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THE INSTITUTION OF ROYAL ENGINEERS.

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EXPERIENCES AT FOURTH ARMY HEADQUARTERS

ORGANIZATION AND WORK OF THE R.E.

By MAJOR-GENERAL SIR REGINALD U. H. BUCKLAND, K.C.M.G., C.B.

(*With 2 Maps.*)

IT is probable that the experiences of the Chief Engineer at the Headquarters of one Army on the Western Front during the Great War were much the same as those of the C.E. of any other of those Armies, so it seems fit that one of them should publish a record of such R.E. work as was done in Corps and in back areas, as came under his personal observation.

The position of the C.E. of an Army was peculiar, in that he himself could do nothing beyond trying to make smooth the path of others. He was therefore in a particularly favourable position to appreciate the good work they did. The real hard work was done by the C.E. of Corps, and the O.C. of the E. and M. Coy. of the Army. As regards staff, the E. in C. having provided a very capable Staff Officer, and equally good officers for Stores, Water Supply, and, later, for Bridging, it was necessary only to keep them informed as far as possible of what was likely to happen in the near future, to give them their heads, and afford such moral support as would prevent them from being interfered with in carrying out their duties.

At Fourth Army Headquarters things were made particularly easy for the C.E., in that the Army Commander had exact knowledge of what the R.E. could, or could not, do, and was always sympathetic and encouraging in times of stress. His Staff were the same. A quite remarkable Camp Commandant took all the R.E. work at A.H.Q. off my hands from the very start, and dealt direct with the O.C. of any detachment, or complete unit of R.E., that was placed at his disposal. The various moves of Army H.Q. were accomplished almost without my knowledge, although on each occasion a great deal of R.E. work was done.

In compiling these notes I have had the advantage of being able to refer to the old diaries at Audit House (thanks to the kindness of Brig.-Gen. J. E. Edmonds), and have had at hand complete copies of the reports of the Water Supply and Bridging Officers. To avoid repetition of detail, references are made in footnotes to the volumes on *Water Supply—France* and *Bridging*, published

by the Council of the Institution of R.E. Finally, with regard to the period 8th August to 11th November, 1918, I have frequently referred to Maj.-Gen. Sir A. A. Montgomery's *The Story of the Fourth Army*, a book with which every officer who is studying strategy and tactics is likely to be familiar.

FORMATION OF THE FOURTH ARMY, 5TH FEBRUARY, 1916.

The Fourth Army was formed at Tilques, 3 miles N.W. of St. Omer, on the 5th February, 1916, under the command of General Sir Henry Rawlinson. The senior officers of his staff were: Maj.-Gen. A. A. Montgomery,* M.G.G.S.; Maj.-Gen. H. Sutton, D.A. and Q.M.G.; Maj.-Gen. N. Birch, G.O.C.R.A.; and myself* C.E. Maj.-Gen. M. W. O'Keefe was D.D.M.S., Col. R. G. Earle, R.E., Chief Signal Officer, Col. V. Vivian,* Intelligence, and Maj. E. A. Parker,* Camp Commandant. In May, Maj.-Gen. C. E. D. Budworth* took the place of Birch, who went to G.H.Q., and, in November, Maj.-Gen. H. C. Holman replaced Sutton, who went to Mesopotamia. No further change took place before the end of the war.

THE SOMME, 1916.

(See Map A.)

Late in February, A.H.Q. moved to Querrieu; 7 miles N.E. of Amiens, on the main road to Albert, and took over a large area from the Third Army. The front extended from Fargny Wood on the Somme, S. of Mericourt, northwards to Hebuterne, some 15 miles in a straight line, the French being on our right, and the Third Army on our left.

