

**REPORT ON THE WORK OF THE SEVENTH FIELD SURVEY COMPANY R.E.
EGYPT, SINAI, PALESTINE & SYRIA.
DECEMBER 1916 TO OCTOBER 1918.**

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I - HISTORY

In the Autumn of 1914, application was made to the Survey of Egypt for the loan of surveyors for Military Survey work on the east bank of the Suez Canal. Two surveyors, Mr. C.F. Montagu and Mr. G.W. Murray were supplied in a civil capacity.

Maps on a scale of 1/15,000 were made and published. These Maps were primarily for the use of the Artillery, and were used during the Turkish attack on the Canal in February 1915. All the work asked for was finished off by the Summer of 1915, and the work was closed down.

In October 1915 further Survey work was required and the Survey of Egypt supplied the necessary Surveyors in a civil capacity. Owing to the obvious difficulties which arose, it was decided to put the work on a Military basis. Accordingly, in December 1915, the G.H.Q. Topographical Section was formed, and local and temporary commissions were given to Members of the Survey of Egypt, as follows :-

Major	W.J. Maule	Commanding.
Capt	W.H. Crosthwaite	
Capt	P.A. Curry	
Capt	C.F. Montagu	
Lieut	G.S. Laird Clowes	
Lieut	W.M. Hayes	
Lieut	O.H. Little	
Lieut	G.W. Murray	
Lieut	F.S. Richards	

Detail work was now done on 1/20,000, and contours at five metres V.I. were surveyed. The Triangulation was extended, and occupied, to an average distance of 12,000 yards East of the Canal, and points further out were fixed by intersections. The scheme was for the detail ground survey to be extended to a distance of 5000 yards East of the trench line, which was about 8000 yards East of the Canal, and for this to be extended eastwards another 5000 yards or so by aeroplane photography. To enable the aeroplane photographs to be joined on to the ground survey, the ground was marked by means of groundsheets, small trenches and sandbags at the trigonometrically fixed points. The relative positions of the ground marks, and the fixed points, were surveyed accurately, and immediately sent to Ismailia, where the Headquarters of the Section was situated. The R.F.C. was informed by signal as soon as any point was ready for photography. A group of 10 or fifteen overlapping photographs was taken round the point, and sent to the Headquarters of the Section. Here the Group was formed into a mosaic, and the scale and orientation were determined by the aid of ground marks. The mosaic was then photographed down to 1/20,000, and fixed by means of the triangulated point in its correct position on the grid. Groups then could be linked up by a series, and so the whole area could be surveyed by overlapping photographs. In cases where neighbouring groups were linked up the photographs joined up remarkably well.

In practise this scheme was found unsatisfactory, because the R.F.C. was not always able to photograph the ground marks immediately they were put down. Owing to the loose nature of the sand, and the prevailing high winds, the marks were almost invariably obliterated after being down for a few days. The R.F.C. Observers sent out to photograph them were then unable to locate the place, or if they could it was found to be very difficult to find the marks on the photographs. The outcome of this was that the ground marks had to be re-dug sometimes three or four times. Consequently it was found that instead of aeroplane photography being a quick method, it was no quicker than ground survey, so the method was abandoned in March 1916, in favour of ground survey.

When looking back on these early efforts of aeroplane photography, one wonders why they were not successful in spite of the keen-ness and ingenuity displayed by all concerned. It must not be forgotten however, that these were the earliest experiments, on the front, that altitudes of 5000 feet were only occasionally attained, that a moderate wind was sufficient to prevent flying altogether, and that in the earliest efforts photographs were taken with an ordinary hand camera held over the side. These experiments were not without their value, for the experience gained proved to be of very great use when the present methods of utilising aeroplane photographs for mapping were being evolved.

The triangulation was observed on two arcs with five inch micrometer Troughton & Simms theodolites. Reciprocal vertical angles were also observed on each line. In open country the average length of the side was from 8 to 10 kilometres. The marks used were screw piles (of special design) in sand, and cairns of stones, quadripods or any other mark obtained locally, in the hills. Re-observations were made for triangles closing with more than 15 seconds, if time permitted. The average error of closure was about 6 seconds.

Ground survey on 1/20,000 kept pace with the advancing Army during the Spring of 1916. On the morning of April 23rd 1916, when the Turks attacked our advanced posts, one Survey party was at Ograntina, and was completely lost, the officer in charge Lieut O.H. Little being taken prisoner. Two other parties were at Romani and withdrew only losing their kit. Until August 1916 no advance was made by the Army, so the time was spent in adding Railways, pipe lines, and defences on to the existing Maps. As much work as possible was done in front of the line, Surveyors accompanying the Cavalry reconnaissances.

Early in April 1916 the need of a more accurate map of the Coastal belt between Alexandria and Sollum was felt, so Capt Montagu was withdrawn from the East, and sent to the Western front. As more surveyors could not be spared by the Survey of Egypt, the services of Lieut H. Sanderson, 2nd County of London Yeomanry, and three capable O.R.'s were placed at the disposal of the Topographical section, for work on the Western front. After a short time Lieut Sanderson was able to undertake all classes of work, and the O.R.'s became reliable plane-tablers. In the Autumn of 1916, Lieut Laird Clowes relieved Capt. Montagu, who went into hospital. The work on the Western front continued steadily until March 1917, when it was finished, and all Survey parties were withdrawn, and came over to the East. As well as extending the triangulation along the coast, and making a detailed survey on a scale 1/50,000, Surveyors accompanied many of the Armoured Car patrols, and helped the Army in every way required.

After the Battle of Romani in July 1916, the advance of the Army from Katia to Bir el Abd was so rapid that Survey work could not keep pace with it. The area stretching from Katia to Bir el Abd, bounded on the North by Lake Bardawil and including Mageibra and Hod Bayud on the South (approximately 600 square miles) was triangulated and surveyed on 1/40,000, by five Surveyors in the short time of six weeks. Survey work then kept pace with the Army until Gaza was reached. In September 1916, Capt. S.N. Maclean, 7th A.L.H. (an Australian Licensed Surveyor) and Lieut W.D. Beatty, R.E. joined the section, which was further strengthened in December 1916 by the arrival of Capt. D.R. Meldrum D.S.O.

Capt. D.R. Meldrum, with Lieut. W.M. Hayes had originally been lent by the Survey of Egypt for survey work on the Gallipoli Peninsula. After the evacuation Lieut. Hayes returned to Egypt, and Capt. Meldrum went to the Salonika front, where he took charge off Survey operations until he could be replaced in August 1916, by competent officers sent out from home. For his work on Gallipoli and Salonika, Capt. Meldrum was awarded the D.S.O.

When first taken on the strength of the Topographical Section, Capt Meldrum accompanied several Armoured Car patrols in the Western Desert and fixed the positions of Camps, Depots and prominent land marks. He accompanied the successful patrol to Siwa at the end of 1916, as the Official Surveyor. Operations on the West having been brought to a successful conclusion, Capt. Meldrum went to the Eastern front, and joined the Survey Party at Sheikh Zaeid in February 1917, who were preparing to Survey the ground before the Weli Sheikh Nuran position, where the Turks were entrenched. Capt. Montagu having returned from hospital, was in charge of this work. Five Ford cars were placed at the disposal of the Survey party, so five Surveyors went out every day and, working up to the forward Cavalry screen, sketched the detail in front. Each box carried the Surveyor, driver, two Egyptian chainmen, and the necessary instruments. A light car patrol with machine guns mounted on Ford cars was attached as immediate escort. It was not possible to make a proper triangulation but prominent objects were fixed by theodolite intersections from instrumentally interpolated points. The fixing of the Great Mosque at Gaza, was found to be only five metres in error when fixed accurately, so there was no placeable error in this rough work. As soon as the Map was finished, the Turks evacuated their position. That was disappointing to the Surveyors, but much valuable experience had been gained in rapid, and sufficiently accurate methods. The great value of the Ford cars was also amply demonstrated.

A map made from aeroplane photographs showing trench details had also been compiled and printed at El Arish.

In March 1917 the Topographical Section was re-named the 7th. Field Survey Company R.E. and the Headquarters of the Company moved up to Deir el Belah early in April. The triangulation was extended up to the Wadi Ghuzze, and detail survey was done on the East of the Wadi. All the ground between the Wadi Ghuzze and Khan Yunus was surveyed by the middle of April. The fair drawing of the map (Gaza X) for the second battle of Gaza was drawn up in the field by Lieut. N.L. Shiels, A.I.F. who joined the Topographical Section in July 1916, and entailed 26 consecutive hours work with only brief intervals for meals. The tracing was flown to Cairo by Aeroplane, for reproduction. The printed Maps were sent from Cairo to Belah by Aeroplane. As well as two maps of Gaza town, compiled from Aeroplane photographs, and printed in Cairo, a Map showing details of the Turkish position round Ali Muntar was compiled from aeroplane photographs, and printed in the field.

Early in 1917 when the Turks had evacuated Sinai, a Survey party under Major J.D. Campbell, D.S.O. R.E. who had joined the Section in December 1916 was sent to revise the 1/125,000 Maps in all areas of Strategic Importance. All new roads and wells made by the Turks were added to the Map, and practically the whole of Sinai was covered, and the Maps revised West of the Nekhl - Rafa line. In addition to this a full Military report was made on the roads and wells. This work was finished by the Autumn of 1917, and Major Campbell then proceeded to Akaba, where an area of 144 square kms. was surveyed on a scale of 1/30,000.

After the second battle of Gaza a period of trench warfare started. Survey parties were distributed along the front, to survey in greater detail than had been possible before, the country behind our lines. This survey was done on 1/20,000, and the 1/10,000 series (as well as the later 1/20,000 series) were compiled from this Survey. The British trenches were surveyed on scale 1/10,000 for the 1/10,000 series of Maps, and the 1/40,000 detail was extended Southwards so as to cover off the Southern flank of the British position. All survey to the East of the Wadi Ghuzze was done on 1/20,000, and by October 1917 this Survey extended up to the Turkish defences all along their position, and included Khalasa on the South.

Early in May 1917 the possibility of starting an Observation Group to locate enemy artillery positions from gun flashes was discussed. Capt. Meldrum, who had studied the organization of Survey Companies on the French front during the previous autumn, drew up a scheme and spent many nights in O.P.'s looking for flashes.

Capt. Meldrum's experience proved that the Turks did very little night firing, and what they did was from very well concealed positions. The C.R.A. 52nd Division who was very keen, arranged to provoke the Turks into activity one night by opening up a very heavy fire, as if a raid was contemplated. The Turks returned our fire, and Capt. Meldrum arranged for theodolite intersections to be made on to their flashes from trigonometrically fixed points. By this means eleven enemy battery positions were detected with various degrees of accuracy, the majority of which were confirmed by Aeroplane reconnaissance next morning. In spite of the results of this experiment the matter was allowed to drop partly owing to the difficulty of getting personnel, stores etc., but also because of the lack of interest displayed by the authorities concerned.

With the commencement of trench warfare, aeroplane photographs of enemy trenches were extensively used for map making purposes. For this, methods had to be evolved and the staff trained. The methods in use on other fronts were not applicable to this front because of the scarcity of fixed points.

In August 1917, the Headquarters of the Company moved from Belah (where it was attached to "East Force") to G.H.Q., at Kelab. From this time onwards, Survey Company Headquarters always remained at G.H.Q., moving first to Sejid, and then to Bir Salem.

In September 1917, "N" and "V" Sound Ranging Sections arrived from France, and came into action on the front between the coast and Mendur. At first they were principally used for the location of hostile batteries. Not many ranging shots were carried out. This was chiefly due to the scepticism of the gunners who did not realise that a ranging shot carried out by means of sound on to a hostile battery which had just been located was more accurate than the error of the gun even if the location was only a poor one. This practice of firing on enemy batteries every time they fire has the advantage that

casualties are caused to the gun's crews, and the enemy gun silenced. Later on however, particularly with "V" Section on the XXth Corps front in the summer of 1918, it was realised what a Sound Ranging Section is capable of, and no opportunity was ever missed of carrying out a Sound Ranging shoot. In fact "V" Section were continually being rung up by the Artillery even when conditions were unfavourable for Sound Ranging, and asked if they could not manage to range some of our batteries. This close cooperation between the gunners and the sound-rangers was very gratifying, and speaks volumes for the tact and perseverance of the Sound Ranging Officers, and the open-mindedness of the gunners who were at first very conservative and antagonistic to new methods. When however, the gunners were convinced of the powers of Sound Ranging, they welcomed it with open arms, and did everything possible to help the Sound Rangers so that their work could be extended.

During periods of trench warfare it was found to be the best to allot one Officer and one O.R. topographer to each Divisional front. This was done when possible. They camped near Divisional Headquarters, and kept close touch with the Divisions, making surveys of any new ground occupied, and supplying tracings of any part required. They also fixed all battery positions and datum points, and in short did any Survey work required by the Division. The services of the Surveyors were very much appreciated by the Divisions, who kept them fully employed.

In July 1918, two Corps Topographical Sections were formed one for each Corps. Lieut H.R. Wardill being attached to XXI Corps, and Lieut G. Parsons to XX Corps. They each had draughtsmen, and reproduced sketches on the Ellams duplicator. No topographers were attached to the Topographical sections, as none were available.

XXI Corps made full use of their Topographical Section and gave Lieut Wardill all the help they could. Consequently most excellent work was done by this Section. The results obtained by XX Corps Topographical Section were not so fortunate partly owing to the fact that Lieut Parsons was rendered very little help by the Corps, owing to the unfortunate fact that XX Corps Headquarters was at Jerusalem, and 14 Squadron R.A.F. (XX Corps Wing) was at Wadi Surar Junction. Lieut Parsons was sent to Wadi Surar Junction so as to be near the Corps Wing. Consequently XX Corps Topographic Section to some extent lost touch with the Corps Staff. This meant that the enormous amount of work done by XX Corps Topographical Section was not applied to the best advantage.

Early in 1918 the possibility of starting an Observation Group on the XXI Corps front was discussed and Major Maule and Capt. Musgrave the Aeroplane photographic Officer, G.H.Q. had several conferences with the Senior Artillery Officers. The outcome of this was that a complete Observation Group was asked for from France. The 28th Observation Group arrived, and got into action in July 1918. At this time there was only one small sector of the front not covered by a Sound Ranging Section, so the Observation Group went into this Sector to fill up the gap. Owing to the well concealed positions chosen by the Turks, and the small amount of night firing indulged in, very few guns were located by means of gun flashes. The long range gun however, which was shelling Jaffa, was located by the Group and silenced by our Artillery after it had only fired a few rounds. Many opportunity targets, working parties, transport etc., were located by the Group, and were sometimes fired on by our Artillery. The Group was not in action long enough for the gunners to imbibe any new ideas so full use was not to be made of their capabilities for calibration, ranging shots etc.

In July 1919 (sic), at the urgent request of the Artillery, a new Sound Ranging Section "NN" was formed, and got into action in August, with Capt. T.A. Evans of "V" Section in command. The nucleus of the section was formed of men taken from the other two sections and the remainder of the personnel were supplied by the Artillery. The instruments were supplied from France. The section was only in action for six weeks, and occupied two bases, the move taking less than twelve hours. Practically all the guns on the front opposite to these positions were located, and when active operations started enemy fire was completely masked by our Artillery.

When "NN" Section came into action they filled up the gap between "N" and "V" Sections, so the 28th Observation Group moved to the Coastal Sector, the move being accomplished in 11 hours. On this Sector however, the Group met with no more success than they did before. There is little doubt that had the Observation Group been in action longer the initial aloofness of the Artillery would have been overcome, just as it was in the case of the Sound Ranging Sections, and greater use would have been made of their capabilities.

METEOROLOGICAL.

