reports from Royal Flying Corps and Observation Section during the week, which will be automatically confirmed or cancelled by the Sunday lists.

(3) Lists of "Positions Determined" as before, which deal only with emplacements whose position is known, and which are, or can be, accurately placed on the map.

It must be clearly understood that this list refers to Emplacements (not necessarily batteries), and that those known definitely to be occupied will appear on the Active Battery List".

#### Conferences

125. In order that the Active Hostile Battery List should really coincide with the studied opinion of those able to judge, conferences were held at which the G.O.C. H.A., the G.O.C. R.F.C. Brigade, General Staff Intelligence of the Army and the O.C. Field Survey Co. were present. These conferences were kept up until September 1916.

#### Counter Battery Target Maps

126. Just as in Battery Survey Lists of positions and bearings had to give way to the battery board, on which things were shown graphically, so the active hostile battery list and the lists of targets had to be printed on maps.

In this case however there were the additional claims of the R.F.C. to consider. Obviously air observers had to have a map to refer to.

Counter Battery and Target Maps were started therefore in May 1916. The first issue showed batteries which appeared on the active hostile battery lists, and included their areas of fire, for the German Artillery tactics of that day were such as to allow of exact knowledge of their positions and arcs.

#### Compilation Sections in other Armies

127. The new establishment of the Field Survey Co raised compilation sections automatically in other Armies. Their work varied widely however from that of the 3rd.

The latter inherited from the Ranging Section, and the Ranging and Survey Section, a record of close and intimate cooperation with the gunners. The institution of the Artillery Survey Section, and the subsequent growth of the O.C.'s position of technical adviser in matters of survey to the M.G.R.A. fostered it, whilst the 3rd Army Staff had made its work an integral part of the Army Headquarters. In the 1st Army the compiling officer was not so used by the Army, but remained a recorder of the results of the 1st Army Observation Section. As these results continued for months to be a negligible quantity the compilation section had little to do, and remained for the next year without interest or influence.

In the 2nd Army the compiling officer continued to be the official recorder of the doings of the Observation Section. He had in fact, belonged to the old 2nd Army R.A. Flash Spotting Section, but his work resembled that done by the 3rd Army much more than was the case in the 1st Army. Even in the scope of his Artillery Intelligence work, however, the beginnings were nothing like so general or far reaching.

The 4th and 5th Field Survey Companies were raised sometime after the introduction of the compilation section in the 3rd Field Survey Company. Their compilation sections were modelled upon it and worked upon the same lines. The 4th Field Survey Company had time to settle down to a regular routine but the 5th had not, before the Battle of the Somme brought up a number of new problems.

#### The Somme Battle

128. During this battle German Artillery tactics changed considerably. Protection gave way to concealment, and positions changed with a rapidity which made an Army compilation out of date almost as soon as lists or maps could be produced.

The appointment of the Country Battery Staff Officer was instituted to deal with the problem and each Counter Battery Staff Officer had a compilation office for his counter battery area.

The Field Survey Company compilation, under these circumstances, became a more studied army view of the same problem, useless for action which had to be taken at once, but useful as a help in doubtful points, as a guide on matters of location for the M.G.R.A. and as a check on the technical work of the Groups and Sections.

The lesson of the Somme Battle spread quickly. Counter Battery Staff Officers and R.A.R.Os were everywhere installed, and in the 3rd Army area the Field Survey Compilation Office became the source from which the Army R.A.R.C. drew his facts for the M.G.R.A. and the O.Cs check on technical location, whilst the Active Hostile Battery List continued weekly and was supplemented by the daily lists from the Corps.

#### Progress in the 1st and 2nd Armies

129. Meanwhile the Groups & Sections in the 1st Army were rapidly improving and a good compilation office was established. The advance over the VIMY RIDGE was the only movement which affected the 1st Army in 1917 so that compilation could be, and was centralised with a good deal of success. A good daily list was issued and although the Corps issued their own lists the Field Survey Company data were of considerable use to the R.A. at Army Headquarters.

