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THE ROYAL ENGINEERS JOURNAL.—JUNE, 1921. Pages 257—304

THE ROYAL ENGINEERS JOURNAL.

Vol. XXXIII. No. 6. JUNE, 1921.

CONTENTS.

CHATHAM:
ROYAL ENGINEERS INSTITUTE.
TELEGRAPHIC ADDRESS: SAPPER, CHATHAM. TELEPHONE: CHATHAM, 669.
AGENTS AND PRINTERS: W. & J. MACKAY & CO., LTD.
LONDON:
HUGH REES, LTD., 5, REGENT STREET, S.W.1.

PRICE: 2s. 6d.

CONTENTS.

Authors alone are responsible for the statements made and the opinions expressed in their papers. [2100—1. 6. 21].

MONTGOMERIE PRIZE.

The Montgomerie Prize for the year 1920 has been awarded to Captain L. C Carus-Wilson, M.C., R.C.S. (late R.E), for his article "Earth Current Telegraphy," which was published in the *R.E. Journal* in January 1920.

The unawarded Prize for 1919 has been specially awarded to Major H. T. Morshead, D.S.O., R.E., for his article "An Exploration in South East Tibet," which was published in the *R.E. Journal* for January 1921.

Conditions.

Attention is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize shall be awarded by the R.E. Institute Council in the manner considered best for the encouragement of contributions on professional subjects, by R.E. Officers, to the Corps publications. From the beginning of 1920 it has been decided that the Prize shall be confined to Officers on the Active List not above the rank of Substantive Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

The following are suggested as subjects for contributions:—

(*a*). Descriptions of works actually carried out in peace or war.
(*b*). Inventions.
(*c*). Design (excluding works of defence).
(*d*). Labour organization on work.
(*e*). Scientific investigations generally.
(*f*). Accounts of exploration work and surveys.

THE R.E. KITCHENER SCHOLARSHIPS FUND.

The original recommendation of the Education Sub-Committee of the General Committee of the R.E. War Memorial for the institution of this fund was stated in the following words:—

"They recommend that a sum of £2,000 shall be put aside from the "capital to form the nucleus of a permanent fund from the interest on "which Scholarships shall be given annually as a perpetual Memorial to "our Comrades who fell in the Great War, and of the part borne by the "R.E. in the War. It is hoped that this permanent Fund may be "increased by special gifts as time goes on."

This permanent Fund has now been established and subscriptions and donations to the R.E. Kitchener Scholarships Fund may be sent at any time to the Secretary, R.E. Institute, Chatham.

THE VALUE OF HELIGOLAND.

By Col. J. C. Matheson.

A considerable amount of interest has been evinced from time to time in the military aspect of Heligoland, and, as a general rule, statements on the subject, especially in the public press, give a very high value to the place. But, when all the facts about this diminutive rock are duly weighed, it is contended that this high value is greatly exaggerated.

In the aspect under consideration the geographical position of Heligoland is naturally of primary importance and in studying this position it is advisable to use a small scale map. From this it will be observed that the island lies near the head of the bight formed by the north coast of the province of Hanover and the west coast of Schleswig-Holstein. It is 28 miles due north of the nearest Frisian island, Wangeroog, 30 miles west of the Schleswig coast, 40 miles from Cuxhaven at the mouth of the Elbe and 50 from Wilhelmshaven in the Jahde.

There is very little difference in the distances of important points on the British Coast from Heligoland and from other German bases in its neighbourhood. This is clear from the table of mileage (approximate) given below :—

Heligoland to Norfolk (nearest British coast) ...	280	miles.
Cuxhaven " "	295	"
Emden " "	240	"
Heligoland to Scapa Flow	530	"
Cuxhaven " "	560	"
Emden " "	540	"
Heligoland to Dover	340	"
Cuxhaven " "	375	"
Emden " "	310	"

An inspection of all these distances shows that Heligoland is too close to Germany to be of value to her as an advanced base. On the other hand the island is too near the German coast and so too vulnerable to be a base for enemy attack on that coast. It is also too far from the coast to form an integral part of the coast fortresses at the mouths of the Elbe, Weser, and Jahde.

Apart from its position Heligoland has inherent drawbacks as a base. The chief of these is its small size. Everything is cramped, the armament cannot be pushed out in advance of the object of defence and it is impossible to obtain proper bases for range-finding. The rock is only 1,700 yards long by 600 yards broad at the south end, while it narrows to a point at the north. The harbour and breakwaters add a little to its size and the Düne Islet, a short mile to the east, is of some assistance, but the longest base available for range-finding was only 2,930 yards.

Its small size and exposed situation prevented the use of Heligoland as an air base for any air-craft except sea-planes. Airships and aeroplanes were never used from it. Another drawback to the place, considered as a base, was that all stores required for the replenishment of any craft had to be transported to the island, even fresh water.

With all these drawbacks however Heligoland undoubtedly had a value for Germany. It covered the access to the rivers of the bight and the exit from them. It gave shelter to mine-layers and mine-sweepers and so facilitated the upkeep of the German minefields although it was not indispensable to them. Its guns could nearly reach all the navigable water between it and the mainland although it could not ensure the safety of a fleet behind it from attack by submarines or small craft at night.

Taking all these points into account it is contended that Heligoland was an outpost and an outpost only and that while it was worth while to fortify it as such, any works on a larger scale were a mistake. That this was not the view of the Germans is plain from the facts of the case. Immediately after obtaining possession of the place in 1890 they commenced its fortification, at first on a fairly moderate scale but at a later date on a much larger one. These later works were completed only about a year before the outbreak of the Great War.

It might have been thought that the Germans would have recognized that the chances of this island being attacked deliberately were almost infinitesimal, but the facts do not bear this out. Not only was the armament a numerous and a heavy one, but the idea of *protection* seems to have been paramount. This is brought out by the following particulars of the works:—

(*a*). The large guns (12″) were in turrets with 16-inch armour.

(*b*). The magazines and all underground works had two metres of the best ferro-concrete over them. These works included power-stations, quarters for officers and men, hospitals, in fact all the elements of a barracks. There were two of these " warrens " on the island.

(*c*). A heavily protected tunnel ran from one end of the island to the other, connecting all the main works.

(*d*). Fire-command posts had seven inches of armour over them, while all the position-finding stations except one (a war construction) had periscopic telescopes with armoured heads. These periscopes introduce chances of error which are avoided in direct sight telescopes and in this case, with the very short bases available, every chance to minimize error should have been sought.

The primary armament of the place consisted of :—

(i). Four turrets, each containing two 30·5-cm. (12″) guns.
(ii). Four 21-cm. guns, mounted singly in cupolas with 2-inch armour.
(iii). Eight 28-cm. howitzers, mounted singly in sunken pits.

The secondary armament comprized :—

(*a*). On the tableland, one 15-cm. gun and four 8·8-cm. guns at each end of the island.
(*b*). At the harbour, four batteries mounting altogether four 15-cm. guns and twelve 10·5-cm. guns.

An ample anti-aircraft armament was provided in addition to the above. This comprized 19 guns varying from 3·7-cm. to 10·5-cm., while there were anti-aircraft machine guns as well.

All the secondary batteries at the harbour were constructed either just before or just after the commencement of the war. Their design was in striking contrast to that of the larger batteries as the guns were crowded together and the protection was somewhat below the average pre-war practice in this country. In one place eight guns were huddled into 150 feet of frontage with practically no traverses between them.

The style of the defences is shown by the drawings annexed to these notes. They are :—

(*a*). A general plan of the island showing the majority of the works. Some minor ones have been omitted for the sake of clearness and the searchlights also are not shown. The harbour to the south of the island is purely artificial, it could be used only by craft up to the size of destroyers or very small cruisers. The Düne Island is very low-lying and its long " tail " has the faculty of most tails in that it can " wag," as gales from north or south cause it to shift to a surprising extent.
(*b*). Plan and sections of the South Group. These give a good idea of the massive nature of the works.
(*c*). North Command Post.
(*d*). East Mole Battery.

The photographs show :—

(1). An air photo of the island taken from the south.
(2). Exterior of the South Command Post.
(3). Part of the tunnel which ran through the island.
(4). Turrets "Dora" and "Cæsar."

Regarding the fortress of Heligoland as a whole and taking into account also the other works on the German coast together with the earlier batteries constructed on the Belgian coast, it would seem that, prior to the War, the Germans had not assimilated the teaching of history as regards coast fortifications. This is especially interesting in view of the fact that they themselves fought one of the most remarkable actions ever contested between ship and shore, in 1849 at Eckernförde on the coast of Schleswig-Holstein against a Danish squadron. In this action the two principal ships surrendered to the batteries on shore. It may be said that much has happened in 70 years, but what has not happened is that the relative value of guns ashore and guns afloat has altered in favour of the latter, even in this great war.

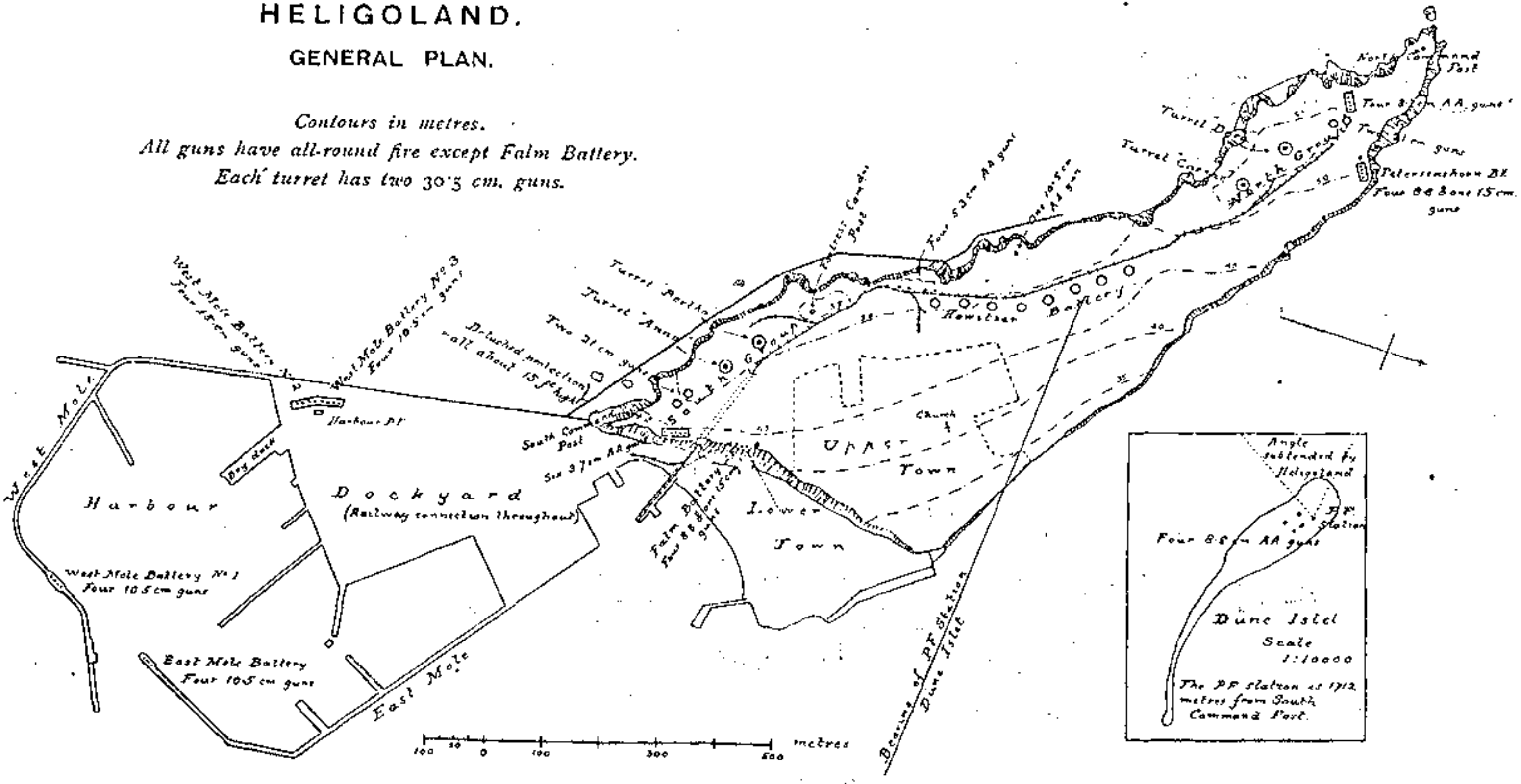
Coast fortifications are good servants but they can very easily become bad masters. They are purely defensive works and while some are absolutely essential they must never be overdone. The opinion is put forward that in Heligoland they were overdone to a very high degree. Heligoland could have served its purpose fully at a fraction of the expenditure that was poured out on it. Who can say what would have happened if the saner view had prevailed and most of the money that was spent on Heligoland had been used for active measures of war instead of passive?

(a)

HELIGOLAND.

GENERAL PLAN.