Early in 1917 the formation of a Meteorological Section was considered, and Pilot Balloon flights were made at El Arish, and the results communicated to the R.F.C. In August/September a Meteorological Station was established at Kelab (G.H.Q.), and at least one Pilot Balloon flight was made daily for the Artillery and the R.F.C. Flights were made more frequently when required. Observations were taken regularly, and published for atmospheric pressure, air temperature and humidity, wind velocity and direction, clouds, evaporation and rainfall. The section was first under the command of Capt. Curry, but in September 1917, Capt. A.J. Bamford M.C. (Superintendent, Ceylon Observatory) joined the Company, and later on took charge of all Meteorological work.

After the Battle of Gaza - November 1917 - balloon flights were discontinued until G.H.Q. moved up to Bir Salem in January 1918, when they were immediately resumed and continued until the end of September, when they became unnecessary. The ordinary Meteorological Observations were continued first at Sejed, and then at Bir Salem.

In April 1918 a Meteorological Section was established at Jerusalem, and ordinary Meteorological Observations taken, and pilot balloon flights made as required. These were also continued until no longer required.

Capt. Bamford proceeded to the Hedjaz in May and August 1918, and determined the Geographical positions of several points on the Railway, including Maan and Shahm, by astronomical observations. In November and December 1918, Capt. Bamford similarly fixed the positions of Damascus, Baalbek, Homs, Hama and Aleppo.

II - HEADQUARTERS.

On the formation of the Topographical Section in December 1915, the headquarters was established at Ismailia, with Major Maule in command, assisted by Lieut. Hayes, who was in charge of Aeroplane Photographic work. Lieut. Hayes' experience with Aeroplane photographs at Gallipoli proved invaluable in starting a Section on this front. In July 1916, W.O. N.L. Shiels, A.I.F. was attached to the Headquarters' staff as chief draughtsman, and when Lieut. Hayes left the Section to take up duties in Mesopotamia, Mr. Shiels took charge of the aeroplane photographic work.

After El Arish was occupied, it was decided to transfer the Headquarters to El Arish, and to start a Printing Section in the field. The office was closed at Ismailia on January 14th 1917, and opened at El Arish (under the command of Capt. Curry, who took charge until the arrival of Major Maule). At El Arish, Meteorological as well as printing work, was first started.

In order to be in closer touch with the field sections when preparing maps for the second battle of Gaza, the Headquarters moved up to Khan Yunus on April 1st, and to Deir el Belah on April 7th. The VIIth Field Survey Company, R.E. which had now been formed, was attached to East Force, and took charge of Maps Office. When trench warfare started, extra draughtsmen were obtained, and aeroplane photographic work increased considerably.

With the publication of the 1/10,000 series of trench maps, the need of a printing machine to turn out maps at a quicker rate than was possible on the hand-press became imperative. This was obtained from the Survey of Egypt, and installed at the Police Post, Rafa - there being no other suitable building available - and was ready for work on May 26th.

Early in July the Headquarters moved, with East Force, into dug-outs on the shore to avoid bombing. In August the Headquarters moved to G.H.Q. at Kelab, and the Company was attached to G.H.Q. The publication of the 1/20,000 series of Gaza was then taken in hand, and entailed an immense amount of work at Headquarters. Lieut. J.R. Ramsey 1/7th Scottish Rifles came to work at Headquarters to help with the 1/20,000 series.

During the whole time at Kelab the Headquarters were visited daily by Major R. Meinertzhagen, D.S.O. G.S.O.2(I) whose technical knowledge proved of very great help. Besides keeping the section in close touch with the trend of affairs all ranks were greatly encouraged by the close interest taken in the work of the Company by the General Staff. On September 27th, the Headquarters was visited by the Commander-in-Chief, who remained some time with the different Sections. Later in the day the I. in C. visited "N" Section in company with the A.M.S., and O.C. Survey Company.

With the increase in the size of the Company, a considerable part of the O.C's time was taken up in purely administrative work, so in December 1917, Capt. P.S. Barlow, 1/5th Sussex Regt., who had joined the Company for Meteorological work, was appointed Adjutant.

Company Headquarters moved with G.H.Q. to Sejed in December 1917, and to Bir Salem in January 1918, where it remained until the Armistice was signed on October 31st 1918.

The Printing Section was moved from Rafa to Ramleh in March 1918, and was installed in a School House, which proved a most suitable building. Lieut. Reekie, Seaforth Highlanders, joined the Company in June 1918, and after visiting the Survey of Egypt in Cairo, to study their methods, took charge of the Printing Section at Ramleh. The Drawing Office had by this time become so large that Lieut. J.W. Crowder, Hampshire Regiment, and of Ordnance Survey, Southampton, was attached to the Company to take charge of this work.

At the cessation of hostilities the work done at Headquarters can be classified as follows : -

1. Administrative.
2. Technical - Including computation of observations, sticking down and pantographing aeroplane photographs, compilation, drawing and checking of maps, fixing enemy guns from aeroplane photographs, and keeping revision copies up to date.
3. Meteorological - Ground observations, balloon flights and instrument testing.
4. Miscellaneous - Sun printing, tracing, marking up panoramas.
5. Lithographic and letter-press printing.
6. Photographic work.

The personnel at Headquarters consisted of : -

	Officers	O.R's	Natives
Officer Commanding	1		
Administrative	1	6	2
Technical	5	12	
Meteorological	2	8	1
Servants			9
	9	26	12

At Ramleh, under the command of the Printing Officer, there were 10 lithographic printers, 13 letter-press printers, 2 photographers, and 4 men working with the Q.M.S. in the Stores.

Transport consisted of one Ford touring car, and one box car at G.H.Q. and one box car at the Printing Section, Ramleh.

TRIANGULATION.

The triangulation was observed on two arcs with five-inch micrometer theodolites (Troughton & Simms). Reciprocal vertical angles were also observed on each line.

In open country the average length of side was from 8 to 10 kilometres. The marks used were screw piles of special design in sand, and cairns of stones, quadripods or any other mark obtained locally in the hills. Re-observations were made for triangles closing with more than 15" if time permitted. The average error of closure was about 6 seconds.

In the winter of 1915-16, a network of triangulation was pushed east of the Suez Canal to a distance of 12,000 yards between Kantara and Suez. This network was continued eastwards from Kantara with the advancing army in 1916, and kept up with the advance until Gaza was reached. A base was measured at Rafa, and showed an agreement of 1 in 6,000 with the length as obtained from the triangulation.

During this time 170 points were occupied and established, as well as a large number of prominent objects - Sheik's tombs, trees, houses etc., being fixed, particularly in the Gaza - Beersheba line.

After the advance from Gaza the main chain was extended along the coast, and at Wadi Surar Junction divided into two parts, one going to Jaffa, and the other to Jerusalem. A subsidiary chain was carried along the Beersheba-Hebron-Jerusalem road, with the advancing army, and joined on to the main chain at Jerusalem, with an error of 20 metres. The magnitude of this closure is due to the rapidity of the advance up the Hebron road, and consequently the chain had sometimes to be carried through ill-conditioned triangles of which only two angles could be observed. As the trench line was pushed further north the triangulation kept pace with it, being extended by four parties working across the front, 117 points were occupied in the period November 1917 to March 1918, and a great many prominent objects were fixed in enemy country extending from Mount Carmel in the north, to Kefr Huda in the east. Owing to the rapidity of this original advance, and the fact that four inch theodolites had to be used the accuracy of this triangulation was not as great as the previous chain across Sinai.

In June 1918 a base was measured N.E. of Mulebbis, on the plain south of Nahr Auja. The error found in the triangulation was 1 in 7,000. An astronomical azimuth was also observed shewing the accumulated error in azimuth of 1 minute, and a complete chain of good triangulation was observed stretching right across the front, from the sea to En Nejmeb.

This new chain of 20 points, computed with the new length and azimuth, gave a maximum difference of 10 metres on any point with the original network. Re-observations were made for closures of triangles, of more than ten seconds, the average closure was 5 seconds. This chain was used as the basis for the triangulation which was pushed forward behind the advancing army, after September 19th. Two chains were observed, one going along the coast to Tul Keram, and then east to Samaria, where it joined on to the other chain which had gone up to the Nablus Road, on Sept 30th.

The two chains formed a circuit 150 kilometres in length, and close to within 30 seconds in azimuth, and 6 metres in co-ordinates. Only one chain was continued northwards and went through Jenin, Nazareth and Kuneitra to Damascus. Owing to the difficulties of supply and transport, the chain from Nazareth to Damascus was not of the same high order of accuracy as the other work. At Damascus an astronomical azimuth was observed, and shewed the accumulative error in azimuth to have amounted to 3 minutes thirty seconds.

From Damascus the chain is being extended northwards to Aleppo, where the triangulation will join on to an astronomical station for position and azimuth, and on to a base (measured by the Turks) for scale. Geographical co-ordinates are being computed.

COMPUTATION.

A field computation was always made by the observer. Computation checks were not usually made. The only check applied was the graphical one on the Plane Table. From these computations the field sheets were plotted, and any co-ordinates required by the Army were supplied. Until May 1917, final computations were done by the Survey of Egypt at Giza, as soon as possible after the observations were taken. After this date computations were made at the Headquarters of the Company, and the observations taken by the various Field Topographical Sections were adjusted for consistency. The observations were still sent to the Survey of Egypt for filing, and final adjustment.

The original belt East of the Canal was computed on rectangular co-ordinates, using the Gauss Conformal projection with longitude 32-24' East as central meridian. The belt along the north coast of Sinai was computed on rectangular co-ordinates. In Palestine the same rectangular co-ordinates were continued as far as Damascus. By computing in this way series of maps have been produced, in which each sheet is the same size, rectangular and bounded by grid lines, also each sheet is a true representation of the earth to the required scale, and the convergence of meridian is known.

III - FIELD TOPOGRAPHICAL SECTIONS.

On the formation of the Topographical Section, G.H.Q. there were six field parties each under the command of an officer, who did all the field work. As the work and the Section expanded, the number of Surveyors increased until at the cessation of hostilities there were 14 officers and 16 other ranks doing Topographical Field Work. Surveying was done with the plane table, controlled by triangulation.

PLANE TABLING.

The usual methods were employed except in the sand dune area, and under direct enemy observation. A brief account of the special methods employed in these two cases is given below.

DETAIL SURVEY IN THE SAND DUNE AREA ON THE COAST OF SINAI.

Triangulation points were established completely covering the area, the points being about 8 kilometres apart. Detail survey on 1/20,000 or 1/40,000 scale was done by means of a plane table, telescopic alidade fitted with stadia hairs (for reading distances), Indian clinometer, trough compass, and usually three chainmen carrying staves. The party was mounted on camels, and consisted of one Surveyor (usually an Officer) five chainmen, and a camel-man to look after the camels whilst the party was working. This is an ideal party, and very often in practice a much smaller party had to be used because of shortage of men owing to sickness etc. Of the chainmen, two stopped with the Surveyor at the plane table, one to hold the umbrella, field glasses, pencils, india-rubber etc., as required, the other to give the signals to the staff men so as to get them into the positions required by the Surveyor. The method of signalling was to have three flags of three colours (one for each staff man) - white, orange and green.

On arriving at the station (usually the top of a hill or spur) the staff men were sent out, whilst the Surveyor resected his position, using the compass to get a first approximation of the orientation. When the position was obtained, the height was determined by means of clinometer readings on to triangulation points, or other near points - not more than two kilometres away if possible. Having determined the position and height, the staff men were then used to determine spot heights. By reading the distance on to a staff by means of the alidade, and plotting that distance along the ray, the position of the staff was determined on the plane table. Then by means of a clinometer reading, the difference in height between the station and the staff was obtained, and from this the height of the staff determined. Spot heights in this way were determined at all salient points as a guide. It was found convenient to use two staff men for distant work - from 600 to 800 metres - and one for near work - up to 400 metres. The staff men often did all their work mounted on camels. They moved about quicker, and covered larger distances, on camels than they could on foot. Having finished with the staff men, and signalled for them to come in, any additional plane table work was done, such as drawing rays to prominent objects etc. If the plane table station was a prominent hill, the spot was marked before leaving by means of a palm leaf, or a knot of grass. This was then used as a subsidiary point for determining positions and altitudes of other stations. In general, the plane table was set up every 600 or 700 metres, but this varied greatly according to the nature of the country, and the number of staff men available. Working in this way, and surveying 5 metre contours, an average area of four square kilometres was surveyed per working day. Inking-in was usually done in the evening on return to camp, during the summer, but in the winter the hours of daylight were completely taken up in surveying, and the inking-in was done during a spell of bad weather.

SURVEYING UNDER DIRECT OBSERVATION OF THE ENEMY WHEN WITHIN RANGE OF FIRE.

Under this heading is included work along the British front line, and work during a reconnaissance in force. For obvious reasons the party was kept as small as possible, usually only one man accompanied the Surveyor. The plane table was often set up behind the crest of a hill so as to be just out of sight of the enemy. As much work as possible was done in this position. The plane table was then moved a yard or two up the hill until it was level with the top of the hill, and a little to one side of the crest. From this position detail in front was sketched. Before moving the plane table up, the ground in front was carefully reconnoitred so that the actual time spent with the plane table was reduced to a minimum. It was not found advisable to remain working with the head and shoulders under direct enemy observation for more than a quarter of an hour at a time. Periscopic theodolites and alidades, although indented for, were never supplied to this Company.

When fixing the positions of points in enemy country it was found advisable to occupy two stations close together (say 500 metres apart) and draw rays to all the points, thus getting approximate positions for them before they have changed their relative positions. Then when another station was occupied, the approximate positions already found enabled the points to be identified, and so rays were drawn to them which fixed their positions with well-conditioned intersections. This same principle was found to be of great use when fixing points by theodolite intersections.

Stations on the forward slopes of hills in full view of the enemy were sometimes occupied with a plane table. In these cases the Surveyor reconnoitred the ground thoroughly first and worked alone, setting up the plane table only when there was a suitable background to make him almost invisible to the enemy.

Surveyors also accompanied day and night patrols in front of the line, taking observations by compass and aneroid barometer. On returning to camp the information obtained was embodied in the map.

In all front line work the first essential was to fix as many prominent objects as possible, and it was found that more accurate positions of points in enemy country could be fixed by theodolite observations from triangulated points some distance behind our lines, and out of range of any but the largest guns, than by any other method.

Points which could not be sighted from triangulation points, and which could not be fixed by plane table owing to the nature of the country, were sometimes fixed by means of a three-inch theodolite which was taken out in front of our trenches and stood on the ground - the legs not being used - in such a position that the Surveyor and the theodolite were completely hidden from the enemy by the scrub etc., growing on the hillside. To enable sights to be taken, the scrub was slightly displaced by means of a stick. Fixed points as well as others were sighted, and the position of the theodolite was determined by computation, using the observations on to three known points for this purpose. Other surveyors found that a sextant was more convenient for this work than a theodolite.

It sometimes happened that a point was sighted by a theodolite from one triangulation point only, but was fixed independently by plane table. If it was considered that the plane table fixing would be strengthened by means of the theodolite observation, this was done as follows : -

The approximate position of the point being known, its approximate distance to the triangulation point was also known, and so two distances were taken, one greater and one less than the approximate distance. By using these two distances, and the known bearing of the point from the triangulation point, the co-ordinates of two points were computed which lay on the known bearing, and which fell one on each side of the unknown point. These two points were then plotted on the plane table, and the line joining them was drawn graphically. The point whose position was required then lay on this line. It sometimes happened that the triangulation point itself fell on the plane table. In this case it was necessary to compute and plot only one point falling on the other side of the required point. Then the line joining this point to the triangulation point passed through the point required.

RECOMMENDATIONS.