In the 2nd Army the compilation office was sent up to the Army location report centre far from Army H.Q. and issued its lists from there. Such a procedure appears unsound. A tabular statement of the locations made by Groups & Sections can only be of value to the O.C. Field Survey Company since each location is reported by telephone to the Counter Battery Staff Officers directly after it is made. On the other hand Counter Battery Staff Officers make their own analysis of the work of the different branches, and have never shown much enthusiasm for an Army list. It is therefore at Army H.Q. that such a list should be produced.

#### Growth of Compilation Offices

130. The number of photographs received constantly increased both in number and in areas covered. Investigation of the evidence they gave of the intentions and organisation of the enemy increased proportionally, and the volume of work soon necessitated an increase of Staff and a separation into counter battery and Intelligence (or enemy organisation) sides. Here again it may be objected that one is purely the work of the artillery and the other the work of General Staff Intelligence. Both however are necessary to the preparation of the map and it is the man who deals continuously with a circumscribed area and the photographs dealing with it who is generally the first to spot new material for the map.

The compilation offices and the R.A. H.Q.

131. In those armies in which the Field Survey Company had been more an adjunct of Intelligence than a general servant of the Army Headquarters\*, there arose a demand that the compilation Sections should work at the R.A. Headquarters under the direct control of the M.G.R.A.

It was only in these two Armies in which direct touch with the M.G.R.A. had been maintained from the start that such procedure was found to be unnecessary.

Since the summer of 1917 therefore that part of the compilation office which dealt with purely artillery matters has been detached in three Armies from Battalion Headquarters and had become virtually a part of the M.G.R.A.'s office.

The examination of air photographs for matters of "organisation" - ie, light railways, tracks, deviations, dumps etc remains, naturally, at the Battalion Headquarters in all cases.

The final estimate of position

132. The first 1/10,000 compilation maps on the 3rd Army front were quickly followed by good mapping of a similar sort along the whole front. Cases did happen here and there of distortion but on the whole these maps would stand comparison with almost anything which has been produced and in extremely few cases could an error of over 20 yards be detected.

Results obtained by flash or sound location are of an inferior order of accuracy to this. In the British Army, therefore, the final arbiter of position was the map, and the plotting on it from an air photo.

This is a point worthy of note because German procedure differed essentially. The German Manual for flash spotting and sound ranging lays down that in many cases locations thus obtained may be taken as a sort of fourth order triangulation and accepted in preference to the map. This ruling follows rather naturally from the inferior order of topography observable in their maps.

If, however, it is possible to turn out such a map of such accuracy that it may be regarded as the final arbiter, it obviously lightens the task of the compilation office and affords a base on which all other results may be plotted and compared.

There is no question that our locations are of a much higher order than the German and probably the same applies in a lesser degree to French results also.

In the light of our 4 years experience, however, it is clear that we might have improved not only the maps themselves, but the plotting from air photographs upon them if we had made a sort of fourth order triangulation from air photographs.

Cross roads, corners of woods, hedge or ditch junctions or corners, abandoned tanks, and in fact any natural or artificial objects would have been included.

Lists of the coordinates of such points would have materially improved and assisted the plotting not only in Field Survey Battalion drawing offices but in Counter Battery Offices also.

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\* In the French Army, the Groupe de Canevas de Tir is under the direct orders of the Chef de l'Etat Major: not of the 2eme. Bureau (or General Staff Intelligence).

## Strength and Duties of a Compilation Office

133. Taking the case of a compilation office which has not been split up in order to detach artillery work to the M.G.R.A's office the strength found necessary is

3 officers  
10 NCOs and men.

Their duties are the examination of all air photographs received and the identification and plotting of the map of

(a) Battery positions active.

for M.G.R.As information and for assessing correct positions.

(b) All Battery Positions active and inactive for plotting on the map.

(c) Preparation of "enemy organisation" map for M.G.R.A. and G.S.I. approval.

The number of air photos which arrive for investigation vary from 300 - 400, after a fine clear day, to 100 on an average day. It very rarely happens that none are taken at all.

## Lessons for the future

134. There appears little doubt that all "location" units will eventually come under the R.A. and with them will go the compilation office.