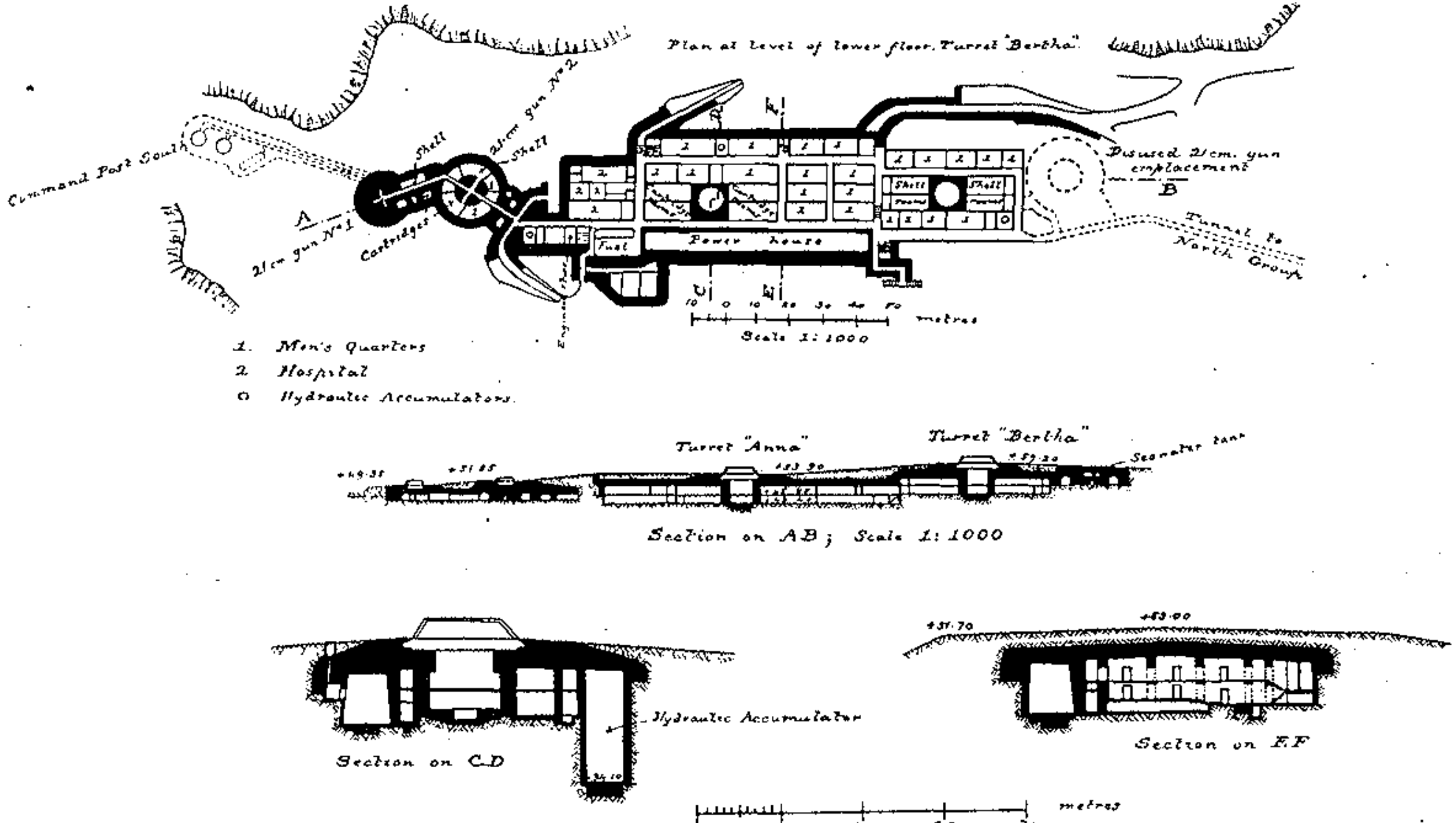
Contours in metres.
All guns have all-round fire except Falm Battery.
Each turret has two 30·5 cm. guns.



HELIGOLAND.

SOUTH GROUP.

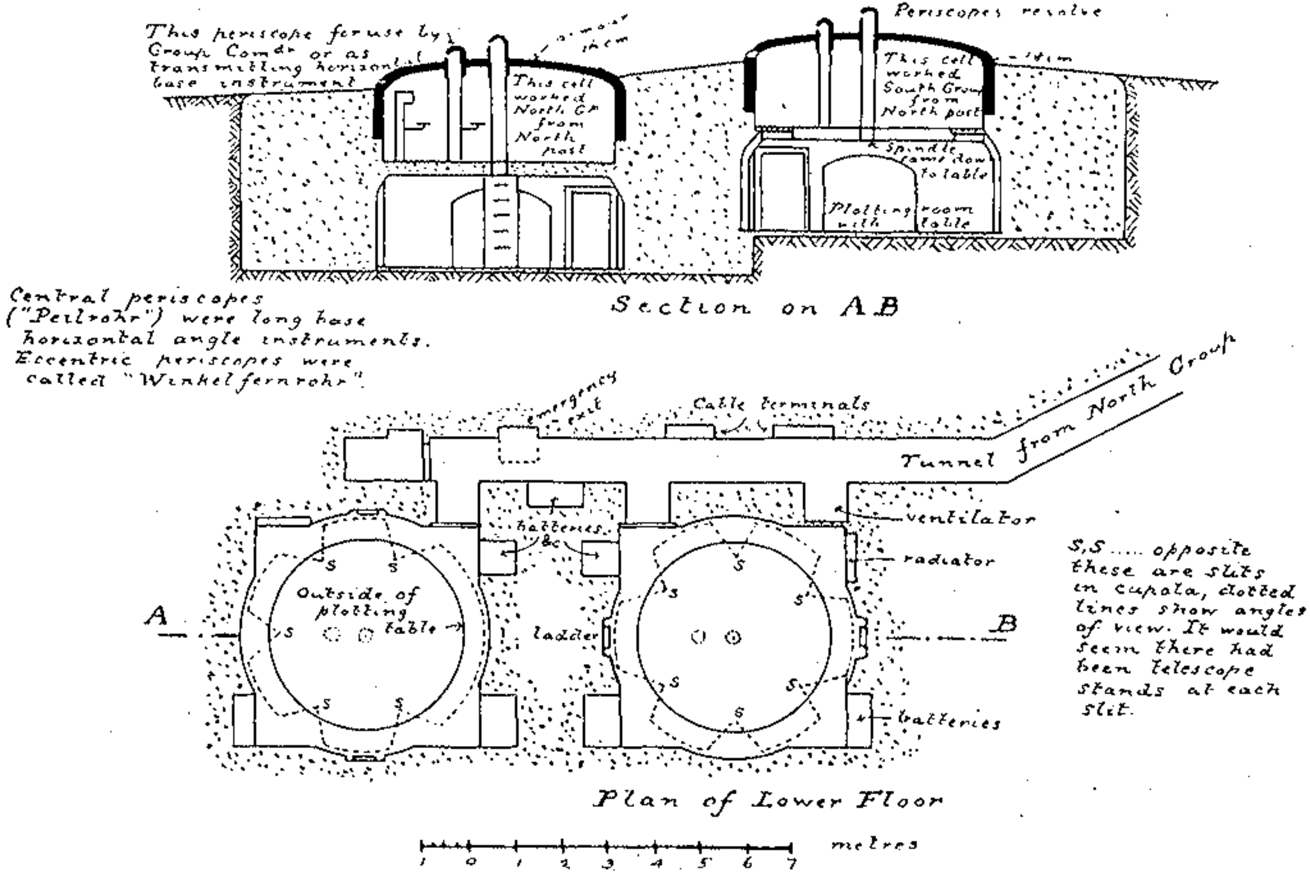
Heights in metres.



(b)

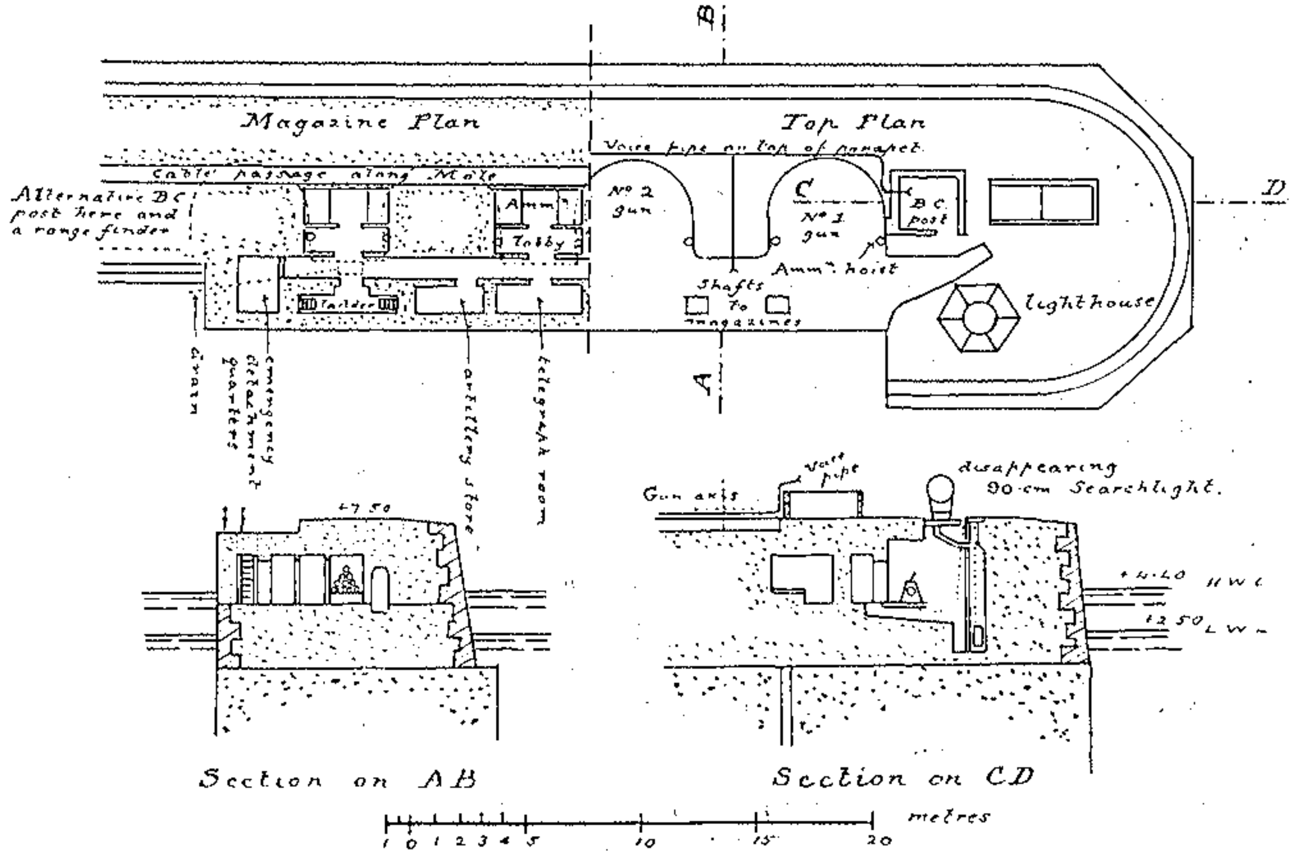
HELIGOLAND.

COMMAND POST, NORTH.



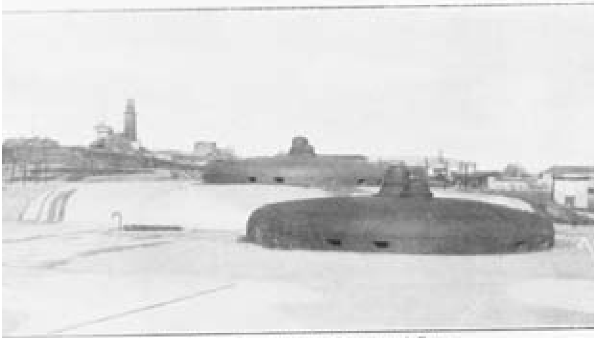
(c)

HELIGOLAND.
EAST MOLE BATTERY.



(d)

(1). Air photograph of Heligoland, from South.



(2). Exterior of South Command Post.

(3). In the tunnel which ran through the islar...

PICTURE

PICTURE 2

ENGINEER INTELLIGENCE.

A lecture delivered at the S.M.E., 17th Feb., 1920, *by* Brig.-General J. E. Edmonds, C.B., C.M.G.

During the War one of the thoughts that constantly occurred to me, and no doubt to many others, after finishing a bit of work, was "how much better I should do that job if I had to do it a second time." My purpose to-night is to place before you my experience in regard to Engineer Intelligence, so that, at any rate, you, if you ever have to deal with it, may, to some extent, be able to begin where I left off. Experience is one of the few advantages of middle age over youth. What I shall say relates solely to Belgium, France and Germany, but of course will apply to many countries. I may be a little critical at first, but I hope I shall also be constructive.

A short paper condensed from a report that I wrote on the subject at the end of the War has already been published in the *R.E. Journal* (February, 1920, "Organization of Engineer Intelligence and Information.") It gives a useful summary of the work done, and forms the frame-work of what I have to say to-night.

When some years ago I sat where you sit, as a young officer, I knew nothing about the Intelligence Division of the War Office, not even of its existence. I suppose that the world has advanced since then and that you are acquainted with its general organization. You will find an excellent article on Intelligence in the *Army Quarterly* for January.

It is unnecessary to define Engineer Intelligence to this audience. I will merely say that it means any information that will enable military engineers to prepare for and execute their work. It includes information about the theatre of war, of the enemy's engineer practice, also of our own practice and that of Allies, and of experimental work. To give you an example, it will include information of the water supply of the theatre of war; but it is not sufficient to know that there is an elaborate peace system of reservoirs and pipe supply, for this may be destroyed; there must be information of the geological formation of the country, so that we may know where to bore for water; we should know the boring apparatus required, and the nature of pumps that are most suitable, in order that they can be provided in good time. We must have information of the nature of the rivers and canals, so that our bridging equipment may be suitable. That we must know all about the enemy's engineer methods and stores is obvious; two stores we certainly borrowed from the enemy: the wire entanglement screw picket and the spring percussion fuze for firing charges. The organization of defence in deep zones, outpost, battle and rear, we undoubtedly copied from him. We also learnt of spider wire, and that 1.5 metres of ferro-concrete is sufficient protection from even heavy shells.

Then there must be circulation of information of new methods, etc., in our own and Allied Armies. To give two instances we borrowed *Réseau Brun* (French wire) and the Elephant shelter from the French; the "A" revetting frame worked out in the Second Army, the cork float bridges devised in the XV. Corps, and Colonel Sankey's floating bridges for lorry transport, had to be made known to all, etc., etc.

We had very little engineer information about the theatre of war when hostilities commenced. This was not the fault of the General Staff, nor of the R.E. authorities, nor in particular of those officers who were both G.S. (I.) and R.E. To convince you of this, I need only enumerate a few names of those who had this double qualification in the years before the War:—Sir John Ardagh (once Commandant S.M.E. and later D.M.I.), Lord Nicholson (who followed him as D.M.I. and was subsequently the first C.I.G.S.), Sir George Macdonagh, Agar, Bruce-Williams, Manifold, Bannerman, S. H. Wilson and Bowdler.

Engineer Intelligence, nevertheless, is not difficult to obtain in peace time. But, as Sir Charles Caldwell has said in his *Experiences of a Dug-out*, with regard to lack of information of a certain theatre:—

"To have obtained full information as to the Gallipoli Peninsula and the region round the Dardanelles, but especially as to the peninsula, was a matter of money—and plenty of it."

The collection means visits to the country concerned and keeping in touch with persons, not in the Army, who for business or pleasure visit it. It may mean arranging for persons to reside in that country and getting in touch with persons who permanently live there. The matter never rests—if one has compiled a complete handbook, it must be kept up to date. Even if the material can be got for nothing, there must be a staff to collate it, to sift out what is of military value, to watch for changes and innovations, and arrange to get the information about them. All this means money.