After the Turks were defeated at Gaza, our advance was not seriously held up until Jaffa was taken and Nebi Samwil occupied. Maps showing both our own and enemy country were then urgently required. The map of our own country was made entirely from ground survey, and of enemy country from aeroplane photographs. It was of the utmost importance that these two surveys should be placed in their correct relative positions with respect to the grid. The only way of doing this was to use points in enemy country, accurately fixed by triangulation, to control the map made from aeroplane photographs. In this particular case this was not possible in the first editions of the maps published, because the necessary points in enemy country had not been fixed, all field parties were fully occupied with the urgently required ground survey. As a temporary measure ?????? approximate grid. As soon as points in enemy country were fixed and identified on the photographs, it was possible to re-publish the sheets, showing the detail in the correct position on the grid. So as to tide over the few days that elapsed before new editions could be published, a few copies of the maps, north of Jaffa, were overprinted with the correct grid in red. These were given to the Artillery and R.F.C. only. The difference in the grids was only 300 yards, and a certain amount of confusion naturally resulted in the

existence of the two grids. The matter was immediately put right when new editions appeared, and the old ones were withdrawn.

In order to avoid similar trouble in future it would be advisable to detail an Officer to devote all his time to fixing points in enemy country. He should be very mobile, and should have a box car so as to be able to visit Company, Corps and Divisional Headquarters to study the photographs, and identify the points he had fixed. He would visit the whole of the front in turn, and do nothing else but triangulation in our own lines, and fixing points in the enemy's. No officer was available for this work in this Company, every available surveyor was needed for detail survey, but in future it would be well to allow for an officer for this special work on the Establishment.

NOTES ON SURVEY INSTRUMENTS SUPPLIED BY THE ARMY.

Theodolites.

These were all vernier instruments, except one five-inch and two four-inch theodolites. The five-inch micrometer theodolite (Troughton & Simms) was in constant use, and was found to be satisfactory in every way. The two four-inch theodolites which had micrometers on the horizontal circle, and verniers on the vertical circle, were not found to be satisfactory, and were never used unless there was no other micrometer theodolite available. This was due to the low power of the telescope, and to the very poor illumination of the horizontal circle, so that the microscopes could not be read unless the light was very bright. The other five-inch and four-inch theodolites were practically never used because they were fitted with verniers, and all the Surveyors were unanimous in the preference of micrometer theodolites. Four five-inch micrometer theodolites were kindly lent by the Survey of Egypt in 1915, and three more were lent in 1918. Micrometers were found to be not only quicker and easier to read than verniers, but the liability to make mistakes was found to be less with micrometers than with verniers. Added to this micrometers are also more accurate than verniers. It was however the advantage with regard to speed - which was found to be so essential in Military work - that made micrometers universally preferred to verniers.

The three-inch vernier theodolites were often used when working in the front line, and when observations better than compass bearings were required. They were often used without legs so as to make them less conspicuous.

Plane Tables.

The ordinary Infantry pattern plane table was extensively used, and found quite satisfactory. There were however, a considerable number of broken legs. This was due to the unavoidable rough usage of camel transport. It was thought that stouter legs would be an improvement, as the extra weight would be more than compensated for by the greater strength and durability.

The Cavalry pattern plane table was very seldom used. In fact it was never used if an Infantry pattern was available. It was found that owing to the non-rigidity of the legs it was almost impossible to do good work with this pattern. This was particularly noticeable with Surveyors who had not had very extensive experience of plane tabling.

In the Cavalry reconnaissances between Shellal and Beersheba, August, September and October 1917, when distances of 50 miles were covered in 24 hours, the Infantry pattern plane table was used as it was found that it could be easily carried by a mounted orderly, the legs being carried in the rifle bucket.

Sight Rule.

This was found satisfactory. The sights could however be lengthened with advantage for hilly country like Palestine. Also, if an edge were graduated in centimetres it would be very useful when working on scales like 1/100,000, 1/20,000 &c. The addition of a metal inset to increase the weight would make the rule easier to use in a high wind.

Trough Compass.

Satisfactory in every way.

Indian Clinometer.

This was found to be a very satisfactory instrument. The only trouble was the liability of the bubble to get out of adjustment. For the first day or two after adjusting the bubble, in spite of the locking nut, it

did not remain constant, but it soon settled down to a steady state. If the zero error was then small - say 0.001 to 0.002 on the tangent scale - it was better to leave it, and not try to adjust it, as the zero error had only to be applied to long shots - as when finding the height of the station - and it was not necessary to apply the zero error when determining spot heights near the plane table. It was the usual practice to test the clinometer almost every morning by reading on to a distant object from the camp, the vertical angle to which had been determined by theodolite.

Telescopic Alidades.

These were not of much use. They were only provided with one horizontal hair in the diaphragm, whereas three stadia hairs for tacheometric purposes were universally used on this front, consequently two extra hairs had to be put on the diaphragm. The vertical arcs fitted to these alidades were never used, as the Indian clinometer was found to be a much quicker and handier instrument for measuring slopes. The design of the instrument is faulty with regard to its folding up for transport. In nearly every case the upright pillar became dented where it rested on the small supporting pillar when folded up, and consequently the vertical arc rested on the ruler, and was often bent in consequence. This could easily be remedied by making a larger and more suitably shaped head for the supporting pillar. The box was not nearly strong enough, and almost always was broken. The hairs should be engraved thicker.

IV - REPRODUCTION.

The first maps published i.e. in 1914 and 1915, on 1/15,000 scale, were reproduced by the Survey of Egypt direct from the field originals. The sheets were odd sizes - each sheet being chosen so as to show the most convenient area for some particular post e.g. Ferdan, Seapeum, Ismailiya etc. Each sheet was divided into 1000 yards squares, reference numbers and letters were put along the sides, top and bottom, so that each square was designated by a letter and a number.

In October 1915 it was decided to publish all the maps on 1/20,000 scale - on regular sheet lines, and with a continuous grid. All the work on the 1/15,000 scale was reduced to 1/20,000, by photography by the Survey of Egypt, and all new field work was added to the maps.

This series of maps included all the Suez Canal Zone defences. All detail and contours were reproduced in black, but the grid lines, numbers and letters were in red. At the same time a series of maps on 1/40,000 scale was published by the Survey of Egypt, showing detail and contours and names in black, heights in colour layers, water features in blue, trees in green, grid etc, in red. This series was found to fulfil all the needs of the Army at the time, so the 1/20,000 scale series was discontinued.

Field work was still done on the 1/20,000 scale, but the only maps published were on 1/40,000. Field work was surveyed on the 1/40,000 scale after the battle of Romani, August 1916. As the detail work was extended East of Bir el Abd, a sun printing apparatus was always carried by the Officer-in-charge of detail work, and sun-prints of the work were issued to the Divisions in the line as required. This method was continued until El Arish was reached. After the British occupation of El Arish, the existing Topographical Section was formed into the 7th Field Survey Company R.E., and here the Headquarters of the Company was established. From this time forward all field work was drawn up and then reproduced, printed, and published in the field, prior to being sent to Cairo for final reproduction by the Survey of Egypt. Maps were also issued in the field for special operations etc. At the beginning maps printed in the field were reproduced on a lithographic hand press, and were done in black only, or sometimes with a red grid, 100 to 200 copies being printed. The method was slow and laborious.

In the first maps of Gaza a fairly large edition in black was printed off, showing the topographical detail, and subsequent editions had the new enemy trenches in red.

At this period the Survey Company had three rooms for their use in El Arish village - built in the usual mud style. One room was used for Litho printing, the other two were occupied by the O.C. and draughtsmen etc., and the photographers, respectively - the last mentioned being made into a darkroom, and also used as a Vandyke room. These rooms were about 5 yards square - and work was done under great difficulties - water was very scarce, and the sand blowing from the desert caused great inconveniences in working on the aluminium plates. At times it was necessary for plates to be coated with sensitizer during sand storms - this causing a lot of "gumming out" to be done when the plate was

developed, and making extra work and delay - An ideal room for successful Vandyking should be quite dust-proof. The trouble with grit however, could have been greatly reduced had plenty of water been available to ensure a thorough washing.

The Vandyke outfit at this time consisted of a screen printing frame, one wooden acid bath, and a Vandyke roller, together with the various chemicals used in the process. The printing plant was a small hand press which could print a map 74 x 51 cms, two hand rollers, one ink slab, and a small quantity of lithographic inks. At the end of March 1917 orders were given to move the printing plant to Khan Yunis. This was done by Camel Transport, spending nights at El Burj and Sheikh Zoweid en route, and arriving on the 31st. Two and a half hours after arrival a Vandyke was completed, and a two-colour map started, the printer working continuously for sixty odd hours at full pressure, and having meals while operating his machine.

Early in April another move was made to Dier El Belan, where a stable was used for the printing and photography. The necessity for a machine was clearly shown by the fact that printers working on the hand press had to keep going sometimes for three nights and days without a break, in order to cope with the required work.

In June 1917, a hand-driven lithographic machine supplied by the Survey of Egypt was set up at Rafa for the printing of maps in the field. The plate was 'made' at Belah, and carried to Rafa by riding camel. Six Egyptians were used in relays to turn the wheel working the lithographic machine. A few months later a motor cycle engine was successfully fitted to the Lithographic Machine, making a very great improvement, so that 400 runs an hour could be made. From this time onwards all maps possible were printed in the field, and only maps that the machine could not cope with were sent to Cairo for printing at the Survey of Egypt.

In August the whole of the Printing Section moved to Rafa, and the small hand-press was sent to Advanced G.H.Q. to print Operation Maps etc. Most of these were drawn direct on to the plate, and when a proof had been pulled and approved, the plate was sent to Rafa by Car for the required number of copies to be printed on the Machine.

When the 1/10,000 series of maps showing the trench lines at Gaza were published, all detail, including the trenches and grid, was shown in black, with a red overprint on the British trenches, and green overprint on Enemy defences. The whole of this series was reproduced in the field.

The 1/20,000 series of Gaza were all printed in Cairo, and later editions were published when necessary with an overprint in purple showing new trenches, gun emplacements etc, this overprinting being done in the field.

The colours of this series were :-

Black. Showing Wadis, towns, Enemy trenches, trees, and names etc.

Grey. Grid lines, Grid numbers, Grid letters, and North Point.

Brown. Contour and Contour numbers. Form lines, and approximate British front line.

Green. (over black) Enemy defences.

After the British occupation of Gaza, the Company Headquarters eventually moved up to Bir Salem with G.H.Q. in January 1918, and the Printing Section was established about two miles away from them at Ramleh in March 1918.

The printing Section had a School House for their use and were able to make full use of their equipment, which consisted of :-

One big flat-bed lithographic machine, two large size hand presses, and five sets of Chatham Lithographic equipment.

A dust-proof room was made for the Vandyking, and a darkroom for the photographer. The letter-press branch also was started at Ramleh.

The first sheets of the main 1/40,000 scale series were then begun, starting with Fejja and Tireh near the coast, and continuing along the front line to near Es Salt. These were kept up-to-date by subsequent editions, the Bidieh sheet having five editions published. Maps of areas north of the line

were compiled from Aeroplane photographs, and at the same time areas occupied by the British were surveyed, and the whole country linking up with the Gaza work was eventually reproduced.

During September 1918 a series of 1/20,000 scale sheets were published covering the enemy defences in the coastal area. These sheets were enlargements of the 1/40,000 showing more detail as regards enemy trenches, wire, gun emplacements, Machine guns, Trench Mortars, Dug-outs, buried Cable etc. This was an exceptionally busy period and everyone was kept working at high pressure. During active operations, beginning on 18th & 19th September 1918, maps showing the disposition of enemy forces were printed daily.

The following is a brief description of the procedure adopted by the 7th. Field Survey Company R.E. for the reproduction of the 1/40,000 scale maps, prepared and published in the field, this being the main series used by the E.E.F.

The country covered by this series is roughly that portion of Palestine, including Gaza on the South and Liktera on the North, and extending Eastwards from the coast to include Beersheba, Hebron, Bethlehem the Jordan Valley, and nearly to Es Salt.

COMPILATION. Compilation sheets were drawn in coloured inks on tracing linen.

- (a) in the field from plane table Survey.
- (b) in the Office from Aeroplane photographs.

DRAWING. Sheets were drawn up on tracing linen in black waterproof ink, one tracing being made for each colour to be printed. A certain amount of training was found essential for the draughtsmen. They were mostly pre-war draughtsmen, but with little or no experience of actual Map work, and supervision was fairly strict so that sheets could be drawn up uniformly. A specimen sheet showing Conventions, Glossary, types of lettering etc, was drawn up and approved, and a number of copies were made for Office use.

All the lettering on these sheets was done by hand, the stamping method being unsuitable for tracing linen. Tracing linen was found to be admirable for use in the field, and reproductions were made quickly and with little delay from them, by the Vandyke process with little apparatus.

Speed and simplicity are most important factors in the reproduction of War maps in the field, and the compilation and fair drawing of Sheets on paper, and then photographing and reducing, would be a much more difficult and lengthy process, and the apparatus required would be more bulky and difficult of transport. Tracing linen is easily packed, and occupies very little space, is easy to work on if first prepared with a little French chalk, and well able to stand rough wear. The chief difficulties encountered in its use were shrinkage and sand. Shrinkage was to a certain extent counteracted by cutting from the roll, sheets to the size required, and pinning them flat some time before actual use. Sand was a much more difficult problem. In rough or sandy weather the sand would penetrate the wooden hut that was latterly used as a drawing office, and coat everything with a fine layer of grit, the effect of this was to rub the work being drawn up, making the black turn to a dirty grey colour. Opaque black lines being absolutely essential for the best results from the Vandyke process, work had often to be gone over again by the draughtsman before being sent along to the Printing Section. It was found to be quite a good test to hold the finished tracing before a window or light. Any name or portion of detail that was not opaque was then touched up.

At one period, when a dug-out was being used as a drawing office, work was impossible during sand storms, and had to be temporarily suspended.

One other small difficulty encountered was that during the very hot weather the waterproof ink used was apt to dry too rapidly on the pen, causing it to clog, and this trouble was never properly overcome. Stick Indian ink was tried but failed to be sufficiently opaque for the best results.

The actual drawing up was simply tracing from the compilation sheet, or any later source of information that came to hand. Sometimes the actual field sheet or aeroplane photograph. Fundamental points were plotted and conventions, lettering etc, were drawn to the standard previously laid down. "Revision copies" of all latest editions were always kept up to date, new work being added,

and corrections carried out as new information came to hand. These additions were then included in subsequent editions of each sheet.

With this series of sheets four colours :- black, brown, green, and red were used in printing, and a limited number of copies were overprinted in an extra colour (blue) for Artillery information. This meant a separate plate for each colour, and of course a tracing had to be drawn up for each one. The tracing for the Black plate was the most important, the main detail and all fixed points being inserted, together with heading, scale, North point, Grid, Grid numbers, Wadis, Railways, Tracks, dotted outlines for roads, enemy defences (accentuated by red overprint), and the conventions for cliffs or similar outstanding features, trees fixed by survey, Telegraph air lines, Minarets, cisterns, wells etc.

THE GRID Was drawn in thousand yard squares, sub-divided into four, and a co-ordinate scale was drawn at the foot of the sheet so that it could be cut out without spoiling the map, and used for measuring co-ordinates. The grid numbers were omitted where likely to interfere with detail.

WATERCOURSES Main wadis were drawn fairly thick to show prominently, gradually tapering away into the smaller branch wadis. Wadis in blue would perhaps have made a prettier map, but would have made an additional plate and much extra work in tracing and printing, besides being subject to error of register. The Wadis in Palestine are usually dry, except after rain, so the usual blue for rivers as a rule used on Maps, would hardly apply to them. The word "perennial" was written in brackets after the name where applicable.

RAILWAYS Standard gauge was shown by a fairly thick bold line, with the small cross lines, narrow gauge being shown by a similar convention, except that the line drawn was much thinner so as to be easily distinguishable. The only other railway convention shown was "Railway formation", this was the same as standard gauge except that the line was shown broken.

NAMES The spelling of names was taken from the One inch to One mile Palestine Exploration Fund Maps, except in the case of approved allotted names. These grew in number as new editions of sheets showing the front line were prepared and printed.

The tracing for the Brown plate :- This came next to the black in importance, showing grid capital letters, sand, a broad series of dashes denoting approximate British front line, together with the date, form lines, contours and contour numbers.

SAND. Was shown by the usual dot convention, small patches being fully dotted, in other cases only the limit of sand was shown by a band of dot.