It has been proved in practice however that some such unit is a necessity at Army H.Q., and it appears probable therefore that some Staff Officer dealing with all matters of location will form part of the Staff of the M.G.R.A. of an Army and that the Compilation Office of the future will work under his orders.

It is at the Mapping Headquarters that the final judgement on exact positions must remain, however.

Investigation on the accuracy of the work of Compilation Sections in 1915 and 1917.

Note: There has been very little time for accurate investigation on these lines - and none in 1918. As a general rule one may say that 90% of German Battery Positions have been known since 1.5.16. except during the very difficult conditions of the Battle of Passchendaele.

| GERMAN BATTERY POSITIONS              |              | CORRECTLY LOCATED |                     |                         | FAILURES     |                     | Remarks  |
|---------------------------------------|--------------|-------------------|---------------------|-------------------------|--------------|---------------------|--|
| Evidence of Position                  | No.          | Reported Active   | Not reported Active | Total Correct Locations | Not Located  | Incorrectly Located |  |
| 3rd German Map                        | 41<br>(100)  | 36<br>(87.8)      | 3<br>(7.3)          | 39<br>(95.1)            | 2<br>(4.9)   |                     | After battle of Arras<br>May 1917.                   |
| 4th Found on ground                   | 230<br>(100) | 183<br>(79.5)     | 18<br>(7.0)         | 199<br>(86.5)           | 31<br>(13.5) | 13<br>(5.8)         | After German retreat to<br>Hindenburg line, Feb 19   |
| 3rd Found on ground<br>opp P Sections | 38<br>(100)  | 32<br>(81)        | 5<br>(13)           | 27<br>(97)              |              | 1<br>(3)            | After German retreat to<br>Hindenburg line. March 19 |
| 2nd Found on ground                   | 39<br>(100)  | 35<br>(90)        |                     | 35<br>(90)              | 4<br>(10)    | -                   | After battle of Messines<br>July 191                 |
| 1st " " "                             | 13<br>(100)  | 11<br>(84.6)      | 11                  | 11<br>(84.6)            | 2<br>(15.4)  | 1<br>(7.7)          | Batteries in LI<br>after German Retreat April 191    |

(To accompany Part VII)

## PART VIII - CORPS TOPOGRAPHICAL SECTIONS

### The Battle of the Somme

135. Before the battle of the Somme started the future area of operations was well mapped on the scale of 1/10,000. Naturally these maps were not completely up to date in those parts which had not yet been photographed, but the framework was accurate and there were enough draughtsmen available to correct detail and plot new trench work at short notice. There was not enough printing machinery however to provide for a hasty reproduction. Certain civilian printing firms in Amiens could and did, do much printing for operations, but at the cost of time which could ill be spared.

Transport through the captured area, over very much cut up and overcrowded roads added another difficulty.

The advance in artillery tactics (above all in barrages) made it necessary to revise the map frequently and issue it at any short notice. So pronounced was the call for quick editions, that all sorts of temporary Corps and Divisional Maps and sketches were issued.

Accuracy is an essential feature of maps for operations in which artillery tactics play an important role. Accuracy is not obtainable however without a carefully trained staff.

The above arguments pointed so strongly to decentralisation of the production of hasty maps, that a demand arose in many quarters for the authorisation of a mapping unit in the Corps.

### First Proposals

136. In the Autumn of 1916 proposals for the formation of Corps Topographical Sections were received from the 3rd and 4th Armies.

These proposals were in the same sense, and advocated the training of small Corps Mapping Sections, which should be capable to plotting new trenches, and all other information of tactical value, and of reproducing some 300 - 400 copies of the map so compiled.

It was clearly laid down in both proposals that the Corps Topographical Section could not be the authority on the mapping of detail. It is obviously unsound to allow of more than one authority in the Army in this matter.

The duties advocated for the Section were:

- (1) To receive, study, and plot new trenches etc from every air photo taken on the Corps front keeping up record copies.
- (2) To produce hasty maps at short notice in sufficient numbers for the Corps

The Army was to supply these backgrounds whenever possible.