Now, money for Intelligence purposes, through the short-sightedness in things military of one Government after another, was always lacking—there is not a pin to choose between the politicians who govern the country in this matter. Both Unionist and Liberal Ministers refused sufficient funds. Yet you find that the article in the *Army Quarterly* to which I have already referred ends with the words, "Efficient intelligence is the best form of national insurance though the premiums are high." As you may see in the report of the Enquiry on the Conduct of the War in South Africa, the Intelligence Division of those days was allowed £200 a year to collect information about the South African Republics. Just before the outbreak of war twelve Staff Officers were despatched to get information of the theatre of war. But it was too late, such information can only be collected in the leisures of peace. You may recall that we had no maps, far less engineer intelligence of our own territory, Natal and Cape Colony. This kind of history gets forgotten, we remember only our successes. I mention it so that when some of you come to sit in the seats of the Mighty, you may remember the warning of 1899. Affairs improved slightly after 1902. I think we had sometimes as much as £2,000 a year—little enough to conduct enquiries over nearly the whole globe (the Intelligence Branch, Simla, dealt with the countries adjacent to India). For a further trouble was that we didn't know where we might not have to fight next. It might be the Frisian Islands, or Sleswig (according to the views of the late Lord Fisher), Belgium, the Sinai Peninsula, Asia Minor, Afghanistan or China. I don't think the most enthusiastic of us contemplated Germany, the German colonies, Northern Russia, Salonica, Palestine and the Caucasus, far less Central Asia, as possible theatres of war. Germany's problem was far simpler—she had only two theatres to consider, East and West.

The result of want of money and uncertainty as to what information would first be required was that we had only some general descriptions of possible theatres of war, and some route books of Belgium—called "Roads, Rivers and Billeting Reports." These contained hardly enough information for the G.S., and quite insufficient for R.E. work. There was no detailed information, on which engineers could work, of the nature of the waterways, the bridges (though some dimensions were given), nor what is more important, of the banks and approaches near existing bridges; nor plans of the gas and electric power supply, the telegraph and telephone systems; nor data of the engineering works, supplies of engineer material. timber, road metal, etc.

I will give you an example of the information provided in the Route books—it is the worst specimen I could find, I quote it not for the sake of making fun of it but because there is generally much more to be learnt from mistakes than from successes.

The example is:—"From N. to G. a broad granited road was being constructed in 1913, with a stone bridge over a stream immediately south of the latter village. From G. to P. there runs a granite metalled road in bad repair in 1913, scarped in wooded cliffs on north side."

"G. Population 1508. Post office, telegraph office near station, telephone office. Steam tram to L. Pipe water."

"To oppose hostile advance :—

Artillery position near B. Infantry in forest on western side of gorge. Forest difficult for movements, even for infantry. Destroy bridge and block roads into gorge."

I may say, as you will have guessed from the phraseology, that no R.E. Officer collected and recorded such indefinite information. Of course one wants to know how broad the road was ; where there was metal to mend the road in bad repair ; whether the stone bridge would take heavy traffic ; how it could best be destroyed ; details of the stream ; where the pipe water came from ; and what the delivery was. The moral is don't waste money by sending unqualified officers to reconnoitre, and rather record a few accurate details than generalities.

To turn to another example :—

Wishing to find out something about the river Meuse, I looked at the index of the route book, which gave page 2. I turned to page 2, and found it formed part of the "Contents" section. The book began at page 8. Turning over the pages, however, I found a second page 2 in the middle of the volume, but it only described a road. The only mention of the Meuse was

"Observation points (*a*) crest of ridge 1½ miles south of Anseremme: good view of Lesse valley and heights on left bank of Meuse."

I looked up in the index Givet, which is on the Meuse, in order to get on the track. Opposite it was a blank, no reference page given, though the name was there. So I turned up Dinant. The reference (page 13) was there and referred to "route F_3." I found "F_3," but nothing about Dinant. Then I noticed that I was looking at "F_3 side road g." After much turning over pages I found "F_3 main road," reconnoitred in 1911 (time of year not stated). There was Dinant all right described as "a great tourist centre, many hotels." A list of them was given, with garage accommodation. And I noticed, "For details of bridge over river Meuse, see Volume II."

Volume II. had no index, the key map showed no rivers at all. The "Contents" did not mention Dinant or the Meuse, and there was apparently nothing about them in the volume. However good intelligence is, it is useless if one cannot find the matter readily. A good key map with reference numbers should have been provided, as Bradshaw gives for railways.

Eventually I did find something about the Meuse. It was in a military report on Belgium and the Grand Duchy of Luxembourg. It contained this valuable military information :—

"River Meuse. Its current is swift in many places, while its depth is sometimes as much as 45 feet." There was no hint that the great Givet–Namur reach is sometimes fordable at places in summer, or that at the end of the winter blocks of ice come down it and carry floating bridges and weirs away; that piling is impossible above Namur on account of the rocky bottom and boulders, but can be used below that fortress. It would have been far better to have recorded "no reconnaissance of the river has been made, the few facts recorded here were taken from a school geography."

Needless to say that Sir G. Macdonogh, who became head of the Intelligence of the B.E.F. on mobilization, was not responsible for its collection before the War. The gallant officers who gathered the above no doubt did their best with the means at their disposal, but I think they should have refused to compile a book unless given the means to make one that would be of service.

Supposing we had the money, how should Engineer Intelligence be collected and how can it be done most economically? It is obvious that detailed information of an enemy's country, except what can be obtained from the air, can only be got in peace time. A great deal can be learnt from books published for commercial and scientific purposes, and from technical periodicals. Thus many details of the Rhine, for instance, were to be found in a navigation handbook for barges that was on sale. But as a rule more than is published is required for military purposes. Very often professional and business men can help to fill gaps. For instance some months after the war commenced we got a mass of geological information for tunnelling and water supply from the School of Mines in Jermyn Street. A gentleman interested in motor boats provided us with details of the Belgian and German canals. A military staff to do all the collection work is of course out of the question. Much of it can be acquired only by long residence in a country, but it should be known what is available and where it can be found.

Germany's methods may be of interest to you and throw some light on certain methods of collection. There were permanent agents residing in the coast districts of England, who with assistants, no doubt specialists, sent to them for a stay of three or four months, systematically collected and no doubt recorded information; but it would seem that every engineer and intelligent person who travelled was made use of, and only certain work was carried out by official reconnoitrers. I will give you some instances:—

A Professor of Berlin University came over to a scientific gathering at Edinburgh. He said to his host:—"I am told that there are some very interesting cliffs near Rosyth. I should like to take a car and photograph them." His host said: "Rosyth is a naval base, photographing near it is forbidden." "Ach so," said the Professor, "I did not know that; might I make a little pencil sketch?" His host demurred and the Professor asked if he might only see the place. Then his host told him he could not take a foreigner there.

Directly Hither Green Junction was opened a high German railway official asked if he might be permitted to inspect it as he heard that it was the latest thing in junctions. One of two Germans staying in Canterbury for Canterbury Week showed his host—after dinner—a map on which he was marking the water supply arrangements in Kent. Another party sailing on the Norfolk Broads were seen measuring the railway bridges.

This sort of petty spying is not congenial perhaps to the British temperament, we cannot expect this sort of help from our countrymen, but information can nevertheless be obtained through engineering firms, shipping and railway companies, etc., who have relations with persons on similar work abroad and know, at any rate, of the publications dealing with the subjects in which they are interested; and with this preliminary information a specialist will pick up much in a short visit to a district. As regards fortifications the general lay-out can of course be photographed from the air after commencement of hostilities, but details can only be obtained during construction through workmen. However, that is a matter for the Secret Service. The moral is, when you are building fortifications take note whom the contractor is employing. During the construction of the Metz forts by the Germans there were Frenchmen (Alsacians) among the workmen.

One of our great difficulties before the war was that there were very few English living on the continent who could be employed to get information. There was no one living in Borkum or at Cuxhafen, for instance, though there were Germans on the Isle of Wight and at Harwich.

The Germans undoubtedly made full use of some of their Consuls to collect information. When a General Staff officer was giving a confidential lecture to Territorials at a certain port, it was suddenly discovered by one of them that the local German Consul was present. Another was caught taking soundings from a boat with a fishing line, and a member of the German Embassy was detected in a dinghy at one of our disembarkation practices.

Our officials are different. I approached a certain Government official with a view of obtaining assistance to get information before the war. The meeting reminds me of Mr. Dooley's description of the visit of the Boer delegates to the State Secretary at Washington with a view to intervention in the South African War. Mr. Hay is represented as saying:—

"Go back to that great and good man, your President, and say that you found sympathy exuding from every pore, marked 'Private.' My heart beats for you, but not in official hours."

I got no help, British officials seemed afraid of touching anything in connection with a future war. But with Lord (then Mr.) Haldane's assistance, at any rate as regards Home Defence, matters gradually improved in this respect in the half dozen years before 1914. The point we must bear in mind is that to get good engineer intelligence in peace, it is essential to keep in touch with the official, scientific and commercial worlds.

Every Engineer officer however not only when he travels but even round his own station should make a point of noting engineer information, if only for practice. Even whether a railway line is single or double, the width of a road, may be of value later on. And don't forget to record the season of the year at which the observations are made. I think I am right in saying that we knew nothing about the effect of winter in Flanders, *e.g.*, the rise of the water table, of the subsoil water, in winter, though one of the causes of the French defeat at Blenheim should have put us on our guard. Some of you will no doubt think out what special information will be required in the next war, when perhaps all transport will be by tanks, and the nature of the river bottoms may be of interest. Perhaps we ought to know the colour and nature of the fields so that we may prepare our camouflage material to suit them.

No arrangements were made to collect engineer information about Germany, still less about France. We only had the books about Belgium of which I spoke. It was assumed that the 2^e^ *Bureau* would provide us with all that kind of thing if we ever went to war. But for the same reason as ourselves, want of money, they had very little. So don't depend on an Ally. Some little books of a series called *Notices descriptives et statistiques* were served out to us. They contained mainly information that would have been useful on manœuvres. They didn't tell us for instance, that three-quarters of the roads in N. France were closed—*Barrières Fermées**—during a thaw, nor that all the road metal in Northern France came from Belgium. None of these handbooks, moreover, were of recent date; and the 80,000 maps of France first supplied to us contained no military information, and had not been revised for many, many years. As some of you may remember, we were served out in August, 1914, with a map that didn't show the Canal du Nord, nor the causeway, road and railway across the estuary of the Somme near St. Valery, the meadows there were shown as sea even on the 100,000 map issued in 1915; and no one had warned us to learn to read vertical hachured maps.

The Engineer-in-Chief—or as he was called in August, 1914, the Brigadier R.E.—had no staff for the purpose of collecting engineer intelligence. Brig.-General John Tanner, Chief Engineer of the

* These words when placarded over the country indicated to the farmers that their heavy wagons were restricted to certain high roads. In the past possibly the minor roads were actually closed by a barrier.

VII. Corps, said to me only a few days before he was killed in 1917—*à propos* of the lack of engineer transport—that the R.E. was a head and body without legs; I added that the head was at first without ears. In fact the B.G.'s staff consisted of one clerk, and he himself had to share a motor car with the Artillery Adviser; hardly a suitable arrangement, because the work of the A.A. and the B.G. R.E. seldom took them to the same place.

General Fowke in the course of time commandeered various officers, and in October, 1914, I joined his staff. As I always had a predilection for collecting information, useful and otherwise, I began to busy myself to see what could be done to organize Engineer Intelligence. The C.G.S. was specially interested in Lille (as we were opposite to it), Antwerp and inundations. So I commenced on these. The matter is of interest as showing that care must be taken to have information about one's own country available, and to know who have it in their charge. I was directed, as a first step, to visit a certain French General. His staff had no engineer information, but the Engineer-in-Chief of the *Région du Nord* at Boulogne, who some years before had been Chief Engineer of Lille, was said to have complete records of the Lille defences, etc. At Boulogne nothing could be found. It was supposed that the plans and papers must have been left behind when Headquarters of the I. Corps District hastily evacuated Lille. This officer kindly made me some rough plans and sections of the forts. It was suggested that I should try the *Section Technique* in the War Office, Paris. So there I went. Numerous ancient documents about Lille were unearthed, some signed by Vauban himself, but no plans or details of the existing forts. However, I was introduced to the Municipal Engineer of Lille, then a refugee in Paris, who gave me a good deal of information and prepared maps showing the water supply and all important details of the town, and also much about the country round; and he put me in the way of obtaining information generally through the Civil Engineer administration of France, the *Ponts et Chaussées*, which has an Engineer-in-Chief in each Department.

The moral of this is, study the Civil Engineer organization and administration of a country in which you expect to wage war, even your own, for I remember in 1911 at the time of the railway and dock strike, having a great chase to get a large scale plan of the London Docks, showing the entrances and the nature of the boundary walls and fences.

By not going to the right officials, the officer who compiled the water book for the Army manœuvres which should have taken place in 1914 made an important omission: he left out all mention of the great mains which convey water from Lake Vyrnwy in Wales to Birmingham, and which actually ran across the manœuvre area. When the D.A.Q.M.G. and C.R.E. of my Division went down to prospect for camps they smelt them out and found that to supply the camps they only had to tap into these pipes.

There is a further lesson with regard to one's own country—although the French and Belgian *Ponts et Chaussées* was extraordinarily well organized, and staffed by engineers who all had had military training and were reserve officers, not one of them seemed to have considered the department of which he had control from a military point of view. For instance, they knew how to drain marshy areas, but not how to flood them.

However, as we were in an Allied country, it was not difficult gradually to collect and codify a great deal of information obtained from the engineers of the *Ponts et Chaussées*, both French and Belgian. We learnt gradually that the *Maires* kept large scale cadastral maps, useless in most cases since not revised since 1826, and that the Army had excellent up-to-date maps called *Plans directeur*, not of course on sale; and that there were half a dozen or more zero points of the levels on maps.

In the middle of 1915, I was switched off to other work, and Major-General Sir W. A. (then Colonel) Liddell started the organization of Intelligence on a larger scale, and it is to his forethought that we not only had the requisite information when the Germans fell back in 1917, but that we had the bridging, road, and water supply material, etc., to cope with the situation. He had the assistance of only two officers, Captain Sheppard, R.E., and Captain King, a geologist from the Geological Survey.

I would particularly direct your attention to the form in which the information that he collected was made available. It was mostly on maps. There should of course be a full record printed, but the essential information, to be readily available for use, must be graphic. A few simple conventional signs indicate at a glance the class of road or bridge, places where road metal can be found, water supply, etc.; suitable areas for well sinking and dug-outs, etc., I remember that the Gunners complained that the coloured maps issued showing where good, bad, and indifferent dug-outs could be expected did not show the condition of the soil at the surface. So remember to make quite clear what information the map supplies.

Early in 1916 a change was made in the organization of Engineer Intelligence; the B.G.G.S. "I." G.H.Q., who was himself an Engineer Officer, came to the conclusion that part of Engineer Intelligence belonged to him. He took over General Liddell's practically complete work and Captain Sheppard with it to finish it, but then owing to pressure of work had, as the War Office would not authorize an addition to his staff, to convert Captain Sheppard to ordinary Intelligence uses. The moral is:—Don't trust a brother engineer if he is on another job to do engineer work for you: keep an eye on him. The convention of the division of labour was that

G.S. " I. " was responsible for engineer information in front of the British line, the Engineer-in-Chief for anything behind it. As regards the G.S. " I. " share, Armies were responsible for the ground ten miles—I think it was—ahead. G.H.Q. for anything beyond. This definition was, of course, satisfactory, but " I. " and " E. " must always work together.