GRID CAPITAL LETTERS. These were inserted in the centre of the square, or part of a square, to which they referred, and were drawn in bold block type. The brown used was not of sufficient density to interfere with black detail, and yet was strong enough to make the grid letters fairly prominent.

FORM LINES. Were used for showing hill features which could often be obtained from Aeroplane photographs where no survey was available. They were drawn much the same as contours, except that the lines were broken at intervals, and not numbered.

CONTOURS. Were shown by continuous lines with height numbers on the uphill side of each one, except where the lines were too close together. The vertical interval was ten metres up to eighty metres (about 265 feet) and above this height twenty metres. The contours were surveyed in metres which were converted to feet approximately, according to a conventional table, designed to show round numbers as far as possible without departing seriously from correct values. The contours were thickened at about every 200 feet vertical interval. Small hill-top features were sometimes shown by form lines when the regular vertical interval would not involve the insertion of a contour.

The tracing for the Green plate consisted of tree conventions only, two varieties being shown, ordinary trees and Palms. Orchards were represented by the ordinary tree conventions placed in regular rows. Scattered trees were shown by scattered tree conventions. Trees which had been fixed by the Surveyors were omitted from the green, as they were shown on the black. They were in most cases prominent solitary trees, with a spot height inserted alongside.

The tracing for the Red plate was drawn only as a guide for the lithographic draughtsman. Red was used for overprinting the Enemy defences, and showing Road classification. An off set was taken from the black plate, and the work was drawn direct on to the plate. The method counteracted to a large extent any errors in registration due to the shrinkage of tracing linen, or to the printing machine.

Four classes of Roads were shown, namely :-

“Metalled”

“All traffic in dry weather”

“Light Motors only”

and “ Horse Transport”

At one time the main roads were shown in Orange, but later Red was considered an improvement from a military point of view, having the effect of making the roads conspicuous. very few of the Palestine roads are good, so the classification formed quite an important item in a Military Map, especially in Enemy country; and only by much experience in the interpretation of Aeroplane photographs could each of these four classes be distinguished successfully. Information regarding Road classification in enemy country was obtained from Agents' reports and from Aeroplane reconnaissance. A series of Maps embodying this information was always kept up to date by “MAPS G.S.I.” who supplied the Survey Company with the road classification on the publication of each sheet.

The tracing for the Blue was only necessary on sheets where enemy gun emplacements were shown. The Blue was an Artillery overprint showing grid, and grid letters, and enemy gun emplacements numbered with their zone numbers. In some cases a hatched circle was shown for active enemy batteries not definitely located. This plate was overprinted on a limited number of copies only, for issue to the Artillery.

After all the tracings had been drawn up, they were thoroughly checked and corrected, and any later information that had come to hand during the drawing process was of course used. This being completed, the tracings were sent to the Printing Section to be Vandyked.

THE VANDYKE PROCESS. Is a photo-mechanical means of applying a copy of a drawing on paper, or tracing linen, to a plate in greasy ink. Tracing linen is more transparent than drawing paper, and the light therefore acts through it more rapidly on the sensitized plate, a most important consideration on dull days, and when speed is essential.

For this process Zinc plates are mostly used, but in Egypt and Palestine, Aluminium plates only can be used successfully.

The plate is first washed with a weak sulphuric acid solution and then well rinsed with clean water, and while still wet is sensitized in a dark room by coating it with a mixture of Lapin Glue, water, Ammonium Bichromate, and Ammonia, using a whirler to obtain an even thin film. The plate having become sensitized is dried in the dark room. The drawing to be reproduced is placed in the photo-printing frame on the glass, with the work upper-most, on this is placed the sensitized film side of the aluminium plate, layers of felt are added, then the backing boards, and the whole is screwed tight (if a screw frame is used). Later a Vacuum frame was obtained from the Survey of Egypt and was found to be a great improvement on the Screw frame, both in convenience and efficiency.

Length of exposure is made according to the light, an actino-meter being used in cases of doubt. After exposure the plate is well washed, under a tap if possible, and a little aniline colouring is floated over it. This colours the film of glue which becomes insoluble where exposed to light, and shows the drawing in negative; further washing in clean water, together with gentle rubbing with cotton wool, removes the unhardened film, and leaves the aluminium bare where the black work of the drawing shielded the film from the action of light. The plate is dried and rolled solid with Vandyke ink, a composition roller being used, after which the plate should stand, if time will permit, for two hours. The plate is next immersed in a weak Sulphuric Acid solution, which loosens the film of glue with ink upon it, while the reproduction of the original drawing remains on the plate in greasy ink. After drying, the work is touched up where necessary, and the usual Lithographic treatment of rolling up is applied before the plate is placed in the Lithographic Machine for working.

One thing worth mentioning here, is that chlorinated water causes trouble in Vandyking. This was found by experience in the field where only chlorinated water was available. It has the effect of

making the sensitized film adhere to the plate, instead of dissolving it freely, thus causing a scum in printing. If no well water can be obtained, distilled water should be carried in bottles.

PRINTING.

The machine used was a flat bed Lithographic machine by Voisin, and was at least 30 years old. The size was Double Crown, 74 x 54 cms and not more than 600 runs an hour could be made. Over 7,000 copies of one sheet were pulled. The plate was then unspoiled and fit for further use. During the printing of the whole 1/40,000 scale series, the quantity required was always done, and on no occasion was a case of a plate working out experienced, which in itself speaks well for the procedure adopted.

PHOTOGRAPHIC SECTION.

This section was started early in 1916, before the Topographical Section was formed into the 7th. Field Survey Company R.E. The work at that time consisted chiefly of copying to scale from Aircraft photographs and maps, with a copying camera and enlarger lent by the Survey of Egypt. In August 1917 personnel were sent from the S.M.E. Chatham, with the complete equipment for Photography, Lithography and Letterpress, which came into full use when the Printing Section was established in the School House at Ramleh.

The Photographic equipment includes :-

2 Copying cameras.

2 Field Enlarging and developing boxes.

4 Telephoto Cameras, with working and store boxes.

With this equipment, and fairly good accommodation, the work extended considerably, and besides assisting in Map production much miscellaneous photography was done, including work for the C. in C., E. in C., D.O.S., R.A.F., S.O. in C., the Official Geologist, and copying and enlarging captured photographs for G.S.I.

A series of 26 panoramas of enemy country were photographed with the telephoto cameras from points in or behind our front line in Palestine. These photographs covered practically the whole of the line from the Sea North of Jaffa, to the mountains East of the Jordan Valley. Consecutive photographs were joined together, and names of villages, and prominent points written, and scales drawn showing bearings from the camera position (in degrees) from "Grid North".

The size of plates was 5 x 4 inches, and the telephoto lenses were of 12 inches and 30 inches, equivalent - focal length, the latter being used most frequently. From the 5 x 4 negatives, enlargements to about double size were made. On these, one degree of arc equalled 1.1 inches approximately. Conditions were unfavourable for telephotography owing to haze and shimmer during the greater part of the day, and to dust raised by troops, transport and gunfire.

Copies were distributed to the WAR OFFICE, C. in C., G.S.O., G.S.I., M.G.R.A., R.A.F. and Corps, Division, and Artillery concerned.

Difficulty was experienced during the hot season when solutions could not be kept below 80 degrees Fahrenheit without ice. This however only affected the Panchromatic plates."

LETTERPRESS SECTION.

This Section did not start actual work until the beginning of March 1918, the first set of equipment having been sunk while en route to the E.E.F. The second set on arrival was sent direct to Ramleh and contained :-

1 Boston Press

1 Swift Cropper

8 Fonts of Type

and composing sticks, together with the small items which go to make up the letterpress equipment.

On unpacking the boxes it was found that parts of the machinery had been broken in transit, and the type cases were in such a state of "pie" that an immediate start was impossible. The whole of the type had to be emptied and the cases "re-laid", and the broken machine parts were sent for re-casting. It was found necessary to fit up racks etc, to hold the material for every day use, and a wooden bench for the "imposing stones" was made locally by Egyptian sappers.

The three branches of the Printing Section (Lithographic, Letterpress and Photographic) worked in conjunction, in charge of one officer.

Apart from actual Survey Company work, G.S. and "A" kept the Letterpress well employed. The **"Economic and Political Intelligence Summary"** varying from six to ten pages foolscap folio, was done fortnightly, and usually about 300 copies were printed.

During operations 100 copies of a **"Daily Summary"** were printed.

Accompanying the weekly operations map was a slip of **"Principal Troop"** movements. Another big job was the list of **"Distribution of Enemy Forces"** which was printed weekly, and published with the week end "Summary". It was found necessary to "break up" this each week, in order to get other work set up, owing to the insufficient quantity of type available. Could these forms have been left set up a great deal of time and labour would have been saved, as they were composed of tabular work, and only slight alterations from the previous week were needed.

The important printing done weekly for the Survey Company was the **"Meteorological Report"**.

"The Soldiers Guide to Jerusalem", of which 5000 copies were printed, was rather a big undertaking, as it was possible to print only two pages at a time on a small Cropper machine. This book contained 37 pages of letterpress, a Map and a number of half-tone illustrations lithographed by the Survey of Egypt.

Another book printed was the **"Water book of Northern and Central Palestine"** of 97 pages, of which 400 copies were printed.

Following this were a small hand-book **"Notes on Water in Northern Palestine"** consisting chiefly of tabular matter in 31 pages. **"Topography of Central Palestine"**, 39 pages, and **"Instructions for Divisional and Intelligence Officers"**, 20 pages, and **"Palestine Censorship"**, of about 40 pages.

About four months after the starting of the Letterpress Section another set of equipment arrived, known as the "Tight Set" which, with the addition of another press and more type, helped considerably.

V - "N" SOUND RANGING SECTION.

"N" Section arrived at Port Said on August 29th 1917, was moved by rail to Deir El Belah, and the O.C. (Capt. I.G. Gott) reported to G.H.Q. on the 3rd September. The Section moved to the Wadi Ghuzzee on September 5th, and was in action on the 14th. The type of base adopted was a regular circular one of 25 seconds radius, with consecutive microphones 4.5 seconds apart. The centre of the base was near Gaza, and guns were located between the coast and the Ali Muntar Ridge. Owing to the close nature of the country round Gaza, and the natural camouflage afforded by the cactus hedges and orchards, the location of enemy batteries had been very difficult. As soon as "N" Section got into action it became possible to limit the search on aeroplane photographs, and in a very short time a large percentage of the Enemy's guns in the neighbourhood of Gaza were located on the photographs, and published on the Maps.

All locations were immediately communicated to the 97th and 100th brigades R.G.A. XXI Corps H.A. and batteries were ranged for neutralisation or destruction on several occasions.

The section also carried out wind observations extending over a period of three weeks, to assist the gunners in the use of gas shells.

During the eight weeks that the Section was in action 410 locations were made, and our batteries were ranged on 18 occasions. The Section came out of action on November 8th, owing to the evacuation of Gaza by the Turks. The ground was then examined by Capt. Gott. Of six enemy emplacements which had been ranged on by our batteries five received direct hits, and in the other case two craters were conserved within 10 yards, and the Ammunition Depot hit. Emplacements were found corresponding to all the locations given, most of them had been detected on the photographs, and shown on the Map. During the last day or two of the Turkish occupation many new emplacements were dug to the north of Gaza, as the Turks were withdrawing, and even those which were photographed were not all identified.

During the period of inactivity that followed, all ranks took leave and reserves were trained.

On November 30th, "N" Section was ordered to move to the neighbourhood of the Jaffa-Ramleh Road. Four tractors were required to move them from the Wadi Ghuzzee to Deir Seneid, and from thence six Motor Lorries moved them to Beit Dejan.

Our line in this sector was held by Cavalry patrols, no trenches had as yet been commenced, so the base was not pushed so far forward as would have been done in trench warfare.

The Section got into action on December 10th 1917 - a regular circular base had been adopted as before - and remained in action until December 22nd, when we crossed the Nahr El Auja, and the enemy guns moved northwards out of range. During this period 65 locations were recorded by "N" Section, and 19 enemy batteries were reported active. No ranging was carried out. Heavy rains and unfavourable winds were experienced in this position, and the maintenance of the lines across the plain over which all the transport passed incurred much additional labour. The services of a despatch rider were requisitioned in order to keep the Artillery informed of enemy activity, as telephonic communications could not be maintained.

In accordance with instructions the Section again moved forward and took up position north of the Nahr El Auja, getting into action on January 7th 1918. The base was a regular circular one as on the two previous occasions, it having been found that this type of base gave very good results. Two microphones were added to the east of this base to enable the location of guns in the neighbourhood of Kefr Kasim. These two microphones were situated off the regular curve and at slightly greater intervals. They were found to be unsatisfactory however, and were subsequently removed. The reason for this was chiefly on account of the prevailing wind being away from the microphones, and the unavoidably big distance between them and the guns.

During the Spring and Summer the prevailing wind was unfavourable, being south-easterly in direction, and very changeable in velocity, consequently ranging for destruction was suspended, although it was still possible to do locating, and ranging for neutralisation.

Early in May 1918, the G.O.C. R.A. XXI Corps asked for guns in the vicinity of Bidieh to be located. "N" Section was accordingly instructed to do this. A base was surveyed and wired with the reserve S.11 cable belonging to the Section, and Headquarters were built. The instruments were to be transferred and installed in these new Headquarters on the 19th May, but on the 18th instructions were received by the O.C. saying that owing to pending operations the Section was to remain where it was. This base facing Bidieh remained unoccupied until "NN" Section was formed.

Our line on the coast having been advanced to a depth of about a mile, it now became necessary to locate guns right on the sea coast. This was impossible from the existing base, so it was decided to survey and wire another base cutting the line of the old base, but oriented so as to locate guns on the coast. There was not enough S.11 Cable available for the new base so XXI Corps Signals established air lines of G.P.14 Cable, connecting the Headquarters with the existing microphones of the old base, and picked up the S.11 Cable, which was then used for the new base. The new base came into action about the end of June. The total front covered by these two bases was about 20,000 yards. They both remained in action until September 19, when the Turks were driven out of their positions. From January 7th until September 19th 1015 battery positions were located, an average of 4.0 per day. On 43 days no locations were made owing to unfavourable conditions. Our guns were ranged on to hostile batteries on 15 occasions. After the end of April 1918 no ranging shoots were carried out.

It had been arranged that as soon as the expected advance commenced, "N" Section should follow up the Army as quickly as possible, so as to get into action immediately there was any check to our progress. Consequently on coming out of action all the instruments and microphones were packed up, the cable which was very old having been in use for a year, being left on the ground, and the Section moved forward. The extra transport was supplied by H.A. XXI Corps. When they got to Kalkilieh it was seen that there was no possibility of the enemy making a stand, nor of his having any guns to locate, so the Section was ordered to stand fast. After waiting for some days at Kalkilieh they were withdrawn to a rest camp near Jaffa.

Because of this rapid move, Capt. Gott was unable to report on the batteries located, but other officers of the Company who visited the Enemy's position found gun emplacements corresponding to all

locations examined. Practically all of these had been well shelled, and in some the guns themselves remained. The success of the operations, and the ineffectiveness of the enemy's artillery, testify to our great knowledge of his dispositions, to which the Sound Ranging Section had contributed its share.

VI - "V" SOUND RANGING SECTION.

"V" Section arrived with "n" Section at Port Said on August 29th 1917, and the O.C. Capt. J.R. Cockburn, reported to G.H.Q. on September 3rd. The Section moved up to the Wadi Ghuzze on September 5th, and got into action on the 18th. The base was a regular circular base of 25 seconds radius, with the microphones 4.5 seconds apart, and was placed in the Sheikh Abbas salient, with its centre near Atawineh. The microphones were situated in very broken ground, and no two could see each other. This made the survey work very difficult, and caused a delay of a few days in getting into action.