### Reproduction

137. A certain amount of discussion ensued as to the best method of reproduction. Hand presses were suggested of the type authorised for the 1st Printing Co R.E. before the War. The great drawback to lithography is the time which it takes to print by hand. Speed was an essential feature of the proposals, however, for deliberate work can always be carried out at Army H.Q. and finally an Ellams Duplicator printing a surface of 16.2" x 12.7" was chosen. 250 copies an hour can be pulled from this duplicator in one colour.

Subsequent experience has shown that the printing surface is too small. In order to cover a Corps front at a scale of 1/10,000 maps should be at least 20" x 15".

#### Raising of the 1st Corps Topo Section

138. The final sanction for the formation of the Corps Topographical Section was not received until the 20th January 1917, but in September 1916 the 3rd Army started to raise and train the personnel. Officers and men did a very thorough course in map compilation and in plotting from air photographs. By December all Sections in the 3rd Army were at work.

The certain other Armies notably the 4th and 5th several unofficial sections were also at work, but with a staff relatively speaking untrained.

#### Field Battery Survey

139. Meanwhile very great difficulty had been found in keeping touch with Field Batteries and in fixing their positions. To do so graphically on a plane table seems an easy business, but it must be remembered that the rolling bare country of the Somme battlefield presented great difficulties. All trig points were destroyed almost as soon as they were erected, and those which were sufficiently far off to escape destruction were also too far off to appear on the 1/20,000 or 1/10,000 sheets on which the battle was fought.

It soon proved beyond the powers of the Field Survey Company to follow up Field Batteries, and to resect their positions and this fact led to the proposal to include a few topographers in the Corps Topo Sections, which were then to be held responsible for Field Artillery Survey.

Opinion was much divided on this proposal. Obviously it is desirable that each Corps should have its survey expert. On the other hand to go through the numbers of air photographs taken on a Corps front, and to feed the Divisions in the Corps with up-to-date information, is, in itself, more than one man can do during operations. Moreover the due supervision of plane tablers is the work of an expert, and very few such could be found.

It was decided however to include three plane tablers on the establishment, which was duly authorised in February 1917.

#### Organisation - Internal and External

140. The strength of the Corps Topo Sections was fixed at:

1 officer  
6 draughtsmen \*  
3 topographers  
1 litho draughtsman  
Transport: 1 motor cycle and side car.

The Corps Topo Sections were raised as integral portions of the Field Survey Company. They were, however, detached to Corps Headquarters and worked under the immediate orders of GENERAL STAFF (Intelligence).

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\* Two of these draughtsmen were supplied to the Branch Intelligence Section by the Topographical Section.



In practice there was little connection between them and the Field Survey Company. In some cases the Topographical Sections were not visited by the O.C. of the Battalion for months on end, and in others any change of personnel, or of O.C. was disapproved of by the Corps, with the inevitable consequence of stopping promotion, and interfering with desirable changes.

Branch Intelligence Sections had been formed about the same epoch, and for some time there was considerable overlapping of work, and doubt as to their exact relative spheres. The Branch Intelligence Section was instituted for the information of the Royal Flying Corps Pilots themselves, rather than for the reproduction and sketches for Corps and Divisional Troops. The latter duty falls to the Topo Section.

#### The work done

141. Many Corps Topo Section Maps have been produced, for different purposes, and at different scales. The following is a resume of the more important ones:

- (i) Trench maps 1/20,000 or 1/10,000 showing new trench detail, the position of our own front line, and any additional topographical features which the Staff of the Corps desire to emphasize.
- (ii) Counter Battery or Target Maps at 1/20,000 or 1/10,000.
- (iii) Barrage Maps.
- (iv) Secret Editions of our own trenches.
- (v) Road Control, Light Railway, and communication maps and diagrams generally.

During operations mapping was generally confined to trench maps as described under heading (i), but in a normal war of position, all the above, and some other varieties, have been produced.