Meantime, the Engineer-in-Chief's staff had been slowly growing. General Liddell found it necessary to bring in some specialists: for Bridging (Captain Hopkins, N.A.), Machinery (Lieut.-Colonel Du Cane, N.A.), Electrical work (Major Rich, T.F.).

As tunnelling ceased after Messines, Lieut.-Colonel and Professor David, F.R.S., of the Australian Forces, became available for general geological work. As regards specialists it is important to keep one's eyes open so as to get hold of the best. I may interpolate what Lord Wolseley said to me once: " Keep a notebook and put down the name of any good officer you may hear of and his qualifications. The time may come when you may want a man for a special job. It is no good going to the Military Secretary; he doesn't know one officer from another. You might as well go the Army and Navy Stores."

When General Liddell went to be C.E. of the First Army and I resumed dealing with Engineer Intelligence of the theatre of war, I found that there were really hands available to cope with the details. Soon afterwards the Engineer-in-Chief, General Heath, added to his staff a special officer to study inundations.

A new head of the Intelligence, the third R.E. officer (the late Brigadier-General E. Cox), took over and fresh arrangements were made with him. He managed to get authority to add two officers to his staff, both R.E. officers, to give their attention mainly to Intelligence of the country ahead and to do *liaison* with the Engineer-in-Chief. All Engineer information that came in was passed to the Engineer-in-Chief, and he was also warned when prisoners or refugees who could give information were available. On his side the E.-in-C. nominated one officer of his staff as the connecting link with " I." The E.-in-C.'s specialists examined the information obtained, prepared it in a suitable form for publication, directed " I.'s " attention to what further information was required. Thus " I. " and " E. " worked together, and did each his own work. It is obvious that Engineer Intelligence is not a whole time job for any particular specialist, but all the same " I. " must have this assistance.

On the other hand " I." alone is in a position to find out the changes behind the enemy's front. Peace information may not hold good—bridges may be destroyed, roads widened, railways torn up, water supply, etc., improved. " I. " of course is the proper authority to issue intelligence.

This system worked admirably at G.H.Q. and was partially applied in the Armies. It would appear that, in addition to the collaboration of "E." and "I." at G.H.Q., there should be an Engineer officer on each Army Staff—it really doesn't matter whether he is labelled "I." or "E."—who should be specially on the look out for Engineer Intelligence.

The Engineer-in-Chief had a great piece of luck, as four of his specialists happened to know German well. I hope that the present generation of young officers are better linguists than mine were; the Intelligence throughout the War was embarrassed by want of officers who knew military German and military English. Intelligence work cannot be done without a knowledge of the enemy's language. I might draw your attention to one little matter. New foreign technical words are rarely to be found in dictionaries, so specialists in Engineer Intelligence should provide themselves with the latest text-books of their subject in the language of the country in which they are interested and learn the new words as they occur. They should make a vocabulary of them for the benefit of their successors.

So much for intelligence about the theatre of war.

I now come to information about Military Engineering, the collection and dissemination of Intelligence with regard to the enemy's methods and the results of our own and our Allies' experiences. As regards the enemy—this also must be begun in peace time—you may say that we shall learn all about the enemy within a few weeks of the commencement of the war. This in a way is true, but as a fact we did not know many Engineer details until the Boche was driven back in 1916 and we began to capture documents in large quantities. Besides learning during war is always an expensive process. The German text-books of Field Fortification, Explosives, Mining, Bridging, etc., were all on sale before the War. When I was in the German Section of the Intelligence they were sent regularly to the S.M.E., but almost invariably came back, with the request that they might be translated, which was unfortunately impossible, owing to the time and labour involved. There was no difficulty about studying the German methods, no objection was raised to British officers being present at German Engineer manœuvres. There was a very full printed English report of an accelerated (manœuvre) attack on the fortress of Ehrenbreitstein in 1908, at which the methods of trench warfare were employed, from digging in on ground gained to going over the top. Loop-hole shields, periscopes, sniper's suits, light ball pistols, and even hand-grenades were used, the last represented by model sandbags which the men threw at each other. I don't think that many officers read the report, as it was of course marked "confidential." I have never yet seen the German *Feste*, the super fortress, described in English. The Editor of the *R.E. Journal* and the new R.E. Board may perhaps, in future, be able to keep us up-to-date as to the Engineer methods and Engineer text-books of foreign Armies.

As regards intelligence of German military engineering during the war, a system grew up gradually, but it was not fully working until 1916. An arrangement was made between "I." and "E." that all documents and secret information received by "I." with regard to enemy field defences and engineer apparatus should be passed to the Engineer-in-Chief, who then advised whether it should be published at once in the Daily Summary of Information, or in a series prepared at greater leisure called "German Field Work Plates." Thus, a sketch of the German silent delay action fuze went out at once, pictures of dug-outs went into the general series. Translations on Engineer subjects were similarly selected. They were made by "I." and checked by "E." before publication.

The responsibility for information with regard to captured defences, which required engineer knowledge to measure up and draw, rested with the Engineer-in-Chief, who made the necessary arrangements through R.E. channels. Thus, after the capture of Messines, the R.E. collected all information possible about the Pillboxes. Much information of this kind was obtained on the initiative of C.R.E.'s and Field Company commanders; without their help little could have been done; but there must be someone at Headquarters to collect, collate, and disseminate. There must be someone too to look ahead and see that experiments are made or data collected to supply information which is likely to be required. For instance, the effect of mobile charges of various sizes on dug-outs, the comparative value for building cover of monolithic concrete and blocks.

Information as regards our own and Allied methods, experience and experiments, was collected by the Engineer-in-Chief, and issued in various series :—

1. Plates of field work designs (simple plates).
2. Field work notes.
3. Mining notes.
4. Domestic plates of huts and camp accessories.
5. Stores circulars.
6. Standard bridge drawings.
7. Articles made in R.E. workshops.
8. Miscellaneous.

Full lists will be found in the *R.E. Journal* of February, 1921.

It is best to send out such matter with serial numbers, so that those who read them may keep them together and notice if they fail to reach them.

An important question is how far should such information be distributed. It is a mistake to overwhelm officers in the fighting line with too much paper. It seems to me that it need not go beyond C.R.E.'s, and that they should have spare copies which they can issue if necessary. For some cases it is best to send out a small sketch and say working drawings are available if required. I am afraid that the lists of information issued, which are given in the *R.E. Journal* for February, 1920, look formidable, but the Engineer-in-Chief had to consider the Training Schools in France and at home, and other theatres of war, which were all clamouring for the results of experiences in France. The number of copies sent home rose from 1 to 200, to 500, and finally to 800. The usual method of issue in France was to send a proof to the C.E. of each Army, who then said how many copies of each, if any, would be required. Thus the C.E.'s controlled the issue in the Armies.

To save bothering fighting units with paper, a good deal of information can be passed on by C.E.'s and C.R.E.'s verbally—it saves everybody's time. I remember that when Major General Sir C. Fergusson was Inspector of Infantry he seldom came round to the Division that I was then in without telling us of some good device or method that he had seen in another division, and this always seemed an excellent arrangement. Besides, it made us look on him as a friend, instead of a critic.

The notes, etc., should be printed in a compact form, not foolscap size—which the Stationery Office love—but on sheets 7 by 3 inches, punched with three holes, so that they can be put in a cover or loose leaves. Each officer can keep the sheets that he thinks he may want. The Americans used this system.

One further point requires notice, G.S. "O." are responsible for the issue of training manuals. The Engineer-in-Chief must therefore keep in touch with the Editing Branch, so that the G.S. publications intended for the Army generally contain the latest Engineer views. The special R.E. training manuals were of course written in the E.-in-C.'s office and then passed to G.S. for approval. For the material for the manuals the E.-in-C. was dependent on C.E.'s and C.R.E.'s sending in, or supplying when requested, reports of the latest methods.

The best course is for the central authority to compile, and then send out the type-script to be read by selected authorities. The officers who know most rarely have time to write, but can find time to check other people's work.

To conclude. If we are to make Engineer Intelligence a success in future, we must keep in touch with our civil brethren and with the scientific world. The new R.E. Board will no doubt help us much. But all must bear a hand. Every officer ought to know one language besides his own. Remember Lord Kitchener got his start in life by being able to speak Arabic.* In the late War, Germany fortunately gave us time in 1915–16, by attacking Russia and then the French at Verdun, to shake ourselves together and consider our problems. Next time we may not be so fortunate. We should have been in a bad fix had we, for instance, run up against the great excavation of the Canal du Nord in our retreat in August, 1914, when we had nothing more than pontoons and trestles with which to bridge it.

* The story was told to me by Major-General Hon. E. Stuart Wortley. He was, in 1882, Military Secretary to the Sirdar, and busy collecting officers for the new Egyptian Army. Kitchener called to see him, to get employment, but unfortunately too late, as all the appointments were filled up. When he was told this Kitchener said "I ought to add that I speak Arabic," Stuart Wortley said "That makes a difference, I will speak to the Sirdar." A job was found for him. It was as an Intelligence Officer that he first made his name.

AEROPLANE PHOTOGRAPHIC SURVEYING.

THE DEVELOPMENT AND PRESENT POSSIBILITIES OF AIR PHOTOGRAPHY FOR MAPPING.

By LT-COL. H. ST. L. WINTERBOTHAM, C.M.G., D.S.O.

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DURING the war a great impetus was given to this latest method of survey. From balloons, or kites, air photography had been gradually evolving for 70 odd years, but the introduction of photography from airships and from aeroplanes, combined with the necessity of mapping inaccessible areas, led to the extensive use of air photographs for the revision of existing maps and for the detail survey over triangulated areas. The actual sphere of usefulness and limitations of the air photograph do not seem to have been grasped, however, by many more than the surveyors and some of the photographic staff employed on these war surveys. Even to these few the economic possibility of the method is still an uncharted region, for no statistics as to cost were kept, as far as I know, and as a consequence many extravagant claims as to the possibilities and economy of aerial photography for mapping have been made.

The present article is an attempt to outline, in two parts, the development of air photography as a survey method and the stage it has now reached.

PART I.—THE DEVELOPMENT OF AIR PHOTOGRAPHY FOR MAPPING.

Pre-War History.

The idea of replacing the personal work of the surveyor and topographer by photo-mechanical means dates from the time when both balloon and camera became available. We have literature on the subject which covers the last 70 years, and a fair measure of success was secured even before the war.

The camera, of many different designs, sometimes single, sometimes multiple, was used at lowish altitudes from fixed balloons or even kites. A recent German publication states that such a system had its first application in war at Solferino and its next at Richmond. Now the balloon does not lend itself to the taking of a series of plates more or less parallel to the earth's surface. This is obviously impossible if the balloon is stationary, and when it is free its movements are naturally erratic and more or less unforeseen. Photographs taken for mapping purposes were then taken obliquely at an angle of dip (below the horizontal), of something of the order of 30 deg. in order to cover as much ground from a single station as possible. The actual position of the balloon in space was easily enough determined either by intersection from ground stations or by photographing a base in the form of a cross (of known dimensions) immediately below the balloon. These early experiments were very widely distributed—French, Americans, Russians, Germans, and Austrians all taking part. So far, these oblique photographs were regarded as perspective views of flat ground. No corrections could be made for difference of height or ground form. Towards the close of the last century a big stride was made by the introduction of photogrammetry from the air, whereby ground forms and contours could, theoretically, be dealt with, although practical success can hardly be said to have been obtained. Between 1905 and 1914, however, renewed progress was made, and special instruments were manufactured by Zeiss, both for photography and for measuring angles upon the developed negative or upon contact prints. It may be said that mapping of both detail and contours from oblique photographs was now practically possible, but that the calculations necessary were too cumbrous and involved to hold out hopes of economic success. These latest developments were, I believe, entirely German or Austrian. It will be seen, then, that on the outbreak of war the Central Powers had secured a substantial lead.

War Experience.

It is probable that photography from aeroplanes (as distinct from balloons) had reached the stage of development at which it began to be of use to the map-maker quite early in 1915 in all the larger armies. The first photograph used for mapping purposes by us, for example, was one of Neuve Chapelle, taken immediately after the battle. French and British methods developed side by side, and naturally took on the same complexion. German methods, influenced by their pre-war experience and hampered by the Allied command of the air, were somewhat different. In each case, however, progress was governed by some common factors, which should be enumerated.

In the first place, air photography was not begun, in the war, for mapping, nor was it, except in rare circumstances, ever exclusively directed to that end. This fact had a great influence upon the development of mapping from air photographs, because the surveyor was not consulted in the design of camera, or in the methods of photography.

Secondly, the airmen were never able to give up much space to the camera and its fittings, because they had to carry so much armament, and were seldom allowed by enemy aircraft, and by anti-aircraft guns, to give their whole attention to photography.

These two factors were responsible for the fact that British surveyors made few special demands upon the airmen, and were content to take whatever photographs were supplied without further ado than to ask for some lenses of a shorter focal length than was usual for intelligence work, in order that larger areas might be covered upon a single plate.

Still more important in its bearing upon our methods of mapping from air photographs on the Western Front was the existence of a fairly universal trigonometrical framework and a fairly complete series of cadastral plans at a large scale. No doubt the Allies were here in a happier condition than the Germans, but it was in the main true that all mappers on the Western Front had a skeleton ready to hand, and wanted only a photographic field sheet, as it were, and not a photo-theodolite. It is in the development of an oblique photography, or of photography on a vertical plate, and of angles measured by its aid, that progress must be looked for in determining the positions of additional control points, but it is to the photograph taken vertically downwards (*i.e.*, a horizontal plate) that one naturally turns for the amplification and correction of detail, and such photographs are obviously procurable if the aeroplane can fly over all the country to be mapped. One further item must not be forgotten; neither the French, Italians, Americans nor ourselves were as far advanced as the Central Powers in the possibilities of photogrammetry from the air, nor did we possess the instruments necessary to its development.

We relied then upon the trigonometrical framework, and upon the detail survey of Napoleon's time, for position and accuracy; upon topographic maps and bench marks for contours; and upon photographs taken as nearly as possible vertically downwards for topography. Now experience soon showed that very few photographs were taken truly parallel to the earth's surface, or were, in fact, a correct representation of topography. The aeroplane was almost invariably tilted at some slight angle to the desired position, and the camera was, as rule, rigidly attached to the fuselage. Other small distortions due to shutter or lens were not unknown, and very occasionally, on the Western Front, ground forms were sufficiently marked as to introduce error. In the main, however, the only error of sensible proportions was due to the tilt of the plane. On the other hand, a high standard of accuracy in our maps was called for and was obtained, and the distortions due to the perspective effect of photographs had to be overcome in various ways. It is usual now to speak of the "rectification" of a photograph in describing the methods employed to bring the perspective picture to the desired plane. The methods of rectification evolved on the Western Front are very ably handled by Lt.-Col. MacLeod in a pamphlet recently published by the War Office, entitled *Mapping from Air-Photographs*. They need no description here, for although it is important to realize that nearly every photograph has to be rectified in some way before it can be used for mapping at large scales, it is immaterial for the purpose of this article to go further into detail.