During the 8 weeks that the Section was in action, 291 locations were made (not including 44 A.A. battery positions). Of these, 84 were of different battery positions. Ranging was carried out on 6 occasions for our guns. On coming out of action the enemy's battery positions were carefully studied, and Capt. Cockburn report: -

"Fifty eight positions which appear on the Map, or had been located by "V" Section were visited. Of these, 32 had been reported by "V" Section - 21 were found not to have been occupied. One active position in our area had not been reported, and 4 positions a little South of our area were found to have been active.

Of the 32 batteries reported by "V" Section in this area 27 were clearly identified on the ground, and 5 locations of field guns fell where no pits were visible.

The 10 cms. Guns and 15 cms. Howitzers were evidently moved about quite frequently, but contrary to the enemy's usual custom the 15 cms. Howitzers at U.G.1 and U.G.11 were kept there even after very severe shelling.

Most of the field guns on this front were the Turkish 7.5 cms. But there were a few 7.7 cms. Guns.

The revised Atawineh 1/20,000 Map (made entirely from Aeroplane photographs_ must be extremely accurate, as in each case when an X location had been obtained it has fallen within 25 yards of the Map position."

"13 of the batteries in the Gaza district were also located by "V" Section, and have been visited. In each case the locations fall well within 100 yards of the battery position."

Advantage was taken of the period of inactivity which followed to train more men and to carry out numerous experiments because some of the methods used in France were not applicable to this front.

Jerusalem and Ram Allah having been occupied, the XX Corps asked for "V" Section to operate on their front. Accordingly Capt. Cockburn reconnoitred the country and concluded that locations could be obtained although on account of its hilly nature he did not anticipate and very great degree of accuracy. The Section moved out of the Wadi Ghuzze on February 3rd., by Motor Transport to Gaza, by rail to Ramleh, and thence to Ram Allah by Ammunition Column where it arrived on February 11th, 1918. The Section came into action on the 17th February, five days after the commencement of Survey, wiring etc., and came out of action on March 10th when the Turks were driven out of their positions.

During this period 55 locations were made, 27 of which were of different battery positions. Ranging for our guns was carried out on one occasion. Practically all the locations from this base were of Z value - probably due to the deformation of the advancing ground wave as it travelled over the hills, and by the great distance between the microphones and the hostile gun.

The Section was able to move on the 20th March to a position North of the Wadi El Jib, where it came into action on March 27th. Headquarters were built in a small Wadi just off the Jerusalem-Nablus Main road. They were shelled out of this position, and moved into the Wadi Jib.

It now became very necessary that guns should be located in the neighbourhood of Furkah and Selfit, so another base was laid out to the West of the first base, Microphone 5 of the old base being Microphone 1 of the new (West) base. Both bases were connected to one Headquarters. The West base came into action on May 10th. The extra personnel required to work and maintain the new base were supplied by XX Corps Artillery.

It was subsequently found that the Turks concentrated a number of guns in the neighbourhood of Jalud and Mugheir, which were too far round to be located by the existing bases, so a third base was surveyed and wired on the East of the original base. Microphone 2 of the first (centre) base was Microphone 6 of the new (East) base. As there was not enough S.11 cable in the country air lines were erected from the Headquarters to a point near the centre of microphones from which S.11 cable was laid to the microphone. This base came into action on July 6th. This three bases consisting of 16 microphones were operated from one Headquarters under one O.C. A front of 27,000 yards was covered and the total personnel required consisted of 3 Officers and 70 O.R's.

The transport of the Section consisted of one Ford touring car, one box car, one G.S. Waggon, four draught mules and three bicycles. In order to economise transport the forward posts were relieved only occasionally. They were rationed by neighbouring units.

The Section came out of action on September 20th on all three bases. During the period from March 27th to September 20th, 1106 locations were made, nil returns being rendered on ten days only, and 63 ranging shoots were carried out as shown in the following table : -

	West Base	Centre Base	East Base	Total
Date in action	10-5-18	27-3-18	6-7-18	
Date out of action	20-9-18	20-9-18	20-9-18	
No. of locations	268	728	110	1106
Daily average	2.0	4.1	1.4	6.2
No. of ranging shoots	7	50	6	63
No of rounds registered	169	1132	214	1515

There was very close co-operation between the Corps, Heavy Artillery and the Sound Ranging Section on this Sector of the front. No opportunity was ever lost of using the Sound Ranging Section to range our guns, and on no occasion after a satisfactory shoot had been carried out, was the hostile battery ever reported to be active again from that position.

After the Section came out of action the ground in front was carefully examined and 36 battery positions were visited and reported upon. Of these, 13 had been identified on aeroplane photographs and their co-ordinates given to the C.B.S.O., 16 had not been identified although the area had been repeatedly photographed, two were not dug in and so would be unlikely to show, whilst 5 were dug after the latest photographs had been taken. This shows how extremely difficult it was to locate batteries on aeroplane photographs in this thickly wooded hilly country. It also shows how very valuable Sound Ranging was to locate and range on to batteries which were so successfully camouflaged as to be invisible from the air.

Reporting on positions visited, Capt. Cockburn said : -

“Of the 167 positions located by “V” Section on this front, 36 positions have been visited and identified. As this is the first occasion on which an extended trial of Sound Ranging has taken place in a mountainous country it is of interest to check the accuracy of the locations made. Although the films are more difficult to read and the locations given are very frequently of “Z” accuracy it is found that the mean position of a number of “Z” locations is usually very near to the actual location of the gun, while even single “Z” locations are usually much nearer than is claimed for them.

The only exception to this which has been found is the second position of the 24 cms. Mortar which was about 150 yards from the position given by us. This error is probably due to the mortar having been placed immediately behind a steep rounded hill, so that the sound had to travel round or over the hill for some considerable distance. This would have the observed effect of throwing the location too far back.

Owing to the practical invisibility of most of the battery positions ranging has been a very important part of the work of the Section, and seems to have been quite successful. Nearly all the positions have been well shelled and the enemy has been compelled to dig very numerous pits and to change positions very frequently in order to attempt to escape.

The conditions for ranging have usually been difficult because of the very rapid changing weather conditions, but the difficulties have been overcome frequently by getting the ranging over as quickly as possible.

In the estimation of calibre only one mistake has been made but that has been made several times. A new charge has been introduced for the 10.5 cms. Howitzer, which gives it an increased range, and a time of flight nearly equal to that of the 15 cms. Howitzer. This has led to 10.5 cms. Howitzers being reported as 15 cms. Howitzers on several occasions.”

Reporting on the work of the Section, Capt. Cockburn says : -

“The hilly nature of the Country and the rapid changes in wind and temperature increases the difficulty of Sound Ranging to a certain extent; but on the other hand the nearness of the microphone bases to the hostile batteries greatly facilitates the work and increases the accuracy.

The Microphones are all placed on fairly high ground and where possible on the forward slopes of hills, but not at the top. The placing of Microphones on peaks was found to be unsatisfactory on account of wind eddies.

The Microphones are placed as nearly as possible 4.5 seconds apart and as nearly as possible on arcs of 25 seconds radius; but none of the bases is quite regular.

At present 23 Microphones are in use - 7 on the Bridges as balancing resistances and 16 in the Field. Nine of the Microphone holders have been made completely at “V” Section, and the remaining ones on the Field have been fitted with larger tubes in order to increase sensitivity.

Twelve additional rheostats have been made and installed so that all microphone-lines can be adjusted to the same resistance so as to permit a change from one base to another being made by a single movement of a specially constructed multiple switch having 48 contacts - 12 on one side and 36 on the other.

Very little difficulty is experienced in keeping the bridges balanced.

The only other point worthy of mention concerning the apparatus is that Battery bridges are used instead of the standard “Wheatstone” bridges, thus effecting a slight increase in sensitivity and a considerable economy in current consumption.

Much inconvenience was experienced owing to the lack of a reliable generating set for charging accumulators. The “Lyon & Wrench” set brought out from France had a very short life in the heat and dust, the Cylinders being worn out after two months use. After December 1st 1917, a 2 ³/₄ H.P. Douglas Motor Cycle engine was used to replace the “Lyon & Wrench” Motor - the original dynamo was still used. This charging set was only a make-shift and required constant attention and broke down frequently. A new charging set was received at the beginning of August 1918 and relieved the situation.

A good reliable set having a capacity of from 10 to 20 amperes at from 30 to 60 volts would mean a great saving in labour and worry and has been ordered from France.”

Earth Returns for Microphone Lines.

Experiments with earth returns have been made by “V” Section. It was found possible to work with them but the extreme dryness and the rocky nature of the country made it very difficult to obtain good earth contacts. The continual change of earth contact resistances was very serious when switching from one set of Microphones to another. For this reason alone metallic microphone circuits are required.

“METHOD EMPLOYED BY “V” SECTION FOR SAFEGUARDING MICROPHONE EMPLACEMENTS.

The co-ordinates of the microphones were given to the G.O.C. each Division whose front was covered by “V” Section. The Division in turn detailed the nearest unit to each microphone to look after the microphone or microphones. Each unit then detailed an officer to be personally responsible for the microphone. This officer was shown the position of the microphone by a member of “V” Section, and given instructions how to dispose of it in case of the enemy penetrating out lines.

This arrangement was very satisfactory and microphones were handed over as part of the unit’s front when reliefs took place.

When a new battalion took over a portion of the line the necessary instructions were given to the officer concerned. This arrangement had two good things in its favour.

1. It insured that the microphones were not tampered with, and that the lines running to them were treated with due respect. It relieved the personnel of the Section, especially the O.C. Section of a great deal of worry, as well as guarding the microphones much more securely than could otherwise be done, in what at times appeared to be semi-open warfare.

2. It established a union between the troops in the line, especially the O.C.’s Battalions, and the Sound Ranging Section which worked to the advantage of all.”

“In comparing the work of Sound Ranging on the Palestine Front with similar work on the Western Front in France, the following differences are worthy of note : -

1. The artillery activity is much less.
2. Troops are much less concentrated near the front line.
3. It is possible to cover a much wider front, per section. “V” Section having covered most of the XX Corps front without difficulty.
4. Advanced Posts, Microphones and H.Q. may be placed much nearer the enemy in spite of the fact that no continuous front line is held.
5. Greater difficulty is caused by rapid changes in wind and temperature. This makes it more imperative that ranging shoots be carried out with the least possible delay. On the other hand there are no long spells of weather totally unsuitable for Sound Ranging.
6. If the routes for microphone and forward post lines be well chosen the damage from shell fire and our own transport is comparatively slight. At “V” Section, thirteen linesmen were able to maintain the lines which consisted of 80 miles of Z.9 air line, and 120 miles of insulated cable laid on the ground.

No great scope is seen for improving the Sound Ranging Apparatus itself, for it is believed that if any increase in accuracy is to be obtained it must be by gaining more complete knowledge of the atmospheric conditions over the whole area between the Sound Ranging base and hostile gun to be located. This applies particularly to the Palestine Front.

The establishment of a Sound Ranging Section for the E.E.F. is quite sufficient in all respects except perhaps in regard to personnel.

While working with three bases “V” Section had a personnel of from 65 to 75 all ranks the number of officers and N.C.O.’s being as per establishment.

These officers proved quite sufficient, but an increase in the number of N.C.O.’s would have been a great advantage.

Several interesting attempts have been made by the enemy on this front to confuse Sound Ranging records.

The first attempt consisted in firing two neighbouring howitzers at the same time, but as the two batteries were 650 yards apart this naturally caused no difficulty whatever.

The second method was to fire a 10.5 howitzer and two or three field guns at approximately the same time, but as their timing was not perfect this caused very little difficulty.

The third attempt consisted in firing a 15 cms. Howitzer just as the sound of a 10.5 cms. Gun further back reached the howitzer - Two or three field guns were also fired off at approximately the same time. This confused the records considerably, but sooner or later the timing would not be perfect, and the 10,5 cms. Gun and 15 cms. Howitzer would be sufficiently separated to be distinguished.

At present the enemy seems to have abandoned the careful timing, and relies simply on firing a number of guns as nearly as possible at the same time, and also moving his battery positions frequently.

Attempts have also been made very recently to confuse ranging records, - The battery in front of the one being ranged on seems to have fired just as the shell from our battery passes over it. This has caused no difficulty so far, and it is expected that this practice will be abandoned as the necessary corrections were given to our own battery to bring it on to this forward battery with immediate results.

A similar incident happened a few days before the capture of Gaza. In this case "V" Section was ranging one of our batteries on a 15 cms. Howitzer, when another 15 cms. Howitzer tried to mask the bursts of our own shells. This resulted in both Hostile batteries being heavily shelled.

Although "V" Section is working in extremely difficult country such valuable and generous assistance has been given by all areas of the Service of the XXth Corps that the work has been rendered comparatively easy.

VII - "NN" SOUND RANGING SECTION.

Early in March 1918, a third Sound Ranging Section was asked for from France, but owing to the turn of events on that front it could not be supplied. A complete outfit of Sound Ranging instruments was however sent as spares for the two sections in the line.

In May the necessity of locating guns in the gap between "N" and "V" Sections became more acute, and arrangements were made for "N" Section to do this. It was subsequently decided that "N" Section should not move off the Coastal Sector. Accordingly, steps were taken to form a new Sound Ranging Section. It was decided to use the spare instruments which were in the country, and to take men from the two existing sections to form the nucleus of the new section. Further men were to be supplied by the Artillery to complete the new section, and to fill up the gaps in "N" and "V" Sections.

Nothing could be done however until authority was received from the War Office for the formation of the Section. This was received on July 27th, and the matter was immediately taken in hand, and Capt. T.A. Evans of "V" Section was appointed in command of the new section, which was designated "NN" Section, by orders of the War Office. The initial difficulties were considerable. It was practically impossible to obtain men with a knowledge of mathematics, physics or electricity, and consequently such men had to be drawn from the other two sections. The instruments available only consisted of the special Sound Ranging apparatus, and such things as instrument makers' tools, carpenters' tools, a charging set, motor cars and transport had all to be obtained locally. Every help was given to Capt. Evans by the Ordnance, M.T., and R.A. authorities whilst these various stores were being collected, and indents were pushed through all departments at very great speed. Eventually the Section came into action on August 1⁴th, in the position facing Bidieh, which had been prepared for "N" Section in May, and came out of action on September 6th. 24 locations were made in this position. Orders had been received on August 29th, for a move to be made to the West so as to locate guns in the neighbourhood of Kefr Kasim. The survey of this new base was taken into hand at once, and the Section came into action on September 10th the intervening time having been taken up in picking up and re-laying the cable.

Within a few hours of coming into action the enemy mistook a local raid for the main attack, and opened up a very heavy fire which enabled nine of his batteries to be located. The Section came out of action on September 20th, having located 30 batteries from this position. This information proved to be most valuable when plans for the attack were being prepared, but during the night of September 18-129, three new batteries were located which caused the plans to be changed. The effectiveness of our

counter-battery fire in this Sector which was prepared from information practically all of which was obtained by "NN" Section can best be judged by the success of the operations.

VIII - 28th OBSERVATION GROUP.

The 28th Observation Group arrived at Alexandria in June 1918. The O.C. Capt. C.W. Knight, reported to G.H.Q. on June 27th, and made a tour of the whole front to see :-

- a. Where the best place was for the group to come into action.
- b. If it was possible to locate guns in the foothills in the gap between "N" and "V" Sections.

On July 5th, Capt. Knight returned to G.H.Q. and made his report as follows :-

1. *"That XX Corps front would be unsuitable because the high hills and deep valleys would conceal enemy gun flashes and the calibration and ranging of our own guns would be difficult because of the nature of the ground.*
2. *That the Jordan Valley would be unsuitable because it would be necessary to go a long way back from the front line to see anything, and the poor visibility in conjunction with the long distances would make observing very difficult.*
3. *That the XXI Corps front would be the most suitable for the useful employment of the Group. That a base of 10,000 yards between Medjel Yaba and Berukin with 4 posts in the Sector where the location of guns is most urgently required, being in the gap between "N" and "V" Sections. That it would be best for the group to get into action on this sector first, the posts could command extensive views of the enemy country a great deal of which could be seen from all of the posts, whilst some of the ridges behind which many guns were suspected were not high enough to hide the flashes, and good locations should confidently be expected.*
4. *That, as experience and knowledge of the Sector was gained, the posts could be moved if necessary to command views of special portions as the case may be, or extend to either flank as desired."*

This report was submitted to the Authorities concerned, who agreed to all the proposals, and on July 9th, the Section was ordered to proceed to Kefr Insha, and get into action as soon as possible. The survey of the posts was taken in hand at once, four Observation Posts were built and wired. Headquarters were built and the group got into action and located the first gun on July 20th. This was the 5.9 gun which was shelling Jaffa. It was located and silenced by our guns which were ranged on to it by the group after it had fired 6 rounds. The position was well shelled and immediately abandoned.