No personnel or transport was included for the issue of Army or regular series maps in bulk. This has continued to be a duty of the Field Survey Company itself. In some Corps, however, an effort has been made to convert the Topographical Section into a map store, and where this has been done it has resulted in an unnecessary 'middleman' in a considerable waste of maps, and in no improvement of speed of issue. Neither in personnel or in transport is the Section capable of dealing with this problem.

The topographers have been kept busy at field battery survey. In most cases, however, the plane tablers themselves have not been supervised, and gradually their work has eased off until very little is now done. On occasions plane tablers have been used for mapping back area trenches and areas under cultivation by the Corps. Occasionally also they have been used for contouring. Few of the Corps Topographers are, however, expert enough to contour properly, and little reliance could be placed on the results of their labours.

#### The manuscript work for the Corps Staff

142. At every H.Q. there is a mass of manuscript work, some no doubt of utility, some obviously of little value. Maps are coloured up in chalk to illustrate different activities. The position of the opposing lines is corrected day by day, maps of this area or that are layered in chalk or in flat wash. For the above services very few draughtsmen are authorised, and demands were perpetually being made, not only on the Corps Topo Sections, but on Field Survey Battalions and on Maps G.H.Q. for this comparatively unskilled work. In a large percentage of cases

the Corps Topo Section has been completely swamped by it with the result that when the time comes for hasty, and yet accurate map making, the staff is untrained and inexperienced, but the work is bad and slow, and troops lose confidence in the information supplied to them.

#### Faults of the organisation

143. The original Corps Topo Sections raised by the 3rd Army were raised for a certain specific purpose ie, that of rapidly mapping new trench detail during operations and of supplying maps overprinted with this information quicker than could be done by the Field Survey Battalion. Superimposed on this duty was the question of field battery survey, and superimposed again by the Corps was the manuscript work mentioned in the preceding para. The organisation, therefore, was far too small for the number of ends in view. It is certainly expedient that every Corps should have a survey expert. He cannot however be an expert adviser, and at the same time keep up his knowledge of the Corps front and the photos taken of it.

The transport provided is entirely inadequate. Efforts have been made on many occasions to increase this transport by the provision of a box car, in order to facilitate field battery survey, and the issue of maps to the Divisions of the Corps. Three box cars would be necessary however to carry out these duties successfully.

Whilst then the Topo Section, as originally designed, was sufficient for the original end in view it has proved quite unequal to the tasks put on it and except in very few cases has become an inefficient and unnecessary organisation.

#### Lessons for the future

144. Battery survey, sound ranging, and flash spotting will no doubt come under the orders of the Artillery in the next war. The Corps Topo Section of the future will not, therefore, include plane tablers for battery fixation. Some mapping unit will be necessary none the less, and its strength and methods will depend entirely on the size of the Army of which it is part. Providing that it has a Field Survey Battalion at its back it need not cater for printing machines. Providing that the Army has a strong trig section, and that Artillery trig sections carry out all the work necessary for the artillery, the Corps Topo Section need not include any particular trig expert. On the other hand it should always include 2 officers and it should without doubt include a staff for the receipt and issue of all maps. Lastly its transport must be adequate for the work.

## PART IX - SCREEN CALIBRATION

### First trial on Salisbury Plain

145. Early in 1917 the Overseas Artillery School carried out some experiments in Screen Calibration. Lieut Tucker who was then O.C. Experimental Section arranged his sound ranging installation so as to measure the time taken by a shell in passing through two screens at a known distance from each other.

The Einthoven Galvanometer has the advantage that twelve or more strings can be used and that intervals of time as small as 1/25,000 of a second can be measured without much trouble. For our first experiments 1/10,000 of a second was considered a small enough interval. A special attachment to the ordinary sound ranging apparatus made this quite possible.

Lieut Colonel Marten R.A. suggested the idea and obtained some good results from Lieut Tucker's measurements.

These results formed the subject of reports and letters to the M.G.R.A., G.H.Q. France.

At the same time the Ordnance Committee stated that no value was to be expected from M.V. Determination because the M.V. of any worn gun was no exact criterion of what it would do: or in other words that so many factors besides the M.V. influenced the range that the measurement of the M.V. answered no useful purpose.