It will be necessary now to leave the Western Front, and to consider the problem confronting the map-maker on one of the less civilized fronts, and it will be convenient to choose Palestine, because we have full descriptions of the methods evolved there from the pen of Mr. Hamshaw Thomas, who was himself largely responsible for the excellent results obtained. Palestine had, luckily enough, been surveyed on behalf of the Palestine Exploration Fund, by Kitchener, Condor and others. The resulting map, at the scale of one inch to the mile, was not of a modern order of accuracy, nor did it show much detail, but was fairly reliable as to the positions of towns and hamlets. As a framework for this new map, then, the surveyor in Palestine had the triangulation upon which the Palestine Exploration Fund's map was based, and the positions of towns, etc., as shown on the map. It will be seen that there was no universal and large-scale skeleton upon which each photograph could be identified and rectified, like that supplied by the cadastral maps of France, and that sequences or traverses of photographs had to be considered as a whole, and scaled off between control points. On the other hand, there was much less actual warfare in the air, and pilots were able to give more undivided attention to photography. Moreover, as the surveyor had been unable to anticipate the demand for good maps, the subject assumed such importance that special measures were taken to photograph for mapping, as distinct from intelligence work, and special training was given on the subject to pilots. It is natural, then, to find air photography playing a more important rôle here than on the Western Front, even though, broadly speaking, the use it was put to was the same. In both cases air photographs, whether used singly or in strips, filled up blank spaces in the topography between trigonometrically fixed control points. The differences were in matters of detail, but are of interest none the less. In order to bridge the longer gaps in the controlling skeleton and to make up strip mosaics or traverses great care had to be taken to keep the camera as nearly as possible in a vertical position. It was found that by putting pilots through a thorough course of instruction a great advance was made in this particular. It was also found that when flying as steadily as possible the spirit-level was a great help in eliminating tilt, although it could not, naturally, be relied upon implicitly. These two factors enabled the surveyor to reach so fair a degree of accuracy that for his one in 40,000 scale it was unnecessary to "rectify" each photograph, and the photo-traverses were pasted on to brown paper and then photographed up or down to the correct scale. So comparatively well did this photo-traverse scheme work, that where there were particularly few trigonometrical points, additional control points were fixed by flying over and photographing the sides of triangles, and thus fixing the position of the apices, just as the detail surveyor does by measuring the sides of triangles with his chain. A further point of interest lay in dealing with the distortions due to the steep and hilly inland areas. Whereever you meet with differences of height on the ground you must get differences of scale on your photograph, for the scale depends upon the height of the camera above the ground, and we get a certain amount of displacement which can best be understood by taking a concrete case. Supposing we take a photograph from a camera held rigidly vertical, nearly, but not quite, over some factory chimney. The ray from the lens to the top of the chimney, then, is not absolutely vertical, and if prolonged to cut the ground will fall to one side of, and not over, the base of the chimney. Now nothing that one can do to the resulting photograph will put the top of that chimney in its right position in plan, but the displacement becomes less as we get nearer to the centre of the photograph.

It is partly because of this trouble, due to differences of height, and partly to the trouble of tilt, that experience led surveyors to use no more than one-third of each photograph and to arrange for a correspondingly larger number of exposures.

One more point of interest from Palestine (and Mesopotamia) is that air photo-topography proved most valuable, as one might have foretold, for mapping large Eastern towns, with their tortuous and narrow streets.

We may now sum up the experience gained by us in the war.

Firstly, we invariably had a network of triangulation on which to base our new surveys, and sometimes we had reliable old cadastral surveys also.

In the second place, all photography for mapping was done from a camera held as nearly vertical as possible; but

Thirdly, we had failed to evolve any means of holding it absolutely vertical, and practically every photograph was sensibly distorted in consequence.

Fourthly, we mapped at scales which varied from 1 to 6 in. to the mile. At the larger scales every photograph had to be rectified, and at the smaller scales, after considerable training of the pilot, it was found possible to use photo-traverses.

Fifthly, we dealt with the problem as if the earth were flat (a safe assumption in Flanders!), and we evolved no method of actually measuring differences of height or of contouring, although we made use of the stereoscopic effect visible from two photographs which were partly of the same area.

In short, we had made it a quick and efficient, though not necessarily a cheap, method of detail survey at medium scales, but had in no way made it possible to dispense with the trig. observer or the contourer.

Our British experience is probably representative of that gained by the Allies in general. Indeed, German methods and achievements followed on much the same lines, with this essential difference—that they did occasionally employ photogrammetric methods from the air, and were able to contour inaccessible ground to some extent in consequence. We know this from articles which have appeared since the war in German surveying papers, but I am bound to say that one could not have suspected the fact from an examination of German war maps. It is probable, too, that much of the German mapping of our trenches and of the area in our occupation was done from oblique photographs.

Post-War Experience.

The important problems confronting the air photo surveyor of to-day have resulted in a good deal of research but little practical advance as yet. There are, however, three post-war air surveys of interest to mention. Most interesting is a survey carried out in North Africa by the French. The problem confronting the surveyor in this instance might occur frequently in war. The French outposts ran along the edge of a very mountainous, difficult, and hostile country, which could not be entered by surveyors. It was desired to map a strip of 60 kilometres broad. Triangulation had been pushed up to the outpost line. The programme of work may be considered under the headings:—

Additional trig. control: Fourth order.
Air photo-control: Fifth and sixth orders.
Air photo-topography.
Air photo-contouring.

The first stage was to intersect with the theodolite a number of peaks, and these are classed by the French as the fourth order of control, and serve as the base for the fifth and sixth orders. To carry out these further controls planes ascended nearly, but not necessarily quite, over trig. points, and took panoramas as nearly in a vertical plane as possible. These panoramas included various already fixed peaks, and the position of the camera at the moment of exposure was resected from these known points. The positions of exposure were then plotted and forward rays to other points were drawn in. By repeating these panoramas at a variety of points and at different altitudes a number of points of the fifth order were established. Points of the sixth order followed in much the same way, but with the difference that they were intersected by rays measured on panoramas taken during flights over the ground to be mapped, in conjunction with the air photo-topography, and corresponding to marked horizontal plane photographs. The photo-topography was done on a cinematograph film, exposures being governed mechanically, and the result, controlled by its sixth order interpolations, was plotted from compiled and mounted photo-traverses. Here we see, then, a further development of Hamshaw Thomas's traverse scheme. Finally, heights were calculated from the plotted distances, and from vertical angles measured on the vertical panoramas, starting from the height as given on the barograph in the aeroplane. It is noteworthy that no claim is made of an accuracy greater than that wanted for a survey on the 1 in 200,000 scale, and it is probable, I think, that errors in linear measurement between control points are of the order of 1/500 (which may therefore reach a sensible total), and errors of altitude of the order of ± 100 ft.

Quite recently, in an Engineering Supplement of *The Times*, we read of American experiments in air photo-hydrography and air photo-topography. Little progress seems to have been made in the former, for it was found that contrast in tone on the photograph did not correspond necessarily to relative depth, but followed more generally the colour of the bottom.

The air photo-topography, however, proved its value in the revision of a coastline strip, which was chosen as one of the natural subjects for this method. Here again we find the air photo-traverse employed without rectification of the individual photographs. A noteworthy feature of this survey is the reliance upon a camera controlled by gravity and fitted with spirit-levels—which adds another confirmation to the soundness (within certain limits) of our war procedure in Palestine.

The third and last survey to mention is one reported in a German work on photo-grammetry from the air. A party of trig. observers preceded the photography and fixed an additional number of points in the area in question, and another survey party named, and revised on the ground, the plotted map. Air photography was entrusted with the fixing of additional points from the measurement of horizontal and vertical angles on negatives taken obliquely, with photo-topography partly from these obliques and partly from horizontal plane photographs, and with photo-contouring.

The most interesting feature of this survey, and of the literature which deals with it, is that it establishes definitely that the position (and height) of exposure in space, and the direction and magnitude of tilt, can be fixed easily enough if three known points appear on the photograph, and it describes instruments for calibrating the lens and for angular measurement on the negative (which is tilted to correspond to its position at the moment of exposure).

PART II.—THE PRESENT POSSIBILITIES OF AIR PHOTOGRAPHY.

It will be convenient to a *résumé* of the subject to adopt the following headings and to omit an unnecessary repetition of the prefix "air."

1. Photo-control.
2. Photo-traverse.
3. Photo-topography.
4. Photo-contouring.

1.—*Photo-Control.*

All previous surveys have emphasized the fact that photo-control cannot give an adequate support for a map, except for short distances. It may follow either from oblique or from vertical-plane photographs, and in either case, to be of value, from refined measurement on the plate. It postulates interpolation from previously fixed points appearing on the plate (and a determination of the magnitude and direction of tilt in the case of obliques). A high order of accuracy in measuring angles from photographic plates has been obtained for some purposes, but so far photo-grammetry has not given us much precision for surveying, and, with the added difficulties of resecting in space and then rectifying it is not to be expected that the error of linear measurement will fall below something of the order of 1/500, if indeed it falls so far. It is, in my opinion, highly unlikely that any graphic interpolation depending on geometrical construction or upon any mechanical device will give us results which will do more than hang two or three photographs together. To mention one point alone, the lens itself must be carefully calibrated, and the corrections which result to the position of points on the photograph may assume serious dimensions. In German practice the angular measurement on the plate follows from observation with a specially-designed theodolite looking through the lens used in the aeroplane (or one precisely similar) at the plate which is set to the actual angle of tilt.

At this present moment we have no experience in the provision of a photo-control, although the matter is in capable hands, and we may hope for speedy developments.

One may say at once, however, that no photo-control is likely to do more than amplify the trigonometrical control, or carry us some few miles from it, and that only where suitable and identifiable points are to be seen on the negative.

No photographic method will give control points in a forest, for example.

2.—Photo-Traverses.

A photo-traverse is a form of control from the horizontal-plane plates, and has proved its utility, but it must be remembered that it can give accurate results only in flat country. Its value must depend largely on the previous training of the pilot and upon the vertical position of the optical axis. Now to ensure the latter we can, at present, do no better than hope for a steady "air-speed" and rely upon gravity and the spirit-level. It is suitable for scales smaller than 1 in 20,000. A gyroscopic attachment has often been discussed, and may yet appear, however, in which case greater accuracy may result.

3.—Photo-Topography.

With our control (and possibly traverses) plotted, we now turn to the detail, and here we must think in the first instance of scale. No photograph will give a ground plan of a thick hedge, or the boundary of a wood, or of a house with eaves, etc. It can, in fact, give only what it sees, and, as has frequently been pointed out, it cannot hope to give us cadastral plans whenever overhanging detail is met with. For large-scale maps (shall we say from 1/5,000 to 1/20,000) each photograph must, at present, be "rectified," but if we secure a good gyroscopic or other device for holding the optical axis vertical, we may escape this laborious step. Indeed, we must do so, on economic grounds, if photo-topography is to compete, over ordinary country, in the open market with the surveyor. For small scales and in flattish countries trained pilots have already shown us that "rectification" is unnecessary, except perhaps under war conditions. In Palestine the errors in position due to the hilly nature of the ground were assessed at a general figure, of about 70 metres, and one can see that special rectification must follow in mountainous country.

4.—Photo-Contouring.

To be of any accuracy, heights must at present be calculated from vertical angles measured on the plate and a previously computed height of the camera at the moment of exposure. Considerable calculation is necessary, but as a method it is feasible enough, and in the recent German survey, mentioned above, it is claimed that errors of height varied from one to two metres. It may become quite practicable to rely on stereo-photo-grammetry applied to two photographs "placed" on the detail and rectified, but we have no experience as yet in this method.

Finance and Summary.

Now, having discussed our various stages, let us turn to finance. One may assume that the taxpayer will remain indifferent as to which of his pockets the money comes out of. His chief preoccupation will be the gross total. It serves no purpose, therefore, to assume, as recent articles have done, complacent departments which may, by timely loans of men and material, diminish the apparent total.

I do not myself see how the price per plate can be less than 15s. or so, if we allow for expenses in rectification and in fitting to the map. It is, however, useless to elaborate this point here, for there are no recorded figures to show us exactly where we stand. We must await experience. We can say, however, with certainty, that except in certain extreme types of country we may economize in time, but are unlikely to economize in money. These three points will help to realize the position :—

1. The Ordnance Survey is a standing proof that cadastral plan at a scale of 1 in 2,500 can be surveyed at a cost of £12 18s. a square mile (pre-war figure).

2. Our pre-war Colonial Surveys show examples of fully completed topographical surveys at 1 inch to the mile for 10s. a square mile, and ½ inch to the mile for 5s. per square mile.

3. The inevitable preliminary to an air-photo survey is a triangulation and the inevitable sequel a visit to the ground for examination, naming, etc.

To sum up the present position we may then say :—

(a) As far as can be seen at present, air-photo surveys cannot give us cadastral plans.

(b) Medium scales (1 in 10,000 to 1 in 40,000) offer the most favourable sphere.

(c) There is no likelihood that photo-control can take the place of triangulation except within small areas.

(d) A visit to the ground will always be necessary for examination and naming.

(e) Photo-survey has taken its place as a method, and a useful one, but has not replaced, and does not seem likely to, except in special cases, the older methods.

(f) The Classes of survey for which air-topography is especially suitable seem to be :—

i. Where the ground to be surveyed is inaccessible to the surveyor.

ii. Revision for economic and statistical purposes where accuracy is not essential (*e.g.*, areas under cultivation, index maps to properties, etc.).

iii. Plans of large towns, archæological sites, etc., at medium scales.

iv. River channels, estuaries, and deltas, where shifting detail and difficulty of survey combine to obstruct land survey.

(g) Existing methods of air survey have been sufficiently exploited already to allow of a fair estimation of their possibilities. Progress will come most surely then from research and experiment directed upon the following (amongst other) points :—

i. The ensuring of the verticality of the optical axis.
ii. The measurement of magnitude and direction of tilt.
iii. Measurement on the plate of horizontal and vertical angles.

EXPERIMENTS IN AEROPLANE PHOTO SURVEYING.

By Lt.-Col. S. F. Newcombe, D.S.O.

A Professional Paper, No. 19, entitled "Experiments in Aeroplane Photo Surveying," by Major C. G. Lewis, Royal Engineers, and Captain H. G. Salmond (late Royal Air Force) has just been published by the Survey of India, Dehra Dun.

The experiments made were for :—

(*a*). One-inch topographical maps ;
(*b*). City surveys.