The group remained in action on this sector until 4a.m. August 31st. During this time 9 enemy guns were located, on two of which our artillery was ranged by the group. Calibration of our guns was carried out on three occasions, and movement behind the enemy's line was observed on 192 occasions, on 6 of which our guns were ranged on to the target.

After the group had been in action for a month it was found that the Turks did very little night firing, and that owing to the depth of the valleys it was very difficult to get locations even when they did. Consequently it was decided to move to the left flank into more open country. The ground was reconnoitred, and surveyed. Two new Observation Posts were built and wired, and Headquarters were established in a house in Mulebbis. The Westerly Observation Post of the first base at Khurbet Dikerin became the Easterly Observation Post of the new base. The other 3 Observation Posts of the old base were dismantled.

The group came into action again at 3 p.m. on the afternoon of August 31st, in the new position, between Castle Hill - north of Mulebbis - and Medjel Yaba. Thus the group was not out of action during any of the hours of darkness.

The group came out of action on September 19th. In the new position 4 guns were located, and movement behind the enemy's line was observed on 89 occasions.

IX - 20th CORPS TOPOGRAPHICAL SECTION.

On the formation of this Section, the O.C. Section submitted to the G.S.I. Corps, the four following schemes for the publication of sketch maps so as to cover all the Corps front to a depth of 10,000 yards behind our own :-

- (1) To publish 1:10,000 Maps covering the whole area, and in addition to publish 1:40,000 outline maps for overprinting enemy dispositions etc.

- (2) To publish 1:20,000 Maps covering the whole area, the 1:40,000 outline maps for dispositions, and in addition 1:10,000 maps of important areas such as El Burj and Furkah..
- (3) To publish 1:40,000 maps of the whole area, and in addition 1:10,000 and 1:20,000 maps of important areas.
- (4) To publish 1:40,000 maps of the whole area, and 1:20,000 maps of certain important areas.

Of these, Scheme (4) was approved, and it was decided that two 1:20,000 maps were wanted only. This necessitated 11 maps in all. These maps were to be based on the regular 1:40,000 series of Maps published by the Survey Company, and all the latest information available from aeroplane photographs, or other sources, was to be shown on them.

After due consideration by Corps Staff, it was decided that the Section should be attached to the Corps Squadron R.A.F. so as to be in closest contact with the Squadron Intelligence and Photographic Officer. Tents and office furniture were accordingly sent from Corps Headquarters at Jerusalem to the Corps Squadron at Wadi Surar Junction for the Topographical Section. Unfortunately the first consignment was lost in transit, and the Section started work at the end of July in temporary quarters at G.H.Q. Lieut Parsons, the O.C. worked with the Aeroplane Photographic Officer, G.S.I. and the draughtsmen were accommodated in Survey Company huts. After about ten days extra tents and tables etc, were collected from various sources and the Section moved to Wadi Surar Junction where work started in earnest.

The photographs taken by the Royal Air Force were received within a few hours of the plates being exposed; the O.C. annotated the photographs, and from these any additional detail of trenches, wire, dug-outs etc, was added to the Map, which was ready for distributing within 24 hours of the photographs coming to hand.

Detail was usually added by proportional compasses, i.e. where a single photograph showed two or more points easily recognisable on the base map. In certain cases, however, the photographs had to be fastened down, scaled and reduced to the required scale, and from this, pantographed tracing, the detail was transferred to the map. In the more difficult cases access was always possible to the compilation groups and map sheets of the Survey Company, so that the possibility of any great error was overcome. A copy of all maps published was sent to the O.C. Survey Company, to ensure uniformity between the Maps of the Company, and of the Topographical Section.

All Intelligence reports relating to the Corps Front were received and kept in Map form. These were of great use, for the examination and annotation of photographs, and in addition this information when not corroborated by the photographs was shown on the Section's maps in a distinct colour, usually green.

In addition also to the routine work of the Section tracings of certain useful information that could be shown in map form, e.g. new roads, Headquarters etc, were forwarded to G.S.I. Corps with a view to being printed if required. In one case a tracing of the new roads and classification to the North of the Telfit sheet was sent to Corps for approval, but it was decided not to publish the map.

REPRODUCTION. The maps were printed on the Ellams Multi-colour Duplicator, brief size, 16,000 yards by 10,000 yards on the 1:40,000 scale being the area covered on each sheet. A map in five colours could be produced, and the detail was shown in the following colours:-

BLACK	- Grid, Towns, Trig points, all lettering.
BLUE	- Wadis.
BROWN	- Contours.
RED	- Enemy trenches, dug-outs, M.G.'s wire.
GREEN	- Information received from various sources but un-confirmed by photographs.

The question of supplies of paper and ink was a troublesome one, and often the above scheme could not be followed. It was found that by actually printing at night, better reproduction and more copies per stencil could be obtained. This was thought to be due to the cooler and calmer atmosphere at night time; 380 copies was the maximum ever taken off one stencil. The time required to produce a map varied of course according to the amount of detail shown, but on average it was found that a

draughtsman required two hours for the black stencil, and one hour for each of the other stencils. The actual printing was a rather long process, but in ten hours 600 copies of a map in 5 colours was completed and despatched. In no case did it take longer than 24 hours to compile and despatch the required number of copies. The O.C. dealt with all photographs, and compiled the sheet. Draughtsmen did the actual printing.

The Total number of editions of the regular series published was 13, and 4,100 maps were issued. In addition to this many smaller jobs were undertaken particularly when the Section was at G.H.Q.

With the commencement of our advance it was decided by G.S.I. Corps that no more useful work could be done by the Section, which was accordingly closed down on September 20th, and returned to the Headquarters of the Survey Company.

X - 21st CORPS TOPOGRAPHICAL SECTION.

During the interval between the great push of General Allenby's Army from GAZA, and the last successful thrust in September 1918, Trench Warfare conditions again developed on this front. In consequence of this, it was suggested by G.S.I., G.H.Q. in May 1918, that Topographical Sections similar to those doing very useful work in France, should be established with each Corps Headquarters. In July it was definitely decided that that such Sections should be organized and equipped by the O.C. 7th Field Survey Company R.E. and for all technical matters be under his orders, but as to actual work to be produced, under the direct orders of the Corps Commander.

The 21st Corps Topographical Section was formed on July 19th 1918, and was established at Corps Headquarters. The personnel had all to be drawn from Units in the Corps, and transferred to the R.E.'s and attached to the 7th Field Survey Company R.E. It consisted of 1 Officer, 3 Draughtsmen and 1 Clerk Orderly. Two Topographers were suggested on the Establishment, but owing to the difficulty of obtaining suitable men, it was decided to dispense with them, and any topographical work required by the Section would be done by Surveyors of the 7th Field Survey Company, who were already on the Corps Front. Instead of the two Topographers 2 additional Draughtsmen who were actually the Corps G.S.I. Draughtsmen, were absorbed into the Section, and the Map work of G.S.I. was combined with the general work of the Section. In addition, the Officer in charge of the Section combined the duties of Corps H.Q. Maps Officer with the Corps Topographical Section's duties.

The object of the Section was to provide large scale sketch maps giving the latest information from all sources, and to reproduce quickly in map form any intelligence which G.S.I. Corps was desirous of having circulated.

The programme of work decided on by G.S.I. after consultation with Divisional Intelligence officers, was as follows :-

- (1) 1/10,000 scale sketch maps to be prepared shewing the whole of the enemy defences opposite Corps Front and giving all information obtainable from Aeroplane Photographs.
- (2) Sketch maps on 1/40,000 scale, shewing detailed dispositions of Enemy Forces on Corps Front.
- (3) Maps shewing Enemy Headquarters, Camps and Bivouac Areas on 1/40,000 scale.
- (4) Sketch maps shewing Enemy Communications on 1/40,000 scale.
- (5) Maps shewing any new roads behind Enemy lines gathered from information supplied by Prisoners of War, Intelligence Reports, or Aeroplane Photographs.

In addition to the above the Section was to be in readiness to reproduce maps, and do tracings etc, if required, for other departments of Corps Headquarters, for example the Artillery, and "A" & "Q" Branches.

The Section remained at Corps Headquarters until a week before the commencement of operations in September 1918. Corps Headquarters then becoming mobile, the Section was moved back and attached to the 113 Squadron R.A.F. at Sarona. The reasons for this move were :- firstly, to be on the

spot so that as soon as fresh Aeroplane Photographs were developed, all latest information gathered from them could be produced in map form, and flown by Aeroplane to the Divisions pushing forward in the advance; secondly, the impossibility of work being produced under mobile conditions.

A draughtsman from the Section, was attached to the Mobile Corps Headquarters to do small jobs for G.S.I. Any work that he could not tackle was sent back to the Section at Sarona.

The rapid advance of our troops, and the consequent disorganization of the Turkish Army, resulted in the finish of the work of the Section, as our airmen had no more defences or strongholds to photograph, and thus the Section had no more information to produce in Map Form. It was therefore decided to disband the Section, which was done on the cessation of hostilities on this front.

The personnel were eventually absorbed into the 7th Field Survey Company R.E.

RESUME OF THE WORK DONE

1/10,000 SKETCH MAPS.

These maps were based on the 1/40,000 Operations Maps compiled and issued by the 7th Field Survey Coy R.E. Each Sketch Map covered an area 4,000 yards by 3,000 yards. They showed the Enemy Defences, Gun Pits, Machine gun emplacements, Observation posts, Listening posts, roads, tracks, headquarters and other Camps, and any other items of tactical interest.

12 Map sheets in all were produced covering the whole of the enemy defences on the Corps Front, which extended from the Coast to just East of Rafat, to a depth of about 8,000 yards at the Coast, and diminishing to 4,000 yards at Rafat.

Photographic Enlargements of the 1/40,000 Maps covering this area, were made to 1/10,000 scale, by the Survey Company, and these were used in making the groundwork of the sketch maps. This method effected a great saving of time which would otherwise have been expended in enlarging the detail by hand.

Distinguishing colours were used in the Maps. The main outline was printed in black; trench systems, wire entanglements, gun pits, machine gun emplacements, observation posts, Headquarters and Camps etc, were shown by their respective conventional signs in red; roads and tracks in green; contours and form lines in brown.

The information was obtained from Aeroplane photographs, and also other sources of intelligence, such as Reconnaissances, Reports, Intelligence Summaries etc. All information gleaned from these latter was verified by Aeroplane Photographs before plotting on the maps. Batches of photographs were received almost daily from the R.A.F. Squadrons. These were all examined, annotated in red, and after the correct scale of the photograph had been determined, all fresh information was transferred to the sketch maps.

Care was taken to show clearly the distinction between fire and communication trenches. This was sometimes difficult to decide from photos, as the Turkish fire trenches were not always made in the usual regular fire bays system, but often constructed as a communication trench. In addition to his remarkable ability to construct trenches quickly, the Turk proved to be adept in the art of camouflage, which meant that a very careful scrutiny was often necessary to detect tactical points, especially gun pits.

When the sketch maps were as complete as possible with all, available and up to date information, copies were made by means of the Ellams Multicolour Duplicator. The Duplicator was Brief Size, and so a sketch map 14.5 by 11 inches could be made, which meant that an area of 4,000 yards by 3,000 yards on the 1/10,000 scale was covered by each sheet.

The process of reproduction was quite simple but needed very careful workmanship, especially with the actual tracing on to wax stencils, and getting an accurate register so that each colour was applied in its proper place on the map.

Many difficulties had to be contended with in the process of reproduction. Climatic conditions were very much against the use of wax stencils. The heat often caused the wax to melt, and if not always actually spoiling the stencil, it reduced the length of wear. The slightest breeze would blow sand on to the stencil, and this caused pinholes in the softened wax, and after a number of copies had been rolled off, ink spots would penetrate and appear on the positive. Whenever possible, the rolling off was left until the cool of the evening, and much better results were obtained.

Supplies of Brief Size Wax Stencils and Brief Size Duplicating paper were unobtainable in this Country. A small size of the former was purchased locally. This necessitated the mounting of each wax stencil on a frame of tracing linen, so that it would fit the Duplicator Frame. Thousands of sheets of foolscap size duplicating paper had to be stuck together to form the Brief Size. Much trouble was involved by these methods, but on the whole the results obtained were successful.

On an average a wax stencil would last for about 250 copies, but in most cases 2 stencils were made for each colour, when over 200 copies had to be taken off.

In all 4500 copies of the sketch maps were made. In some cases second and third editions of sheets were issued at the last possible moment. The copies were issued and distributed by G.S.I. Corps to the Divisions concerned with the area covered by the respective sheets. Copies of each map were sent to Maps, and the Survey Coy R.E.

It is suggested that owing to the great trouble experienced with the wax stencils for the Duplicator, due to heat and sand penetrating the packing, that much of this could have been avoided had they been sent to this country in sealed airtight metal tubes. It was found that in almost every roll opened that quite 30%, and in some cases all of the waxes were useless, owing either to the wax having melted or sand having penetrated. In some cases the cardboard tubes were squashed in, and the waxes damaged.

The composition of the gelatine rollers was also unsuitable for this climate. It was found that if not kept cool, the gelatine melted and the surface of the rollers became so uneven that they were useless.

AEROPLANE PHOTOGRAPHS.

Copies of all tactical photos taken by the 115 Squadron R.A.F. and strategical series by the 5th Wing were received by the Section. If new photographs of any area were required either by the Section, Division or artillery, application was made to G.S.I. Corps, who forwarded requirements on to 113 Squadron, R.A.F., and often within 24 hours, photos would be in the Office of the Section. Copies for Divisions were sent direct from the Squadron. These were enlargements from the original contacts.

All photographs were carefully examined with the aid of strong reading glasses, and fresh work noted. In the case of series of photos, good overlaps were usually made by the photographer, and thus some very good stereoscopic effects were obtainable, which made the interpretation very much easier.

Every photo was registered in, indexed, keyed and filed. A card index was used for the filing. All photos covering the same square were filed under one card. In the case of a photo overlapping other squares, a system of cross-indexing was used, and the photo filed under the first square marked on the photo. This system was found most useful, as one was constantly referring to all photos covering one square, in order to compare them for new work.

A key of all photos received was also kept on a 1/40,000 map, so that at a glance, one could see what ground was covered by photos.

Whenever a good series of photos was received, especially of anything of importance in the more strategical area, or of ground not covered by recent photos, the series was pasted together and mounted on brown paper. These series were very useful for reference; as an example, the strategical series of photos covering the Tireh sheet were mounted, and this enabled the Engineers to make a careful study of the whole of the Iskanderun River, for possible bridging places.

Aspect photos were also much in demand from the Divisions, and were found very useful for the decision of uncertainties in the interpretation of the ordinary aeroplane photograph. These were kept separately in an indexed album.

OTHER MAP WORK.

In addition to the 1/10,000 Sketch Maps several others of different scales were produced shewing special information. The following is a brief description of each.

Headquarters, Camps and Bivouac Areas.

These were a series of sketch maps on the 1/40,000 scale shewing Enemy Headquarters, camps and bivouac areas, and were revised from time to time as was necessary. The information was gathered from Prisoners of War statements, and other sources of intelligence and checked as far as possible by reference to Aeroplane Photographs.

Enemy Communications.