At first we had only the XIII and X Corps, but when the attack took place on the 1st July, we had, from right to left:

Corps.	*Commanding.*	*C.E.*
XIII	Lt.-Gen. W. Congreve.	Brig.-Gen. S. H. Powell, later Brig.-Gen. E. P. Brooker.
XV	Lt.-Gen. H. Horne.	Brig.-Gen. P. G. Grant.
III	Lt.-Gen. W. Pulteney.	Brig.-Gen. A. L. Schreiber.
X	Lt.-Gen. Sir T. Morland.	Brig.-Gen. J. A. S. Tulloch.
VIII	Lt.-Gen. Sir A. Hunter-Weston.	Brig.-Gen. G. S. Cartwright.

1st, 3rd, British, and 2nd Indian, Cavalry Divisions.

On the 15th August, the XIV Corps (Lt.-Gen. Lord Cavan, Brig.-Gen. C. S. Wilson, C.E.) relieved the XIII Corps, and on the 1st November the 1st A.N.Z.A.C. (Lt.-Gen. Sir W. Birdwood, Brig.-Gen. A. C. de L. Lotbinière, C.E.) replaced the XV Corps.

Three R.E. Parks were available for the supply of stores and material: No. 6 (Capt. C. K. Honeywill) at Mericourt l'Abbé,

* These officers had previously served under Gen. Sir Henry Rawlinson in the IV Corps.

No. 7 (Capt. W. White) at Acheux,* and a third at Mondicourt, the last of which we shared with the Third Army. All the water supply stores were concentrated at No. 6 Park, and were issued only on the authority of the C.E. Army, and this rule applied also to a few other stores of which there was a scarcity.

The first few weeks were passed in the usual routine of trench warfare, during which a vast programme of mining, taken over from the Third Army, was carried on. Lt.-Col. F. Preedy, the Controller of Mines, lived with one of his companies at Ribemont, and every Friday evening came in with his maps to A.H.Q., and together we went to see the Army Commander, whose grasp of the various systems of mines, and the possibilities they offered, together with his appreciation of the difficulties of the work, was remarkable. Preedy had also to keep the Corps Commanders acquainted with what was going on in their areas, arranging with their staffs for what assistance he required. This was a comprehensive task to carry out, but so well was it done that unnecessary blowing of mines (somewhat common in the early days of mining) was avoided, and full use of them made when our attack was launched on the 1st July.

In the meantime, the E. in C. had provided me with a staff — Maj. E. E. B. Mackintosh, Staff Officer; Lt. G. H. Hargreaves, Stores Officer; and Maj. H. S. Rogers for Water Supply, assisted by Lts. B. M. Owen, S. Gill, and J.O. Baird. Lt. F. R. Durham joined Maj. Rogers on 17th May, but left on 22nd June to be Water Officer to the C.E. XIII Corps.†

Period of Preparation.

The first matter of importance to be taken in hand was Water Supply, not only the improvement of existing arrangements, but preparing for a large increase of troops in the near future. The difficulty was to extract from Q. some idea of what the numbers would be, and where they would be located. He passed on to me all the information he got from G.H.Q. as soon as it arrived, but what a C.E. wants to find in Q. are the qualifications of an Old Testament prophet! The trouble was greatest in the back areas, as all the A.T. Coys. were with Corps, and fully employed forward. The arrival of cavalry divisions just previous to the attack was worst of all, they always seemed to select new and unexpected billeting areas, and their requirements of water were enormous. Luckily their field squadrons were accustomed to that sort of life, and, so long as we could supply stores, they managed to supplement satis-

* They were shelled out of Acheux during the first week of July, and moved to Lealvilliers.

† On their withdrawal from our army he joined the XIV Corps in a similar capacity, and finally, on 22nd February, 1917, took the place of Maj. Rogers at A.H.Q.

factorily anything that we had been able to prepare. A depot of pumps was established in a field near Ribemont, and a number of Merryweather steam and petrol fire-engines got up from the base, of which Capt. E. Hamilton Gordon (of the London Fire Brigade, and a member of Rogers' growing staff) took charge. They had the great advantage of mobility and volume of discharge, but owing to their small boiler capacity required highly skilled engine drivers, of whom we had not a great number. A small shop for the repair of pumps was started at Varennes, near Acheux,* and from this nucleus 353 E. and M. Coy. was eventually formed at Albert in November, under Maj. B. M. Owen. At the same time Capt. S. Gill started work with the boring plants, which he had been to England to bring out.