The aim of the experiment was to ascertain :—

(*a*). What standard of completeness and accuracy is obtainable in one-inch and City surveys in the plain ;
(*b*). The precautions necessary to give required accuracy ;
(*c*). Whether the method has advantages in time, cost, or results over ordinary methods ;
(*d*). The best arrangements to be made for carrying out big programmes in the future.

The City of Agra was selected as headquarters. The camera used was L.B. type with adjustable cradle. Lenses $8\frac{1}{2}$ inch and 20 inch (for city work). The altitude decided on was 13,000 feet giving 3.5 inches to one mile. The cameras were fitted with 5″ by 4″ plates, the short side parallel to direction of flights. An area of 31 miles east and west, by 17 miles north and south, was to be covered (being the area of two one-inch sheets) by twenty parallel flights east and west, giving a centre to centre distance of ·86 mile and 40 per cent. overlap between strips. An overlap of 33 per cent. between successive photographs was allowed for, nominally one exposure every thirty seconds. Helios were located at the beginning, centre, and end of each 30 mile strip. 'T' ground strips, the elements of which each measured 30 feet by 52 inches, were laid at each helio point. These were easily visible in the photographs. (In flying over Cairo at 6,000 feet, the lines of tennis courts are easily seen in the photographs.)

After describing the method of working the helios, Major Lewis says that the use of helios for various reasons proved very unsatisfactory, and that the cost and labour of the ground work would always be out of proportion to the benefits derived. He thinks it would be worth trying smoke bombs. The number of plates exposed was 1,757, but owing to various causes the number of negatives available for use was 1,495. Charts at the end of the book show the courses actually flown and area covered by negatives, and are instructive in showing how much room there is for error, and how unusual it is for a plane to keep an absolutely straight line. This would point (i.) to more special training for the pilot for the particular work; (ii.) to a cheap but efficient system of land marks to guide him, c.f. ground strips and smoke bombs; (iii.) to allowing more than 40 per cent. overlap between strips to avoid the necessity of extra flights to fill gaps; (iv.) to the use of a wider plate than five inches.

The Royal Air Force photographic officer had a very difficult task to get the large number of photographs mounted in strips with a very much undermanned staff. Attention is drawn to the necessity of very efficient numbering, and of using the best quality plates and paper; unless the photographs are excellent, they are of little value. The photographs were pasted down in strips on pieces of 4-ply Bristol board, and sent out to the surveyors for supplementary field work on the ground. Owing to difference of scale, it was not usually possible to make up mosaics of two or more strips, which would have been more convenient.

The supplementary field work comprised (*a*) pointing; (*b*) inking up on the photographs all detail necessary for 1-inch map; (*c*) preparing village lists; (*d*) colour traces.

The area was covered with points 1½ miles apart, mainly by plane table intersection, these points being given serial letters which were shown on the plane table and on each of the strips on which the point occurred. All necessary detail was inked up on the photographs in the usual symbols in black, red, and blue indelible inks. Heights of hills were obtained by the clinometer, and shown as relative heights. The average daily out-turn per surveyor was three square miles per diem, in fixing points and filling in detail.

Photographs may be brought to the scale of the mosaic either (*a*) by scaling individual photographs from the original negatives in an enlarging lantern, (*b*) by scaling strips of photographs made up of contact prints. Usually (*a*) would be used for enlarging the original photographs, (*b*) for compilations on a reduced scale. In this case the photographs were reduced by (*b*) from 3·6 inch to 2 inch.

The best method of obtaining the necessary line work of the final map is to reduce the strip to scale without previous inking in, which is done subsequently on the completed mosaic, especially when the detail on the reductions is clear, using the original photo strips as used in the field.

The mosaic was built up on stout mill boards mounted with drawing paper. To make the strips fit, it was found sufficient to use a length of paper, cut to the length of the distance between the extreme points of each strip, and reduced to fit through the camera. None of the photographs were free from distortion which resulted in big accumulated errors in azimuth. For instance, a strip of four photographs contained a straight line of railway parallel to the direction of flight—when correctly fitted by overlap, the railway line had changed direction by 8° at the fourth photograph. This would be caused by a constant lateral tilt of about 6° in the axis of the camera.

Before drawing can be commenced, suitable prints on drawing paper must be obtained either (*a*) by tracing the detail from the mosaic, or (*b*) by obtaining a negative on the 1½-inch scale of the inked up mosaic from which ferro-type prints on drawing paper are prepared.

Results and proposals for future work.—Camera required (i.) to have gyrostatic stabilization; (ii.) adapted to take 4″, 6″, 8″ lenses; (iii.) plates or films 8″ by 8″; (iv.) magazine capacity plates or films, rolls of 100; (v.) automatic changing, resetting and exposing with adjustable exposure interval.

Details for organization of field parties are suggested, and also for ground control section for laying out helios, etc., before flying, but it is stated that with improved instruments and training of airmen, it will probably be best to allot a given area to a pilot to photograph as he choses, without artificial ground control. The necessity of having specially trained airmen for the work was clearly shown, and machines specially designed for the work will be necessary or desirable. For making a 1-inch map a scale of 2·5″ to 3″ for the photographs is ample, provided the definition is perfect. With a 6″ lens at 12,000 feet a scale of 2·7 to one mile would be obtained. Each photograph 8″ by 8″ would cover nine square miles, and allowing an overlap of 33 per cent, the working area would be four square miles. For two standard sheets (540 square miles) 140 photographs in nine strips would be required; add 50 per cent. for gap filling, or 210 photographs in 12 strips. Original photographs on this scale would be suitable for topographical maps on all scales up to four inches to one mile.

The total number of points required for a sheet would be 100 (or one to three square miles).

Cost.—Cost of ground work for one-inch survey, average for three years' work is Rs. 9·1 or 12/- per square mile, by ordinary methods.

(*A.*) Probable cost of ground work by an aero-party using photographs would be Rs. 6·7 or 9/- per square mile.

(*B.*) Cost of compilation of mosaics Rs. 0·8 or 1/1 per square mile.

Cost of Royal Air Force share of the work based on figures supplied by Royal Air Force for the Agra experiment:—(1) Movement of machines and *personnel*, hangar, etc., Rs. 1,370 (2) Ordinary—Pay of *personnel*, rations, normal oil and petrol, etc., Rs. 8,230 (3) Extra —Officers detention allowance, extra petrol and oil, photographic stores, Rs. 6,290.

Assuming 8" by 8" plates are used, that only items (1) and (3) are charged to survey, and (2) is borne by Royal Air Force, and that a large area is done of 10,000 square miles, the (*C.*) calculation shows the cost to be Rs. 3.9 or 5/3 per square mile of flying and taking the photographs. If the total cost of the Royal Air Force is taken into account, then the cost rate would be more than doubled.

		s.	*d.*
Total cost rate is given as:	(*A.*) Ground work ...	9	0
	(*B.*) Compilation ...	1	1
	(*C.*) Photography ...	5	3

i.e. 15/4 per square mile, against 12/- per square mile by ordinary methods. The cost of triangulation and traversing has been omitted, as the difference would be at the most 1/- per square mile in favour of aero work.

The summing up is given thus:—It would appear that there is nothing to be gained by adopting the air method for normal one-inch Surveys in the plains of India. For larger scales, however, as two inch and four inch, especially the latter, the new method should eventually prove superior in every way.

City Survey.—The Lohamandi ward of Agra City was selected for the experiment. A 20" lens was used flying at 3,000 feet, giving a scale of 1/1800.

A preliminary mosaic was prepared, and used by the party which carried out the triangulation on the roof tops. An area of 50 acres was covered, with five stations and thirty points. Thus the City of Agra containing 1,600 acres would require about 110 stations, and 600 or 700 points; the photography would take about a week, and two triangulators would take say two months.

Errors in the photographs.—Assuming that the lenses cause no perceptible errors in the area of the plate, there remain three factors; (1) Tilt of camera axis; (2) Distortion due to focal plane shutter; (3) Displacement due to heights of buildings and variations of ground level.

If the elements of tilt are known, absolute correction may be made, otherwise in large scale work with the complication of high buildings, it is stated to be impossible to correct.

(ii.) If the velocity of the focal plane shutter is 40 inches per second, and width of plate four inches, the shutter takes 1/10 second to cross the plate. The plane at 80 miles per hour moves 12 feet in this time, which is serious on a 1/1800 scale. Methods are discussed for overcoming this difficulty.

(iii.) The displacement of house-tops on a large scale is very apparent with reference to the ground. Practically speaking, a stabilized camera is essential; 48″ lenses at 6,000 feet give half the error of 24″ at 3,000 feet, hence are recommended. (Why not fly at the highest possible, say 15,000 feet, and enlarge up?)

Assuming there is no tilt, it is easy to find the position of the point vertically below the camera and hence to calculate the error. After describing the method used in preparing the photographs to fit the fixed points, correcting for heights of houses, the probable errors are estimated to be two to three feet, incidental to the mosaic. Further errors may occur in inking up the photographs on the ground. The various errors to which the air survey method is liable set a limit to the scale of the survey. It is suggested that 1/1000 is rather optimistic. This scale probably meets all requirements for Indian cities, in fact, for the majority of the uses to which a town survey is put, a smaller scale should suffice. The tilting board used with the enlarging lantern had unsatisfactory movements; hence fine adjustments could not be made.

The experiment was thus only partially completed. The results merely show that triangulation will be a sufficient and a rapid process compared with the traversing used in ordinary methods.

When a stabilizing camera is available, one must ascertain (*a*) the nature and amount of errors to which the mosaic will be liable; (*b*) the extent of ground work necessary to interpret the photographs and best method of carrying it out; (*c*) cost.

Methods for carrying out the above are then discussed. The approximate forecast for the cost rate per acre of all operations up to and including fair mapping, is given as 12/- per acre for the survey party, and the cost of photography by the Royal Air Force is given as a small fraction of 1/- per acre, totalling well under 15/- per acre.

In Chapter IV., Captain Salmond discusses the best type of plane to use and suggests one similar to the Pusher of the F.E. 2c type if water cooling difficulties can be overcome; otherwise he advises certain alterations in the Bristol Fighter if that plane is the only one available. He recommends an improved aneroid to fulfil certain conditions, also a statoscope to assist the pilot to maintain one level. Bomb sights are advised. Cameras, their mounting and their special fittings are discussed.

For ground control, he states that some form of controlling the direction and width apart of the strips when flying is absolutely necessary, though he is inclined to think helios are not satisfactory, and similarly doubts whether smoke flares would be cheap enough or satisfactory. He suggests other methods.

He advises flying at a greater altitude than 3,000 feet for city work.

For future work of this kind either machines, instruments, ground control, etc., must be so improved as to eliminate the personal factor in pilots and observers, and so obtain uniform results of a high standard of perfection, or all pilots and observers must have specialized in this class of work, which differs very considerably from Active Service work.

As regards cost, Captain Salmond explains the difficulties under which the experiment was made, and lack of proper equipment making a true estimate impossible. He suggests however:—

	Open country work 3 inches to 1 mile.	City work.
Actual cost of present survey per square mile	26·9 Rs.	340 to 450 Rs.
Estimated cost under ideal conditions	9·5 Rs.	206 Rs.

He gives figures showing how he estimates above, thus:—

	Rs.	a.	p.
Cost of moving *personnel* and stores by train (1,000 miles), say	4,000	0	0
Erecting six temporary hangars or transporting R.A.F. tents, say	625	0	0
Incidental landing ground expenses	100	0	0
Officers T.A. (six Observers and one Photo Officer) ...	600	0	0
Officers' extra pay (Detention allowance), 12 Pilots and Observers and one Photo Officer for eight days	520	0	0
Petrol for photography, 28 hours at 13 galls. per hour ...	773	8	0
Oil ,, ,, ,, ,, ,, 0·7 galls. per hour ...	44	0	0
Petrol for journey to and from site (aeroplanes), 114 hours at 13 galls. per hour	3,148	0	0
Oil for journey to and from site, 0·7 galls. per hour ...	199	8	0
Petrol and oil for journey to and from site, one light tender and one motor cycle and side car	368	0	0
Petrol and oil for above for daily work at site (over and above normal), say 90–100 galls.	220	0	0
Depreciation, say	300	0	0
Photo-stores—cost proportional to that of 20 8″ by 8″ films per strip (28 strips)	1,400	0	0
Total cost for an area of 1,080 sq. miles at 1,000 miles from headquarters	12,298	0	0

Cost if carried out at headquarters of Squadron, Rs. 3·7 per square mile.
Rs. 1.4 per sq. mile for 1st 250 miles from headquarters.
Rs. 2.1 ,, ,, ,, every succeeding 250 miles above this.

To the above, must be added cost of "Post pointing," pasting down strips of photographs, reduction to scale, preparing the mosaic, inking it up, field work for helio lines, etc.

Captain Salmond states that it is greatly to be regretted that the experiment at Agra had to be carried out under the conditions he described, since the conclusions to be drawn from it are of necessity vague and may be misleading. He concludes that :—

(1). Since so small a percentage of the air photograph is used on the 1″ map, it seems probable that Air Survey cannot compete with existing methods for this small scale over open and easily traversed country ; but probably could compete over thickly wooded country or flat country broken by ravines, difficult to plane table. He points out its value for Indian and Burma forests, or for revenue crop survey, or measuring winding streams, etc.

This conclusion confirms very much the Damascus experiment shortly described in the *Geographical Journal*, September, 1920. It might be definitely stated that for 6″ to 2″ maps the air photograph method should under most circumstances be cheaper than ordinary methods in the plains, even now. Had time permitted for one pilot and observer, specially trained, to do the work instead of using a flight of four, much better and cheaper results would have been obtained. At Damascus one pilot did an area of nearly 200 square miles in one flight, with no ground control, though he knew the area very well ; a second flight by the same pilot filled in the gaps. Though the results were not perfect, due to insufficient special training, lack of the proper cameras, instruments, etc., and a Bristol Fighter being used, the cost per square mile was less than the figure given above, and the indication was distinctly that with very little more experience and with the required instruments (c.f. stabilizing camera, etc.) very practical and cheap results could be obtained for a 6-inch map on flat country.

The report does not emphasize the fact that a photograph, if good, can be enlarged up to ten times, while retaining sufficient accuracy ; a map cannot. Hence a photograph taken at 13,000 feet giving a 2·6″ to the mile scale can be enlarged to 12″ or even to 25″ ; the cost for ground-work with the air survey method should be almost the same for a 6″ as for a 1″ map, whereas by ordinary methods this item is considerably greater for the larger scales. Hence it may be said that by air survey a 6″ map can be obtained at almost the same cost as a 1″ map that the cost of a 1″ map by air or ordinary methods is about the same. Smaller scales than 1″ will cost more by air survey than by ordinary methods, but contain much more information.

For City surveys it should not be necessary to fly as low as 3,000 feet. The cost varies inversely as the square of the height flown. Thus flying at 10,000 feet covers four times the area of flying at 5,000 feet. Using a 48″ lens at say 13,000 feet or even higher, one can enlarge up to the required scale.