A number of maps on the 1/40,000 scale were made shewing the bare outline of trenches and the most important camp sites which were likely to be Enemy Headquarters, and shewing all cables, poled or buried, leading to and from them. This information was taken entirely from Aeroplane Photographs. The convergence of a number of cables was some indication of the location of a Headquarters, the importance of the latter was usually determined among other things by the number of different cable lines.

Enemy Dispositions.

These maps were prepared from data supplied by G.S.I. Corps, and were made on the 1/40,000 scale, shewing detailed dispositions of the Enemy Forces on the Corps Front. The reproduction of these was held up until the last possible minute before operations in order that the latest information might be supplied.

Barrage Charts.

These were drawn up on instructions from the B.G.R.A. Corps, to illustrate in Map form his scheme of barrage for the preliminary operations on the morning of the attack (September 19th). As the actual time for the lifting of each barrage was marked on, it was essential that the reproduction of the chart was kept very secret, and not issued until the latest possible moment before the actual zero hour.

Administrative Maps.

A number of 1/40,000 maps were marked up for the "A" and "G" Branch of Corps, showing our own Divisional Areas, Supply Depots, Ammunition Depots, Water supplies, Prisoner of War Cages, Dressing Stations, Light Railways, Routes for evacuation of wounded, and other information which could be shewn clearly on the Map.

Relief Maps.

These were made from cardboard, of the area covered by the 1/40,000 Fejja and parts of Tireh sheets, and were for the use of the Corps Commander. They were similar to some already prepared by the Staff Lieutenant of the B.G.R.A. and shewed the approximate formation of the ground behind the Enemy lines on the Coastal Plain, as seen from our observation posts. As each contour had to be cut out separately in cardboard and pasted on to the next lower, considerable time and labour was expended in making them up. When the whole model was complete each layer of the same height was washed in with distinguishing colour, and a reference made of the different approximate heights.

Mounting of Maps.

A method of cutting and mounting maps, used by Officers of Corps Headquarters, was instituted. The maps were cut accurately into squares or rectangles, and the whole pasted on to tracing linen with a space of 1/8th inch between each square.

When folded, this saved the usual wear and tear of the corners, to which a map is subjected when carried about in the field, and so the map was kept in good condition for a much longer period than is usual. A great saving was thus effected in the map stocks of G.S.I., and the map was in a much handier form for carrying in the pocket.

This method was much in demand with Officers of Corps Headquarters, and lots of the 1/40,000 and one-inch maps were made up for every Officer and Department of Corps Headquarters.

Many other jobs of a smaller nature were carried out and as much information as possible was sent out to the Division in Map form in the intervals between issuing the sketch maps. Hectograph copies were often made of freshly discovered trench work, especially in the event of contemplated raids, when information up to the latest possible moment was circulated to the Divisions concerned.

Later at the request of G.O.C. XXI Corps, a town map of Beirut was made on the approximate scale of 1/5,000. The existing town maps did not cover sufficient area, and were not sufficiently up to date. The personnel of the Section with the assistance of personnel of the Survey Company carried out this work. The map was mainly for billeting purposes, and owing to its being urgently required, the survey was carried out as quickly as possible by compass traverse, and the measurements made by pacing.

Bases were made of the main streets which are fairly long and straight. Suitable arteries from these streets were taken and joined up to make a fairly large triangle or polygon. The streets within these were then taken and the detail filled in. The detail was taken down in a field book and plotted in the Office on return. In some streets where the prismatic compass could not be used, owing to the presence of live wires, a plane table traverse was used. In spite of the somewhat rough methods, a very useful map was compiled.

XI - METEOROLOGICAL SECTION.

The first pilot balloon flights made on this front at El Arish early in 1917, were only of an experimental nature for the R.F.C. so it cannot be said that the Meteorological Section actually started until September 1917, when the usual meteorological instruments were installed at Rafa, and daily pilot balloon flights were commenced at Kelau. All the instruments both for pilot balloon work and for surface observations were supplied by the Physical Department, P.W.M. Cairo. Capt. Curry of this Department was put in charge of the Section. The personnel consisted of one officer, one N.C.O., and two Egyptians, extra personnel was supplied by other Sections of the Company when required for balloon flights. Lieut. Bamford joined the Company in September 1917, and took charge of all meteorological work.

In October the Meteorological screen was moved from Rafa to Kelab, but the barometer was left at Rafa. The meteorological Section moved up with G.H.Q. to Sejed early in January 1918, where the barometer was hung in a cave, the temperature and humidities were taken with a psychrometer as no screen was erected there. At the end of January the Section again moved with G.H.Q. to Bir Salem and work on a more extensive scale was started. Balloon flights which had been discontinued since November 1917 were re-commenced.

Early in 1918 a new establishment for the Survey Company was sanctioned. This included a meteorological Section. In April a Section consisting of one Corporal and one Sapper was started at Jerusalem, and the usual eye readings were taken. Balloon flights at Jerusalem were asked for in July, so an officer took charge of this detachment and remained there until the termination of hostilities.

The Section at G.H.Q. was used as a Depot for men joining the Company on probation, and of these several were later drafted to other Sections of the Company.

The instruments in the screen consisted of dry and wet bulb thermometers, and an evaporimeter. In addition there was a barometer, a wind vane, a rain gauge, a Robinson Cup Anemometer, and a Barograph (Richard Freres) included in the equipment. Eye readings were taken daily at 0800, 1400, 1800 and 2000 hours for atmospheric pressure, air temperature and humidity, wind velocity and direction, and the kind and amount of clouds. Observations for evaporation, rainfall and minimum temperature were taken at 0800, and for maximum temperature at 2000 daily. Priority telegrams were sent daily to the Physical Department, Cairo, giving the readings taken at 0800 and at 1800 of the previous day. These were used for making the forecast.

This was made by the Physical Department, Cairo, at 1300 hours daily, from data wired at 0800 hours daily from various Stations round the Mediterranean, including the Military ones. The forecast covered the period from 1300 one day to 1200 of the next day. It was sent to G.H.Q. by Priority wire and generally received about 1345. It was then reviewed in the light of local conditions since 0800 that morning and a forecast was issued from G.H.Q. in non-technical language. This forecast was sent to

the C.G.S., the D.Q.M.G., the B.G.I., the G.O.C. Palestine Brigade, R.A.F. and the B.G.G.S. of each Corps. These forecasts were issued during the rainy season only.

Daily and weekly reports (averages etc.) of the eye readings were sent to G.S.I. and included in the Intelligence Summaries. Special temperature returns and weather reports were frequently supplied to G.S.I. and the A.D.M.S.

PILOT BALLOON FLIGHTS.

The balloons were filled with hydrogen which was generated at the time of filling. The apparatus consisted of a generating metal cylinder and a metal wash cylinder, both about 2ft. 6ins. High, then a first drying bottle containing cotton wool and lastly a Wolff's bottle containing small stones. At first the upper layer in this bottle was Calcium Chloride. However the Chloride failed to justify itself and was discarded later with no apparent bad effect on the number of bursts and the purity of the gas.

The hydrogen was generated by the action of hot caustic soda solution on aluminium. The aluminium supplied was scrap, and some of it probably contained a lot of impurities so that the hydrogen was by no means pure. It was found that 125 grams of aluminium and 500 grams of Caustic Soda generated sufficient hydrogen to fill three balloons. This was the amount always used, and allowed for bursts. In the summer of 1918 great difficulty was experienced in obtaining aluminium so experiments were made with a view to using silicol and caustic soda solution for the preparation of gas on a small scale. The same apparatus was used, only a wooden plug was inserted in the generating cylinder instead of the threaded metal stopper, the advantage being that the plug could be inserted or withdrawn more rapidly. After several trials it was found that the following proportions gave good results and these were used for some time at G.H.Q. :-

300 grams of Silicol. 500 grams of Caustic Soda. 1 gallon of water.

The Caustic Soda solution at a temperature of 60 degrees Fahrenheit was first put in the cylinder, the silicol was then poured in and the wooden stopper inserted immediately. Should a further supply of gas be required the wooden plug could be easily withdrawn and a further supply of silicol added. It was found that it was better for a steady evolution of gas that the caustic soda solution should be too cool rather than too warm, as generally the heat evolved by the action was sufficient to raise the solution to the temperature required for a convenient rate of evolution. The rubber tubing used to connect the different parts of the apparatus was found to perish rather quickly. Metal tubing would be an improvement.

At the beginning considerable difficulty was experienced with the balloons. These often burst during filling. It was impossible to fill the balloons to an exact fill with the apparatus available. They were filled to the approximate size and the pull was measured when all ready for release. With the first consignments of balloons pulls of 30 grams were about the average, a 40 gram pull was exceptionally large. With some consignments it was only with difficulty that a pull of 30 grams could be reached. From the time that a regular supply of balloons came from the Meteorological Office the burst difficulty disappeared almost entirely and pulls of 100 grams were obtained.

The method adopted for the balloon flights was to observe horizontal and vertical angles on to the balloon at each successive minute after release. For the first fifteen minutes two instruments were used, after that only one. Until July 1918 the two instruments were both theodolites at a known distance apart (about one kilometre) and after that time a theodolite and a rangefinder (Barr & Stroud Infantry Pattern) were used.

The horizontal projection of the balloon's position at each successive minute was plotted using paper supplied by the Physical Department, Egypt, on which were printed radial lines 5 degrees apart for the central 10 cm and thence 1 degree apart.

When using two theodolites one of these, usually the out-station was taken as the centre of the "rose". The position of the other theodolite station could then be plotted on the paper before the flight commenced. The position of the point on the earth's surface vertically below the balloon could then be found graphically at each successive minute. If this method did not give a good enough intersection the horizontal distance from the out station to the balloon was computed, by slide rule using the

horizontal angles if the balloon was not near the vertical plane through the base, or by a graph using the vertical angles if the balloon was near the plane.

This curve formed by successive positions of the point vertically below the balloon gave direction and velocity at any point of the balloon's flight.

In practice a parallel ruler and the printed maps were used for the direction and the scale was so chosen that the distance between the two consecutive minute points could be read direct in miles per hour (44 ft. = 1 mm. or 88 ft. = 1 mm are suitable scales). The height of the balloon at any point of the path was then determined by means of an abac, or by a specially constructed circular slide rule designed by Lt. Thomas, and made in the Section.

When using one theodolite and a rangefinder the computation was much easier. Graphs were prepared giving heights and horizontal distances from the observed vertical angles and ranges. Curves were drawn on the printed "roses", and velocities and directions were obtained as before. When using one theodolite only and an assumed rate of rise the abac or the circular slide rule were used to plot the curve.

The formula used for the rate of rise at first was $10(P+10)$ for velocity in feet per minute where P = pull in grammes. At this time all the balloons were of dead weight of about 15 grams. This was superseded later by the Dynes formula which agrees with the above at a pull of about 35 grams, and is certainly nearer the observed facts.

In all these cases the observations were computed whilst the flight was in progress. When working with the theodolites a field telephone connected the two stations and readings were (usually 3 or 4 at a time) as required by the Computer.

Before discarding the two theodolite method in favour of one theodolite and a rangefinder, several rest experiments were made in which the rangefinder was tested in flights computed from two theodolites. This method had the advantage of making the work more compact, and of eliminating the field telephone. The main reason for the change however was that balloon flights were required at Jerusalem, and no other suitable theodolites could be obtained.

As a disadvantage it must be pointed out that the rangefinder must be very carefully adjusted, that is, to more than the minimum requirement necessary for use at normal rifle ranges, and even so if the balloon travels continuously in one direction it often can not be used advantageously for 15 minutes although it is very valuable in tiding over the most irregular part - say the first ten minutes. Further, the man who uses it must know what he is doing or it will be worse than useless.

On the general question of the need of two instruments at low altitudes on the Palestine front the evidence was convincing. At Jerusalem for example the first few vertical angles observed on to the balloon were frequently angles of depression because the prevailing westerly surface wind after passing over the watershed descended steeply into the Jordan Valley carrying the balloon with it.

The velocities and directions of the upper air currents at every 1000 feet of altitude were all that were required by the R.A.F. and the Anti-Aircraft sections. These were obtained directly from the plotted curve. The Artillery however required corrections to be applied to their ranges according to the time of flight of the shell. These were obtained as follows : -

The whole altitude traversed by the shell was divided into layers such that the shell remained equal times (five seconds) in each. The values of these altitudes were calculated once for all for the time of flight required. The balloon trace was divided up into sections accordingly; the Sections becoming shorter as we ascend. For each section the mean velocity and direction was taken. Each section thus contributed a vector which was plotted graphically, with the help of a parallel ruler, and the resultant of the vectors so plotted was found graphically.

This auxiliary curve was not often used for the short times of flight (10 and 20 seconds) of the shell, but mostly for the larger times of flight.

A suitable staff was found to be five when working with two theodolites (that is two at each station, and one computer) or four for theodolite and rangefinder. With these conditions it was possible to get the Artillery wire off in 25 minutes. When it was necessary to work with one less, the computing did not begin until the second theodolite or rangefinder came out of action, and the time of despatch was accordingly delayed.

Artillery wires were sent out to the B.G.R.A. and the C.R.A. of each Corps, and the C.R.A. of each Division. Priority wires were also sent to the R.A.F. and to Anti-Aircraft formations giving the information they required. A miniature trace of the flight of the balloon at G.H.Q. was also delivered to the Palestine Brigade, R.A.F.

The number of flights varied from one to six per day at G.H.Q. and from one to four at Jerusalem. Chinese lanterns made in the Section were employed for night flights. The weight of the lantern and candle was about 10 grams.

Special flights were made when requested. These were required by the Artillery for Calibration etc., and by the R.A.F. for bombing raids and long distance flights, such as the over land flight to India and long distance reconnaissances.

Wind velocities were latterly supplied to the Sound Ranging Sections.

As well as information obtained from the balloon flight barometric pressure reduced to sea level and ground temperature were telegraphed to the Artillery. At the commencement of this work upper air temperatures as supplied by the kite balloon sections, R.A.F. were included in the Artillery telegrams, or when there were no kite balloons in the air ground temperatures converted for altitude were supplied. A series of observations kindly taken up by the kite balloon sections however proved that it was impossible to get a general formula to correct temperatures for altitude, as sometimes the temperatures increased and sometimes it increased with altitude. The attempt to give upper air temperatures was therefore discontinued and ground temperatures were telegraphed instead.

ROAD AND WEATHER REPORTS.

These were first issued after the extensive movement in September 1918. Information was wired to G.H.Q. from various places such as Beirut, Homs etc., giving the state of the roads and together in such form as "Dull and threatening rain, roads passable for horse transport only". This information was embodied in a report which was sent to the D.Q.M.G. the D.S.D.T. the A.D.R.T. and the B.G.I. The Meteorological Section merely acted as a collecting and re-distribution office. These reports lacked the information as to the state of the roads between towns. They however gave very useful information from which a fairly sound estimate of the state of the roads could be formed.

FIELD ASTRONOMY.

The latitude and longitude of places in the Hedjaz, including Maan, Shahm and Mudhawara on the Railway were fixed by star observations and wireless telegraphy. Latitudes were observed by the method of "circum-meridian altitudes". Great care had to be taken to balance the North and South stars where possible as the "flexure" effect appeared to be rather large. For longitudes the Paris and Berlin wireless time signals were picked up on a 110 yard aerial, at first with a Telefunken and afterwards by a long wave Mark III tuner. Local time was determined by three or four pairs of time stars observed both before and after the wireless time signals were received. Again, great care had to be taken to balance the East and West stars if possible because of the "flexure" effect.

The party consisted of one Officer, one Sergeant, and one Sapper (wireless operator). One spare man for miscellaneous duties was included most of the time. The escort and transport which varied from a Rolls car to camels were supplied by other units as required.

In the Hedjaz the operations were too open to demand a detailed survey and the existing maps were inadequate even for what was required. Positions were altered by five miles from those on the existing map, and a section of the railway was swung through 12 degrees. These are quite appreciable even when one has ceased to think of distances in terms of map squares and co-ordinates in favour of "hours journey".