### Early History in the B.E.F. France

146. In April 1917 on representations from Maps G.H.Q. the M.G.R.A. informed the R.A. of Armies that the measurement of the M.V. by the sound ranging apparatus was at least as accurate as with the Boulanger Chronograph. No special sections were to be formed but screens might be erected, and sound ranging apparatuses employed for the purpose, if considered desirable locally.

In May, the 4th Field Survey Co whose front was much reduced at this time, found it possible to devote a section to calibration and Lieut Tucker was sent there to show his methods and to start experiment in the XV Corps area.

General Kirwan R.A. was G.O.C., R.A. of the XV Corps and General Collingwood R.A. the B.G.R.A. Both were strongly in favour of screen calibration and gave every encouragement in their power.

At the same time the M.G.R.A., G.H.Q. recorded his opinion that he did not concur in the opinion of the Ordnance Committee that the measurement of M.V. was unnecessary.

The experiments were duly carried out near Gouzeaucourt Wood by "S" Sound Ranging Section. 6" Howitzers and 60 pounders were used for the purpose. Fire was directed upon a surveyed point, the locations of bursts being made by artillery observers. The trials with the 6" Howitzers were very good, but those with the 60 pounders were not. "Jump" and "droop" were not allowed for at this time, as they were later, and probably this fact accounts for the indifferent results.

### Experiments on the Coast near Dunkirk

147. The XV Corps and 4th Army now migrated to the extreme North and took over the Nieuport sector. "D" Section was attached to the 4th Army for further experiments. Soon after, "D" Section was recalled for its more legitimate work of location and

was replaced by a temporary "group" (No. 22) with Captain Chapman in command. Experiment continued on the coast throughout July, guns firing out to sea, and the results obtained being reported to Battery Commanders. No check was put on these results and the R.A. were therefore unable to say whether they were valuable or not. In August the O.C. 4th Field Survey Battalion installed three posts of an Observation Group on the calibration front and observed the fall of the rounds in the sea. Naturally the location was simple and accurate, and then for the first time a mass of checked results was available from which to draw conclusions.

The figures showed a curious but steady difference between the M.V. deduced from the screen method and that got from the actual range attained (deduced from the surveyed position of gun and of fall of round).

#### Allowance for Jump and Droop

148. Captain Chapman put this difference down to the effect of jump and droop and immediately set about measuring and correcting for these two factors.

The droop is the angle between the axis of the bore at the muzzle and at the line of the clinometer plane.

The jump is the angle which the line of departure makes with the axis of the bore at the muzzle.

These two quantities vary much in different guns and it was found that their sum could be measured, partly on the gun (by clinometer) and partly on the screen itself.

The sums of the two angles was applied as a correction and, as a result, the M.V. from observation and from screen was found to be nearly the same.

#### Captain Chapman's report in October

149. In October an exhaustive report on the work was submitted. Dealing with so large a number of results it proved conclusively the value of screen calibration. Captain Chapman's careful and thorough arrangements and analysis were thus responsible for a rapid advance both in method and in the confidence of the gunners during the summer months of 1917.

Some interesting effects from different lots of shell were noted. It was also proved that the unsteadiness factor was negligible at medium or short ranges even with guns worn down to the condemning limit.

The smoothness of shell and fuse (or newness) was shown to have a considerable effect.

#### Movement of the Calibration Section

150. The section now moved back from the coast and was installed behind St Omer. It no longer, therefore, had the advantage of observation on the fall of the rounds, and the muzzle velocities measured were given certain standard corrections based on previous experience.

An advance in efficiency was made by providing four screens instead of the original two.

Meanwhile the M.G.R.A., G.H.Q. before taking steps to ask for sections, and to allot establishment for them, desired further confirmation from some other Army.

## Sections in 1st and 3rd Armies and difficulties of personnel

151. The man power question was very acute at the end of 1917. The Russian debacle and our own losses in the summer and autumn offensives were such serious factors that it was impossible to secure additional authorised personnel. Nevertheless it was arranged to borrow enough men from other duties to start one section each in 1st and 3rd Armies in March 1918.