The difficulty of the heights of houses can be got over by multiplying the number of photographs and using only the centres of the negatives.

Both Major Lewis and Captain Salmond suggest experiments with the stereo-autograph for overcoming the difficulties of uneven ground.

The method of making the map from photographs without re-drawing, but merely touching up the resultant mosaic to emphasize essentials and retaining all the detail of the photograph, is not mentioned; if the Indian Survey could also experiment on this it would be interesting to see what benefits could be obtained and what reduction in costs.

The experiments were obviously carried out under difficulties, and without proper equipment, but are most useful in showing that if Survey departments will spend small sums on improving equipment, and in practising the method, the results will eventually be very valuable and cheap for most of the scales above one inch. Without further practical experiment in suitable countries, little progress can be expected.

PROFESSIONAL NOTES.

THE "SMALL HOLDINGS" SCHEME AT SUTTON BRIDGE.

THE Ministry of Agriculture and Fisheries commenced in 1920 on the development of an extensive estate at Sutton Bridge, near Wisbech, on the borders of the Wash, the intention being to provide "Small Holdings" for the settlement of ex-Service men on the land. There is much of interest in the construction of the cottages and farm buildings which is now proceeding, and the following notes are the outcome of a visit arranged by the Ministry.

Each "holding" consists of a parlour-type cottage, farm buildings, and from 5 to 30 acres. The estate is quite flat and there are no water supply or drainage arrangements. The cottages are mainly in pairs, and are distributed at varying intervals, depending on the size of the holdings; there are a few single cottages. The planning of the cottages is excellent, following much on the types recommended by the Ministry of Health.

All cottages have 11-in. cavity walls. The bulk are brick-built, with Fletton bricks from the neighbouring Peterborough district. Some are of the cast *in situ* concrete type. The roofs are etheri tiled, in various varieties of tiles, or thatched. Each has a shallow well and pump, an underground storage tank for 1,500 gallons of rainwater, surface drainage disposal arrangements, and an earth closet. The cost has not been found to vary greatly for the different types of construction, though brick is cheaper than concrete.

The work is being carried out by direct administration. The costs of the first cottages completed were 1s. 4d. per foot cube for a pair, and 1s. 6½d. for a single cottage, 7d. for the farm buildings. The latter are mainly simple in type, and vary according to the nature of the crops to be grown on the land. Costs are now showing a distinct tendency to fall. The figures given above include all overhead charges on the site and an allowance for depreciation of plant.

The following are the features likely to be of chief interest to R.E. officers.

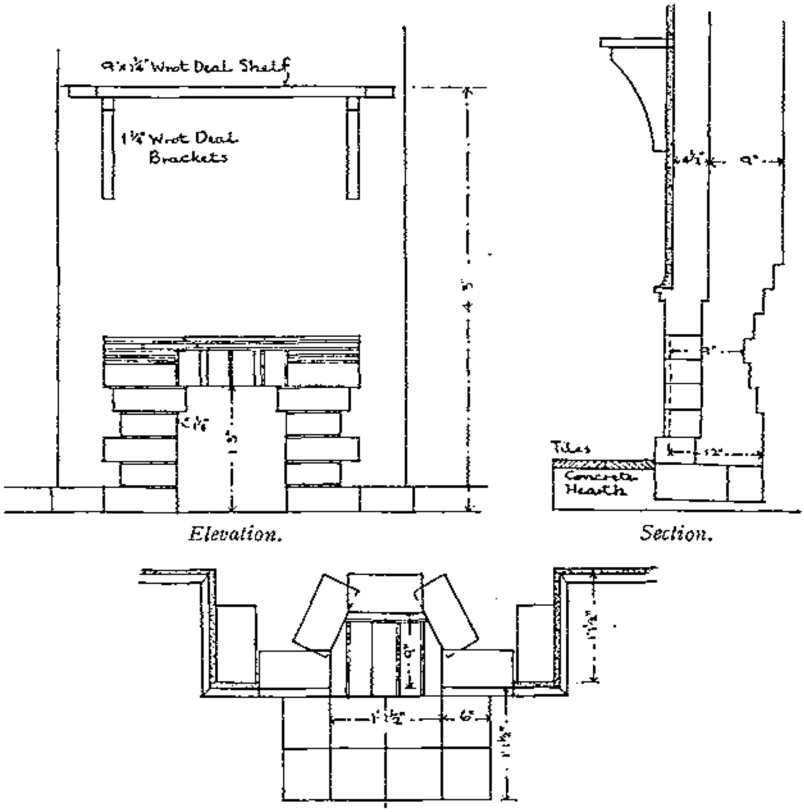
Walling.—The 11-in. brick walls have a continuous cavity, which is ventilated by open external vertical joints about 6 ft. apart horizontally under the eaves and just over the damp course. A similar arrangement is made with concerte walls. Some of the brick and all the concrete cottages are rendered outside with a whitewash consisting of one cement, one sand and four lime, which has been very satisfactory. The lower 3 ft. is usually tarred. Pointing of brick walls has been generally dispensed with, the joints being roughly finished flush. This saves a little cost, and is claimed to be quite effective. Internal walls are mainly $4\frac{1}{2}$ in., plastered two coats, the second coat finished with a wood float to a rough surface to obviate sweating.

Roofs.—Various forms of tiles are used. Pantiles when used are bedded in cement and laid on battens. The most interesting feature of the roofing is the revival of thatching. "Norfolk reed" thatching is still a local industry, and the family of the thatcher employed has followed this trade since the 13th century. While little cheaper than tiles, thatching gives an excellent roof of delightful appearance. The reeds are dark in colour and therefore never have the raw appearance of a new straw-thatched roof. Owing to the big overhang of the eaves, no eaves gutters are fixed; hence the thatched roofs cannot be used as catchments for rainwater. (Where the cottages are thatched the farm buildings are tiled and used to catch the rainwater). A pair of cottages can be thatched completely in 10 days. The slope of the roof is about 50 degrees. Some advantages of thatch are that owing to the ease with which dormer and semi-dormer windows can be formed, the upper windows can be of this type, and there is a saving of a foot or two in the height of the walls; the roof timbers can be of lighter scantling and the battens 12in. apart. With pantiled roofs, the barge board is usually carried up flush with the upper surface of the tiles and a fillet nailed to it over the verge tiles. This helps to prevent wind damage. Half round asbestos cement eaves gutters have been used, and are satisfactory and slightly cheaper than cast iron. In some of the farm buildings solid reinforced cement eaves gutters have been cast *in situ*; these are satisfactory and not expensive if made in quantity as the shuttering can be re-used. Elm fascia boards and soffit linings are used with tiled roofs, the elm coming off the estate. Elm has also been used for weather boarding of gables of farm buildings, and of some cottages.

Floors.—Ground floors are "solid wood" laid on a coating of tar on the concrete seal. Porous or breeze bricks are bedded in the concrete to take the nails, instead of the usual wood fillets. The floors are allowed to become perfectly dry before linoleum or other covering is placed on them, and the Ministry have no fear of dry-rot. Upper floors are constructed as follows:—$\frac{5}{8}$ in. boarding is laid on the joists, then a layer of felt, and then again $\frac{5}{8}$ in. boarding, nailed through to the joists. Both layers of boarding run the same way, but the longitudinal joints are broken. There is no ceiling; the (creosoted) joists are exposed and the underside of the boarding finished white with "Ceilingite." These floors are very fairly sound-proof, and the absence of ceiling gives a little extra height to the rooms (which are 8ft. 3in. floor to floor). An advantage is that the upper layer of boarding need not be finally laid until the plastering of the upper room is completed, and can thus be kept clean from plaster. All boarding is butt-jointed. Ceilings of upper rooms are of the usual lath and plaster type, finished with a wooden float.

Woodwork.—All exposed woodwork is creosoted. This is cheaper than the patent preservatives (1s. 6d. per gallon against about 2s. 3d.) and far cheaper than paint. The appearance is good; if waxed by the tenant, the finish should be lasting. Doors are all of a simple ledged and braced type. Windows are all wooden casements. A size has been standardized, and windows are therefore one, two, or three-light as required. In larder windows one or more panes are replaced by perforated zinc.

Fireplaces, etc.—The living rooms have the ordinary pattern of small cooking range. All the other fireplaces are of the extremely simple brick pattern shown in the figure. These are found most satisfactory; they are easy to light, will burn anything, heat the room very well, are of good appearance, and easy to clean.



Elevation. *Section.*

Plan.

Brick Fire-place Details.

A good hand-made sand faced brick is preferable for the facings. The back sides and hearth to be built in fire-clay bricks. Height of opening should vary with height of chimney. In 1st floor, bedrooms with low stacks should not exceed 1 ft. 6 ins., but on ground floor may go to 1 ft. 9 ins. or 2 ft. Cement pointing should be avoided as the heat tends to crack and loosen it. Lime mortar has been found best with plain flush joint. Back hearths may be raised or not as desired. If raised, height of opening should be taken from top of hearth.

Water Supply and Fittings.—The necessity for strict economy in water, in a country where no water supply arrangements exist, and the annual rainfall is slight, has led the Ministry to omit the laying-on of water entirely. All has to be carried either from the pump which delivers from the well, or from the rainwater tank. The latter will, it is hoped, provide a reserve supply. In some pairs of cottages one side of the whole roof has been allotted, for catchment purposes, to one house, and the other to the other. It is questionable whether this is an entirely satisfactory arrangement, as one slope of the roof (the south or west) may catch much more water than the other, and after an abnormally dry winter the difference in the contents of the storage tanks on some pairs of cottages is marked. The sinks are fixed on iron cantilevers. They discharge through an untrapped outlet into a sealed gulley connected with the surface drainage. The outlet has a hinged flap at its end, to prevent the passage of vermin and draughts. Baths are fitted either in the sculleries or in small rooms with the coppers. The type usually adopted is a fireclay bath, 4 ft. 4-in. by 2 ft. internal. These are a little more expensive than cast iron baths, but are clean, of good appearance, and excellent for rinsing clothes. A smaller size, 4ft. 2in. internal, is to be tried. All baths are fitted with a double hinged flap, by which they are covered when not in use. This is useful on washing day, and helps to keep the heat in when the bath is filled. The method adopted usually is to put first a kettle of hot water into the bath and close it up; at the same time light the fire under the copper. By the time the water is heated the bath itself is warmed.

Work is proceeding on the scheme rapidly and without friction. The costs are low and the quality of the work unquestionably high. These results are being obtained by the Ministry of Agriculture by its admirable "team-work," under the general direction of Sir Laurence Weaver, K.B.E., Director-General of Works and Lands, and the immediate superintendence of the chief architect to the Ministry, Major H. P. G. Moule, D.S.O., M.C.

NOTES ON SOME CONSTRUCTION METHODS.

A SYSTEM of concrete house construction particularly suitable for operation by semi-skilled men has been adopted by Messrs. Sir Robert MacAlpine and Sons in the extensive housing scheme at Hayes, Middlesex, and is favourably reported on. This is known as the C.C.C. system and has been introduced by the Composite Concrete Construction Coy. of 51, Pall Mall, S.W.1., from whom an explanatory pamphlet can be obtained.

As compared with brick construction when bricks and bricklayers are available, there appears to be little, if any, saving in expense in this system; but as the same drawings can be used for buildings whether of brick or on this system, it may well prove a suitable alternative to brick construction, particularly where the employment of semi-skilled ex-Service men is resorted to, or there is difficulty in obtaining bricklayers.

In essentials, the system consists in the construction of an outer and inner skin of breeze concrete slabs, built dry and kept apart by light wall-ties, the cavity being grouted with semi-liquid ballast concrete as the work proceeds. It is claimed, and supported by tests, that complete weather proofness and absence of condensation is obtained. The slabs are hand made, 1 to 4 for the outer walls and 1 to 6 for partitions; kept in moulds for 48 hours and seasoned for 14–21 days. The ballast concrete is 1 to 8. A "band-course" of ballast concrete the full thickness of the wall is run on the upper floor level and again at roof plate level; this serves to correct any irregularities in the height of the wall and to provide a bearing for joists. This course alone requires shuttering. The wall-ties are light hoop-iron, stove enamelled, and are not relied upon for strength to hold the wall together; it is found that the ballast concrete core keys into the slabs so firmly that the wall is practically monolithic. Flues are usually built in brick. The fixing of down-pipes, etc., is much simplified by the fact that the outer skin of the wall being breeze concrete will take nails. The damp course is slate, the cement plinth being tarred.

The experience of the same firm of contractors with the well-known form of construction which consists of steel framework with a plastered metal-lathing external skin, and a light lining, is worthy of note.

Houses built on this system have been found considerably more expensive, in the locality, than those of brick or on the "C.C.C." system. Their planning must necessarily be the simplest possible, and their appearance, beside brick houses, is poor.

Large numbers of skilled plasterers are required, if many houses on this system are to be built. Plasterers are the rarest of skilled tradesmen. The Cement Gun has been used for the external plastering, and while the appearance of work so done is a little uneven, the penetration of the plaster and consequent covering and preservation of the inside of the metal lathing are better than with ordinary hand-plastering.

It is most important that a good covering of concrete over the steelwork, including the framing, externally should be obtained. This is required not only to protect the steel from corrosion, but also to protect it from temperature changes, which by causing expansion and contraction in the steel may cause cracking in the plaster.

BULLETIN DE RENSEIGNEMENTS DU GÉNIE.

In a notice on the re-appearance of the *Revue du Génie Militaire*, published in the *R.E. Journal* in April last, mention was made of 12 numbers of the *Bulletin de Renseignements du Génie* which had been published under the direction of the *Inspection Générale des Travaux et Organisations aux Armées*. By the courtesy of the *Section Technique du Génie* of the *Ministère de la Guerre* the R.E. Institute is now in possession of a complete *series* of the *Bulletin*, which is being bound and will be placed in the Corps Library at the Horse Guards. The period covered by this publication extends from 30th, Sept. 1917 to July, 1919, and many of the articles contained in it are of the greatest technical and historical value.

F.E.G.S.

CORRESPONDENCE.

THE TIBET MISSION OF 1903-04.

To the Editor, R.E. JOURNAL.

DEAR SIR,

I am obliged to your correspondent, Mr. Hinks, for corroborating the essence of my letter in *R.E. Journal* of February.

Major Morshead's phrase therein alluded to led me to conceive that Major-General Sir Ronald Macdonald's services in Tibet might be forgotten, and so my motive in writing was to invite the attention of the readers of the *R.E. Journal* to the distinguished service of a brother officer of a former generation.

I had only my memory to rely on; but now Mr. Hinks produces Blue Book evidence of the validity of my statement. True, Mr. Hinks finds me guilty of not being "quite accurate," and would thus discredit me with my brother officers as a true recorder of facts were it not that he puts the matter beyond possibility of doubt by quoting authoratitive evidence that "preponderance for the present must be given to military considerations, and General Macdonald has been authorized to take all measures necessary to secure safety of Mission."