INSTRUMENT REPAIRS.

A certain amount of general repairs were executed for other Sections of the Company as well as for outside formations. Theodolites, Alidades, Aneroid barometers, prismatic compasses and trough compasses were received for repairs adjusting and standardising. Aneroid barometers, received from batteries on the front, when badly damaged were first sent to Ordnance Workshops or the Physical Department at Cairo and on return were adjusted before being sent back to the battery.

RECOMMENDATIONS.

Pilot balloons kill no Turks and save no Britishers but they can only assist others to do these things. Consequently arrangements should be made for the O.C. Section personally to visit the various batteries and Artillery formations for whom work was being done. It is thought that the work done for the Artillery could have been modified and made much more valuable had this been done. The co-operation between the R.A.F. and the Meteorological Section, particularly at the end, left nothing to be desired, and the R.A.F. made the fullest use of the Section at G.H.Q.

The Section here was apparently the only one that was not controlled by the Director of Meteorological Services, London. Outside ideas were sadly missed, the supply of balloons and aluminium was always a difficulty and much work was done which had already been settled on other fronts. These difficulties it is thought would have been greatly minimised had the Section been in close touch with similar work done elsewhere.

The personnel of the Meteorological Section if not drawn from units where they have had Field Regimental experience should be attached to such units for at least six weeks, preferably six months. This procedure was apparently followed by members of the M.G.C. and R.A.F. units who pursued a general course before the technical course.

Strong emphasis should be placed upon the fact that an ordinary cup anemometer mileage reading is only intelligible if we know something of its altitude and exposure. The instrument is singularly un-fool-proof as no matter how bad its exposure, its dial (or contact if electrical) will still give a statement of mileage.

The legitimacy of assuming a uniform rate of rise throughout, instead of only from an altitude of say 6000 feet upwards, cannot be accepted unreservedly without first enquiring into the particular local conditions of country and apparatus. The smaller the balloons the greater the liability to variation from normal. (The balloons in use in the E.E.F. until the last four months, were very much smaller than those used in the B.E.F.).

XII - CONCLUSION.

At the cessation of hostilities the work of the Survey Company by no means ended. Triangulation was extended from Damascus through Rayak, Homs and Hama to Aleppo, which was reached in April 1919. At the same time detail Survey on 1/100,000 scale was done to cover off the road and railway. An area of 11,000 square kilometres has been done on this scale. Astronomical positions were observed at Damascus, Homs, Hama and Aleppo, and the differences found between these astronomical values and the triangulated values brought all the way from Egypt are as follows : -

Place	Latitude observed	Latitude triangulated	Longitude observed	Longitude triangulated
Damascus	33-30-10	33-30-18	36-15-32	36-15-15
Homs	34-43-06	34-43-09	36-43-06	36-42-57
Hama	35-08-24	35-08-29	36-44-46	36-44-56
Aleppo	36-12-55	36-12-58	37-08-34	37-08-33

The observed value at Damascus was adopted as the fundamental origin for Geographical position.

At Aleppo a junction on to the Turkish base line was made and an accumulated error of triangulation of 1 in 2700 was found. (The length of the base as measured is 7477.883 metres. The value found through the triangulation is 7480.75 metres, a difference of 1 in 2,700.) This Turkish base is joined on to Constantinople by the Turkish main triangulation. Egypt is now joined to Europe by triangulation.

At Aleppo also a junction was made on to the triangulation brought up from Mesopotamia by Capt. Lewis R.E. so that the triangulation of the 7th Field Survey Company R.E. is now joined on to the Mesopotamian Surveys.

In conjunction with this it must not be forgotten that the Survey Company extended the triangulation of the Survey of Egypt westwards along the coast to Sollum and eastwards and northwards through Sinai and Palestine to Aleppo. Sollum is now joined to Aleppo, a distance of 800 miles. Aleppo is joined to Basra, which carries the triangulated arc some 600 miles further on, making the total distance triangulated from Sollum to Basra 1400 miles. All of this triangulation, except the part in Egypt, was done during the war and under war conditions.

The following places in Turkey in Asia have also been fixed astronomically : -
Belemdik, Adana, Aintab, Birijik, Jerablus, Urfa, Tel Abiad, Ras el Ain, Nisidin, Mardin, Marash.

The question of supply and transport was always a difficult one, and at the beginning enough attention was not paid to this important branch of the work. In the winter of 1917-1918, the field parties had their first experience of a winter in the Judaeen Hills. Their equipment was hardly suitable for such a rigorous climate, and they suffered physical hardship. The state of the roads on the lines of communication, and the kind of transport available made the question of supplies a matter of very great difficulty. The camels suffered considerably and rapidly lost condition, many died and those that remained had to be taken out every day because of the urgency of the work. This naturally increased the mortality. During the first three months of 1918, 30% of the Company's camels died from exposure and overwork. The work naturally suffered but it reflects credit on all concerned that it did not suffer more. The lesson to be learnt from this is that as much attention should be shewn to the "Q" side of the Company as to the technical side, and that where necessary a special Officer should be detailed in the field when working at a distance from Headquarters to devote the whole of his time to questions of "A" and "Q".

The Company suffered somewhat in efficiency through lack of touch with the work done by Survey Battalions and Companies on other fronts. Publications were received from time to time from France and proved valuable, but there was no arrangement made for a regular interchange of ideas and experience until the summer of 1918 when the O.C., Major Maule visited the French front. This arrangement only just began to bear fruit when hostilities ceased. The evolution of the Survey Company, however, went hand-in-hand with the evolution of other arms of the Service in the E.E.F. Practically in all matters connected with the scientific side of war our brothers in France led the way. The arrival of anyone from the French front was always seized upon as an opportunity of learning something fresh, and for bringing methods up-to-date. In the matter of utilising Airplane Photographs for the purpose of map-making we had nothing to learn from France. The problem on the French front was to add new detail to a perfectly good but out-of-date map. In the E.E.F. the problem was to make a map out of aeroplane photographs with little or no help from any existing maps, which is quite another story. The methods to be employed by the R.A.F. whilst taking the photographs on this front had to be far in advance of those used in France, and the skill shown by the pilots and observers as well as the willingness displayed by the staff of the R.A.F. to meet the very exacting demands of the Survey Company contributed to a very large extent to the accuracy of the resulting maps. A full account of the methods employed and the experience gained both by the R.A.F. and the Survey Company have been published in a separate pamphlet.

In comparing the work done by the 7th Field Survey Company R.E. with the work done on other fronts it must always be borne in mind that the chief work on the Palestine front was the surveying of the country on a larger scale than had previously been done. During 1918, for example, more than 5000 square kilometres were surveyed on 1/40,000 scale. In addition to covering this area with a network of triangulation some hundreds of prominent objects, sheikh's tombs, trees, houses etc., were fixed by theodolite intersections in Enemy country to a depth of 20 kilometres behind the enemy's line, and were used as the basis of maps made from aeroplane photographs. By September 1918 an additional area of 3000 square kilometres behind the enemy's lines had been surveyed and published on 1/40,000 scale entirely from aeroplane photographs. At the conclusion of hostilities there were 14 Officers and 16 O.R's engaged in topographical field work practically all of whom had needed training in the special methods used on this front.

The help which was given to the Artillery by Survey Companies on other fronts could not be given on this front because the Survey staff was not available. All Battery positions were however fixed and lists of fixed points were supplied. Zing sheets were supplied to the Artillery with paper pasted on them which was divided accurately into 1000 yard squares on 1/40,000 scale. Each Battery was then in a position to make an accurate Artillery Board for its own use. No direct calibration of guns was ever done by the Survey Company, but when the 28th Observation Group were in action they could calibrate the guns of any battery in their sector by observing accurately the positions of the bursts. Very few batteries availed themselves of the opportunity. Corrections to be applied for wind direction and velocity and for air temperatures were given by the Meteorological Section to the Artillery whenever they were required.

Throughout the campaign there was never that close co-operation between the Artillery and the Survey Company that is desirable. The attachment of an Artillery Major to Survey Company as Liaison Officer, as was done in France, would have been beneficial, but if extra work had been needed it would have entailed an increase of Survey Company Staff which was always a great difficulty.

The Survey Company owed a great deal to being at G.H.Q. and attached to Intelligence. It was particularly fortunate that from the conception of the Topographical Section until August 1918, in Colonel Nugent, D.S.O. was the G.S. officer who dealt with the Survey Company. Col. Nugent's previous survey experience in Sinai added to the fact that he knew many of the officers personally before the war proved of very great help to the Survey Company. In the earliest days as G.S.O.2(I) Major Nugent often visited the Field Sections, and by his help and knowledge of the great difficulties to be overcome did much to encourage all concerned. Even after taking charge of G.S. Intelligence in 1918, Col. Nugent still found time to visit the Field Sections and took an active personal interest in the personnel as well as in the work of the Company.

Whilst at Kelab the Headquarters were visited every day by Major R. Meinertzhagen, D.S.O., G.S.O.2(I) whose technical knowledge was of great service to the work in hand. All ranks were greatly encouraged by the close interest taken in the work of the Company by the General Staff.

In August 1918, Col. Nugent relinquished the command of G.S.I. to take up important duties at the War Office. His place was taken by Brig. Gen. B.T. Buckley C.M.G. who made the fullest use of the capabilities of the Survey Company by extending its powers at G.H.Q. The Survey Company absorbed "Maps", and became responsible for the collecting and distributing of all intelligence of a topographical nature. In the month of intense preparation for the final battle with the Turks on September 19 never a day passed without O.C. Survey Company being called sometimes three or four times daily to confer with the B.G.I. In this way the Survey Company was able to render all help possible to every arm of the service.

This brief record shows how the 7th Field Survey Company R.E. grew in a few years' time out of the few Surveyors lent by the Survey of Egypt for Military work. At the commencement all personnel and stores were supplied by the Survey of Egypt. As the Company grew more stores and personnel were supplied by the Army until, at the signing of the Armistice, only 7 officers out of 39 were lent by the Survey of Egypt, and practically all stores were supplied by the Army.

A word must be added in recognition of the important part played by the Egyptian Chainmen, lent by the Survey of Egypt at a time when British personnel were unobtainable, whose untiring services were always most cheerfully given. At times they suffered intense hardship with little complaint.

Throughout its existence the Survey Company has received very valuable help from the Director General of the Survey of Egypt and his Staff, which has always been freely and ungrudgingly given. Without this assistance the work of the Company would have been very seriously curtailed.

XIII - APPENDICES.**FIELD WORK**

Year	Nature of work	Trig points fixed	Square kilometres surveyed
1916-1917	1/50,000 survey along the coast to Sollum	214	6900
1914-1916	1/20,000 survey Canal Zone	45	2150
1916-1917	1/40,000 survey north coast of Sinai	90	1900
1917	1/40,000 survey Palestine up to Gaza front	35	1100
1917	1/20,000 survey Gaza front re-surveyed	-	720
1917-1918	1/40,000 survey Palestine between Gaza & Sinfil Arsuf fronts	117	5700
1918	Extension of triangulation to Damascus	33	
Totals		534	18,470

AEROPLANE PHOTOGRAPHIC WORK.

Year	Nature of work	Photos received	Square kms mapped
1917	1/20,000 Gaza front	3000	1030
1917	1/20,000 Nahr el Auja & Jerusalem fronts	1000	700
1918	1/20,000 Advance of Feb & March 1918	4000	900
1918	1/40,000 Arsuf-Sinjil front	11700	2900
	Totals	19,700	5,530

PRINTING WORK DONE IN THE FIELD.**I - LITHOGRAPHIC**

Year	Series	Scale	No. of sheets or Editions	Maps printed	Maps over printed	Plates made	No. of litho runs
1917	Gaza front	1/40,000	22	6600		33	11300
	Gaza front	1/20,000	15	2500	3100	18	6500
	Gaza front	1/10,000	35	6900		65	17500
	Gaza front	Various	58	1600	800	130	3,800
	Operations Maps						
	Gaza front	Various	25	3200		26	3600
	Miscellaneous						
1917-18	Jaffa-Jerusalem front	1/20,000	21	14800		42	29700
1918	Arsuf-Sinjil front	1/40,000	38	49800		139	196400
1918	Do. Coastal sector	1/20,000	2	5500		9	24900
1918	Do. Operations Maps	1/250,000	11	600		13	1300
1918	Miscellaneous	Various	73	26800	11100	89	25000
1919	Miscellaneous	Various	15	4900		30	12400
	Grand total		315	123200	15000	594	332400

II - LETTER-PRESS

Nature of work	No.	No. of publications	No. of runs
Political and Economic Summaries	15	4480	31410
Daily & Weekly Intelligence Summaries	194	16030	36570
Topographical Reports	19	1920	5170
Meteorological Reports	31	2650	2650
Booklets	10	6120	149380
Miscellaneous	101	88950	169220

Totals 370 120150 402400

**CONVERSION TABLE USED FOR CONVERTING CONTOUR HEIGHTS,
SURVEYED IN METRES, INTO FEET.**

Those emboldened were drawn thicker on the published sheets.

Metres	Feet	Metres	Feet	Metres	Feet
10	30	320	1060	700	2300
20	65	340	1120	720	2365
30	100	360	1180	740	2430
40	130	380	1240	760	2500
50	163	400	1300	780	2565
60	200	420	1365	800	2630
70	230	440	1430	820	2700
80	265	460	1500	840	2725
100	330	480	1565	860	2830
120	400	500	1630	880	2900
140	465	520	1700	900	2965
160	530	540	1765	920	3030
180	600	560	1830	940	3090
200	665	580	1900	960	3150
220	730	600	1965	980	3210
240	800	620	2030	1000	3270
260	865	640	2100	1020	3330
280	930	660	2165	1040	3400
300	1000	680	2230	1060	3465

XIV - LIST OF OFFICERS AT THE CONCLUSION OF HOSTILITIES.

COMMANDING.

Major W.J. Maule, D.S.O.

HEADQUARTERS.

ADJUTANT

Capt. P.S. Barlow.

TECHNICAL OFFICE.

Capt. P.A. Curry.

Capt. F.S. Richards.

Capt. J.B. Ramsey.

Lieut. N.L. Shiels.

DRAWING OFFICE.

2 Lieut. J.W. Crowder.

PRINTING SECTION.

Lieut. E.P. Reekie.

METEOROLOGICAL SECTION.

Capt. A.J. Bamford M.C.

Lieut. W. Thomas.

2 Lieut. A.E. Evans (At Jerusalem).

FIELD TOPOGRAPHICAL SECTIONS.

Major J.D. Campbell, D.S.O.

Major H.S.P. Simon.

Capt. W.D. Beatty.

Capt. W. McDonald

Capt. D.R. Meldrum D.S.O.

Capt. C.F. Montagu.

Capt. G.W. Murray, M.C.

Capt. H. Sanderson.

Lieut. G.S. Laird Clowes.

Lieut. T.W.V. May.

Lieut. P.H. Morgan.

Lieut. K. Rayner, M.C.

Lieut. W.K.W. Taylor.

2 Lieut. H.P. Rowe.

“N” SOUND RANGING SECTION.

Capt. I.G. Gott, M.C.

2 Lieut. W.P. Fuller.

2 Lieut. H.S. Toy.

“V” SOUND RANGING SECTION.

Capt. J.R. Cockburn, M.C.

Lieut. P. Phillips.

2 Lieut. J.G. Taylor.

“NN” SOUND RANGING SECTION.

Capt. T.A. Evans.

2 Lieut. W.J. Dudman.

2 Lieut. J.H. Lockton.

2 Lieut. S.W. Messant.

28th OBSERVATION GROUP.

Capt. G.W. Knight.

2 Lieut. B. Percival.

XX CORPS TOPOGRAPHICAL SECTION.

Lieut. G. Parsons.

XXI CORPS TOPOGRAPHICAL SECTION.

Lieut. H.R. Wardill

The following distinctions have been gained : -

D.S.O.	2
M.C.	4
D.C.M.	2
M.S.M.	1
Mention	8