The latter had not got properly into action before the German Offensive resulted in the loss of the prospective range. It was installed soon after however on a new site and the 1st Army section meanwhile got to work with much success.

## Need for further experiment

152. So far a great deal had been done to enable the carrying out of a systematic and efficient calibration at short and medium ranges. Experiment had made this possible, and there was now no range on which experiment could be continued. The coast sector had been taken over by the Belgians and each range consisted of a few hundred yards only, the guns firing into quarries or cliffs. Naturally a range could have been installed on the sea coast to the West of our area but difficulties of man power and of the transport of guns there and back from the front proved too great.

It was felt none the less that the investigation of the unsteadiness factor was now the most important question and for this purpose Captain Chapman was sent to the Calibration Section on Salisbury Plain.

## Natures of Guns calibrated and value of results

153. Calibration had been confined hitherto to the 60 pounder, 6" and 4.5" Howitzers and 18 pounders. It was probably the work with the latter which was most useful. The accuracy of the barrage is of course one of the main factors of success in a modern attack. It would however have been of the very greatest assistance to map shooting generally had it been possible to calibrate heavy guns and howitzers.

## The "Joly" Apparatus

154. It was with corresponding interest therefore that we heard in July the news of a French method of calibrating heavy guns. The method allows of a rapid calibration in the field. The apparatus is light and portable and the system easy and accurate to work.

It has two great drawbacks however that:

- (a) it depends upon the "shell wave" and cannot therefore be applied to any shell whose velocity is less than that of sound in air.
- (b) it does not enable one to measure the "jump".

Something better is bound to come soon and the "Joly" did not appear to be worth taking up seriously.

## Experiments on Salisbury Plain

155. Some interesting experiments on Salisbury Plain in which the National Physical Laboratory took part (Aug 1918) showed that screens were not really necessary but that microphones might be used instead. The shell passing over these not only allowed of a measurement of time taken between microphones but of the jump of the gun. As a practical drawback however this method will allow of the calibration of only one gun at a time, whereas with screens the guns of a battery can be calibrated

all together firing in salvos, each gun through its own screen.

#### Present position of Screen Calibration

156. The position at the close of hostilities is therefore as follows:

Providing that wind, temperature etc are known it has been proved that the range a gun will attain with a certain lot of ammunition is a direct function of the M.V. at medium or short ranges obtained by calibration with that ammunition. It has been shown that the unsteadiness factor does not complicate the issue at such medium or short ranges. Four calibration ranges, each dealing with 4 guns at a time are at work in France: an experimental calibration is at work on Salisbury Plain.

The perfect registering instrument has not been evolved but it is clear that a string galvanometer is an excellent if not the best solution for ranges where guns can be calibrated in bulk.

A really good apparatus for calibrating heavy guns and howitzers in the field has not yet been evolved.

#### Screen calibration compared with calibration in the line

157. Calibration in the line must play an important role for heavy and siege batteries because there is at present no other method of doing it. It may under careful management be valuable and moderately accurate, but the following information is most important and is seldom got as accurately as it might be.

1. True range (from survey of gun position and of fall of rounds).
2. True angle of sight (from height of gun and of burst).

Both from survey, and not from contours.

3. Good meteorological corrections.

Moreover calibration must be done with mixed charge lots or it is of little value.

Admitting all these preliminaries have been accurately and carefully arranged for, the probable error of a deduced M.V. may be taken as 9 foot per second. If they are not, if the position of the gun is only known roughly, or if the fall of the round is not carefully surveyed, the probable error will rise to about 12 feet per second with outside errors of 50. If one "lot" only be used the calibration cannot have any definite value.

The probable error of a screen determination of M.V. is in terms of three feet per second.

If the M.V. determination for a field gun is based on mixed charge lots (as it always is with screen determination) outside variations due to ammunition may be taken as + 35 feet per second.

To sum up, screen calibration is far more accurate and reliable than the best calibration in the line can be, not only because of the accuracy of measurement but because it eliminates automatically errors of survey and of meteorological data.