To the best of my recollection the actual instructions given to General Macdonald, at this period, are given in the Blue Book, and if I am right, those that are interested can see them for themselves. Doubtless their inclusion would have made Mr. Hinks' letter too long.

It is immaterial to my purpose whether the force commanded by General Macdonald was, technically, an expedition or an escort. I merely copied the words "military" and "expedition" from Major Morshead.

Yours very truly,

J. A. FERRIER, *Maj.-Gen.*, (late R.E.).

REVIEWS.

THE GREAT WAR IN 1914.

By LT.-COL. F. R. SEDGWICK, C.M.G., D.S.O., R.A. (Forster Groom and Co., 16, Charing Cross, S.W.1.)

The author avoids all tactical details and deals only with the strategy of 1914. The initial concentration and subsequent moves in the Eastern and Balkan as well as in the Western theatre of war are concisely laid down and shown on several clear and well arranged maps. There are certain inaccuracies, probably due to insufficient material being as yet available, but the author's comments and observations are full and interesting and if not altogether in agreement with our own opinions will give plenty of food for discussion and thought.

E.H.K.

A MEMOIR OF LT.-COL. EDWARD ANTHONY STEEL, D.S.O., R.H.A. AND R.F.A., 1880–1919.

Compiled by his father, COLONEL J. P. STEEL, late Royal Engineers. (Simpkin, Marshall, Hamilton, Kent & Co. Price 6s.).

This brilliant young Officer died at Omsk in Siberia on 12th September, 1919, from influenza resulting from a wound in the lung received in France three years earlier. He lies in the Cossack cemetery at Omsk, and his father, considering the remoteness of his grave and in the endeavour to keep the memory of this gallant soldier green, substitutes for marble or brass a simple record of his short but eventful life. The story is told mostly in letters, and is one of strenuous work and sport, from his school days at Dover College to his death while training Russian artillery with the British Military Mission. As a Subaltern in L Battery in India, with many football and athletic successes, on the Anglo-Belgian Boundary Commission, and in the Great War, it is a tale of keen work and keen play, qualities always associated with the best type of British officer.

F.E.G.S.

NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 35.—*Why Germany sent Lenin to Russia.*—Ludendorff contributes an article on this subject, and quotes Bismarck to the effect that, in a war for national existence, weapons must be chosen primarily for their immediate efficacy; their after effects must be of only secondary importance. With this principle in mind he agreed to the proposition, put forward by the Chancellor, to send Lenin and his colleagues from Switzerland through Germany to Sweden. According to Ludendorff, the Tzar had shown himself inclined to make peace, so his allies, led by the British Ambassador, brought about a revolution, with a view to putting in power a party that would be willing to go on with the war. This revolution certainly weakened the Russian army, but it did not destroy it, and Germany's forces were too weak to effect much at this time. On the other hand American troops would soon be arriving in France, and if an attack in the West was to be successful, it would have to be made soon. The Chancellor hoped that the dispatch of Lenin would lead to a more rapid development of the Revolution and a strengthening of the peace parties. G.H.Q., on the other hand, was chiefly concerned with the weakening of the Russian armies, to the point of destruction. Ludendorff, who up to then had never heard of Lenin, did not know who advised the Chancellor, but supposed it to be one of the Social-democratic party. This supposition has since been shown to be correct. G.H.Q., finding a weapon ready to hand, used it, but their part in its preparation was confined to arranging the journey. German attacks in 1917 scattered the Russian armies, but it was not until Lenin and Trotski came into power that peace negotiations began. From a military point of view the action of the government was justified. Whether its political consequences were foreseen is another question.

A German view of French and English literature on the War is given by Gen. von Kuhl. He says that all French and English critics reveal how near Germany often was to a military victory, quite apart from any success attributable to the U-boats. Among French writers, Buat, Mangin, and Pierrefeu get attention, and among the English, Capt. Wright, though described as "highly dramatic," is taken seriously.

Protection against Moneylenders.—The poverty to which German officers have been reduced has made them an easy prey to moneylenders; a society has been formed for their protection, and all officers are recommended to consult it before signing any agreement.

Obituary notices.—(18. 2. 21) Colonel-General von Boehn; he commanded an Army group. (13. 2. 21) Major-General Karl von Kraewel. As colonel he commanded the 159th Infantry Regiment and achieved distinction when he took command of the Kraewel Brigade on the 8th September, 1914, when he put up a very good fight at Montreuil-aux-Lions against the British.

No. 36.—*French coloured troops.*—The *M.W.B.* is much concerned with the efforts which France is making to organize the great resources of man-power which her colonies give her. Before the war she had only 60,000 coloured troops, but by the end of it no less than 545,000 had been raised. Naturally training and administrative services could hardly keep pace with such a rapid expansion, but great efforts are now being made to overcome the numerous difficulties met with, in raising and training the various native troops from French colonies. For the year 1921 it is hoped that Madagascar and Equatorial Africa will raise 60,000, which, with 100,000 from North Africa and 40,000 from Indo-China, will make up 200,000. Provision of officers and N.C.Os. for such large numbers is one of the great difficulties. The *M.W.B.* concludes with the usual protest against the employment of coloured troops in the occupied districts, but admits that many of the complaints against them are exaggerated.

The Council system in the Austrian army.—When the old Austrian army was "stabbed in the back" (*i.e.*, on being defeated in the field broke to pieces through internal action) a number of small units termed "People's defence force" were formed. These subsequently formed into battalions and were equipped from the old army's stores. They were ruled by "Soldier's Councils," who saw to it that officers of the kind they desired were elected. Military training or experience was not a necessary qualification; political views were the important factor. Naturally all kinds of administrative "mistakes" occurred, but the Councils were so strong politically that the Government was continually obliged to give way to them. In order to strengthen their position still more and to estrange the real officers from their men, the Councils decided that all training was to be done by civilians! The scandals, which arose in connection with the "People's defence force," became so bad that the less radical parts of parliament decided to work for its reorganization on a new basis; little, however, has been achieved in this direction. The Minister for Defence, Dr. Deutsch, has drawn up rules for the Soldiers' Councils, according to which their powers extend to the following matters—clothing, rations, accommodation, training, complaints, leave, and discipline. They have also to watch over the actual issue of pay, clothing and rations; a fairly comprehensive list!

No. 37.—*The Council system in the Austrian army* (*continued*).—Although the powers of the Councils are of wide extent, their exact limits have not been defined and it is from this lack of definition that difficulties chiefly arise. The fact that the members of the Councils are not subject to military discipline and none of their actions liable to restraint, does not make the situation any better. The establishment laid down for the strength of the Councils is 1117; this in an army where the total number of serving soldiers is under 20,000! Of these more than 100 are struck off all duties, and devote themselves entirely to the interests of their electors. The expenses of the Councils fall, of course, on Army votes and amount to the enormous total of 50 million kroner per annum. In addition to the 1117 men counsellors there are 61 Officer counsellors, instituted by the bourgeois party, to form a counter weight to the very "red" soldiers' councils; 52 of these are struck off all duties, and their cost must be added to the above-mentioned 50 millions. These officers' councils effect no object, as they have little political backing. The men's councils are closely affiliated to the unions formed by the lower grade employees in other state departments, and are really in closer touch with them than they are with the army they are supposed to represent. The more orderly elements in the ranks are beginning to tire of being pawns in the political game and there are signs of a more soldierlike feeling. These symptoms are very unwelcome to those who wish to maintain and widen the division between officers and men, and a system of classes of instruction for soldiers' councils has been started. It remains to be seen what the result of this struggle for power between the Army command and the extremists is going to be. The next step will probably be classes of instruction for officers in political and economic subjects.

L. Chenevix-Trench, *Major, R.E.*

REVUE MILITAIRE SUISSE.

No. 12.—*December*, 1920.

The Training of the Recruit and Physical Development.—The original article is contributed by Professor E. Hartmann, who is of opinion that the best means for ensuring the proper physical development of the recruit would be by making physical exercises a part of the general course of instruction of the youth of a nation, in the same way that the intellectual and the moral development of young people is now made to form part of the educational system in Switzerland. The subject is dealt with under five heads: (1) physical training in primary schools (from the age of 7 to 13); (2) physical training in secondary schools (from the age of 13 to 16); (3) physical training from the age of 16 to 20; (4) stricter examination of the recruit's physical condition; and (5) the posting of recruits to the several arms on the basis of their physical development. In Switzerland, gymnastic instruction must, at the present time, be provided under the provisions of a law of November, 1909, in public and private institutions for all students during the whole period of instruction given them. But apparently no system of inspection has yet been inaugurated to ensure that the Federal Law on the subject is being complied with.

Piecemeal Strategy.—Colonel Feyler deals, in the original article, with General Sarrail's campaign in Macedonia. As an introduction to the subject, he reviews very briefly Napoleon's campaigns of Austerlitz (1805), Jena (1806) and Friedland (1807), to provide a comparison with the conditions under which General Sarrail had to carry on from 1915 to 1918. During the three years, 1805–1807, the main feature of the military effort consisted in the concentration of forces on the part of France, in contrast with the strategy "des petits paquets" of the Allies opposed to her. Colonel Feyler indicates that when General

Sarrail retreated on Salonica in 1915 the Germano-Bulgarian forces possessed an incontestable superiority, which should have enabled them to clinch matters by a march southwards, but political motives reduced these forces to inaction. The Allies resorted to a strategy "des petits paquets," and only after the elapse of three years reaped an advantage from the mistake made by the Germans in not following up General Sarrail. Colonel Feyler points out that there is no hard and fast rule which lays down that theoretical principles are never to be departed from. On the contrary, the teaching of history is that science is not everything, but that art often plays an important rôle in the decisions of a military commander, who can appreciate when it is wise to break from rules. For instance, the Russians were justified, in the circumstances that existed, in taking the risks which they took in 1914 in moving before their mobilization was complete. The Russian defeats at Tannenberg and the Masurian Lakes were not due to numerical inferiority, but to faulty leadership. Victory does not depend upon the maximum of concentration *possible*, but on the minimum of concentration *necessary*. As a general rule, a strategy "des petits paquets" is a mistake; it exposes the side which resorts to it to defeat, not only by an opponent who concentrates the whole of his forces, but also by one who appreciates what minimum of concentration will give him a superiority over his foe.

New Swiss Training Manual.—Colonel Foujallaz discusses, in the original article, the plan to be adopted for training troops for the battle. He points out that "standard attack formations" possess the disadvantage of creating preconceived ideas in relation to the general course of a battle, of giving, so to speak, a recipe strictly to be followed, leading to the belief that one's adversary will adopt that course which is expected of him. A training based on "standard formations" results in the adoption of faulty battle plans, which are too cramped to meet practical needs.

NOTES AND NEWS.—*France.*—In a contribution from a special correspondent is discussed the question of the forces which contribute to the prosperity of a nation. It is held that a nation lives by the external influences it is able to exert as well as by its internal activities and the trading within its borders. The prestige which Germany enjoyed throughout the world up to 1914 was due to the victories of her armies in 1866 and 1870. In defeating Germany in 1918, the Allies have destroyed pro-German influences. The course of events has proved the superiority of the French doctrines; and it is expected that in future a larger number of foreign military officers will study French military matters, and also that the demand for French instructors for foreign armies will increase. There are already in Paris 450 foreign officers, who are making a study of the French Army and its methods; in addition there are military attachés from 25 Armies, many of which are represented by two or more officers, *e.g.*, U.S.A. by 9, Roumania by 4, Great Britain, Italy, and Serbia by 3 each, etc.

W. A. J. O'MEARA.

PROBLEM.

PROBLEM 24 (Solution).

A MAN has 121 francs and 70 half-crowns, reckoning 25 francs as equal to £1, find the number of ways in which the man can pay 1/3 of the money in his possession. What is the smallest number of coins with which he can make the payment?

1/3 of total sum = 453/5 shillings.

Let x be number of half-crowns, y number of francs, with which 1/3 of sum can be paid, then

$$\frac{5x}{2} + \frac{4y}{5} = \frac{453}{5},$$

That is $$25x + 8y = 906.$$

Now $x = 1$ $y = 3$ is a positive integral solution of $25x - 8y = 1$.

Hence $$x = 906 - 8\,M \quad y = 25\,M - 2718$$

is an integral solution of $25x + 8y = 906$.

For the solution to be positive as well as integral

8 M must be less than 906

and 25 M must be greater than 2718.

Hence M must range from 109 to 113 inclusive.

Hence the only possible values of x and y are (34 . 7) (26 . 32) (18 . 57) (10 . 32) (2 . 107).

That is to say there are 5 ways, and the smallest number of coins is 41.

The following is the solution sent by Captain F. Buero, Royal (Spanish) Engineers :—

25 francs = £1 whence 1 franc = .8s.

The man has .8 × 121 + 2 . 5 × 70 = 271 . 8s = 3 times 90 . 6s.

The payment will be .8 × f + 2 . 5 × s = 90 . 6.

The two last figures of 2 . 5 × s, are : 2 . 5, 7 . 5, 5 . 0, or 0 . 0, whence the two last ones of . 8 × f = 90 . 6 − 2 . 5 × s will be 8 . 1, 3 . 1, 5 . 6, or 0 . 6.

As .8 × f is a multiple of . 8, the last two digits will be 5 . 6.

Therefore $$.8 \times f = 10 \times n + 5.6$$

or $$f = \frac{10 \times n}{.8} + \frac{5.6}{.8} = \frac{100 \times n}{8} + 7 = \frac{4 \times 25 \times n}{4 \times 2} + 7 = \frac{25 \times n}{2} + 7.$$

f and $\frac{25 \times n}{2}$ must be integer numbers, and n an even one consequently.

Besides this, $$\frac{100 \times n}{8} = \frac{25 \times n}{2} = f - 7 = 121 - 7 = 114,$$

and $$n = \frac{2 \times 114}{25} = 9.12.$$

n	f	s	No. of Coins.
0	7	34	41
2	32	26	58
4	57	18	75
6	82	10	92
8	107	2	109

Therefore n must be an even number no greater than 10 ; it can be 0, 2, 4, 6, and 8, and we have the 5 following solutions.

The smallest number of coins is 41 . given by the first solution.

J. M. WADE, *Lt.-Col.*

R.E. INSTITUTE.

As a result of the great increase in cost of labour and materials, it has been found necessary to raise the subscriptions of Members, and this will take effect from 1st January, 1921, subject to approval by the next Corps Meeting.

The rates of subscription will then be as under:—

General Officers, Colonels, and Lt.-Colonels	£2	0	0
Majors	1	15	0
Captains	1	10	0
Lieutenants, 2nd Lieutenants, and Quartermasters ...	1	5	0

The subscription for Associate Members will remain as before.

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R.E. Journal	£1	5	0
Supplement		5	0
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Or, if all three be taken, £1 10 0.

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