Maj. Rogers got busy at once to work out a scheme of Water Supply to be developed during the forthcoming attack. The main idea, as evolved by Col. W. Liddell at G.H.Q., to whose foresight we owed so much, was to establish pumps beforehand on existing sources as far forward as possible, and after the attack to lay 4 in. mains on the surface to selected points in the territory gained, and erect watering points there as soon as the ground was sufficiently safe to permit of the crowding which a water point always causes. Special attention was paid to the rapid filling of water-bottles: for this Rogers devised a fitting, which he afterwards improved.

One of the best water schemes prepared before the advance was at Suzanne. From springs here water was piped to Carnoy and Talus Boisé through separate 4 in. mains, but in practice neither of them was an entire success. The pipe for the former, a quick-laying flange-jointed pipe, was afterwards condemned as unsuitable, and the latter was laid too quickly by an eager A.T. Coy., with the result that the joints leaked badly. As it was in a trench 6 ft. to 8 ft. deep, with signal cables on the top of it, repairs were difficult, but water was got through both mains before the 1st July, and the excellence of the scheme was fully proved. The Talus Boisé main was relaid later during a lull in the fighting.

In June, the First Water Column† arrived from G.H.Q. This was regarded as a Q. unit, but as we had to erect the water points at which it filled, and those to which it had to carry water, it practically functioned under the orders of Rogers. On the Somme there were Barge Purification plants‡, and of these he secured complete control. A short time before the attack, Rogers got a comprehensive *Memorandum on Advanced Water Supplies*§, with map, which was issued by Q. throughout the Army, and proved most useful during the fighting.

* Personnel from the London and Tyne, E. and M. Coy.

† See *Water Supply—France*, page 62.

‡ See *Water Supply—France*, page 16.

§ Quoted extensively in *Water Supply—France*, page 57.

It did not seem likely that the intended operations would call for heavy bridging on a large scale, but a memorandum pointing out what might have to be done, and giving a statement of the material available, was issued to Corps. Three Inglis bridges were got up to the R.E. Parks, and No. 3 (horsed) and No. 4 (mechanical) Pontoon Parks joined the Army. There was also a Barge Bridging Unit on the Somme at Corbie, but it was not used.

To turn to the subject of Roads, which came in July to form our most serious problem. When Fourth Army H.Q. moved into the Somme area in February, the roads were under an Anglo-French "Sous-Commission d'Armée du réseau routier," of which Lt.-Col. Pierret, *Ingénieur en chef des Ponts et Chaussées*, Amiens, and the C.E. Fourth Army were members, and Capt. H. H. S. O'Brien, Northamptonshire Regt., attached to the C.E.'s staff, member and joint secretary. I never fully made out the whole area over which Col. Pierret was responsible for the roads, but it extended far beyond our boundaries, and he had only one assistant, M. Magnier. At all times he did his utmost to help, and our relations were of the very best, but he had a most difficult task. To define responsibility for the repair of roads in our area, a yellow line, running approximately through Corps H.Q., was drawn on a map, in front of which Corps did the necessary work, and in rear of it the Army, i.e. the *Sous Commission d'Armée*. Each Corps had two companies of an Infantry Labour Battalion, whilst the *Sous Commission* had 1 Infantry, 2 Coys. of an R.E. Labour Battalion, and 2 Coys. of French *Cantonniers*. Stone was supplied by the *Commission Centrale d'Armée* at G.H.Q., of which Col. Liddell was a member, but the supply was always below our requirements in spite of all Liddell's efforts on our behalf. Much of it came from the Channel Islands until ships were no longer available to bring it over, and later from the Marquise quarries near Boulogne.

The French roads were so well made that at first they stood the traffic reasonably well, but as soon as the advance began, and shelled roads had to bear intensive traffic, they naturally failed. It was a continual problem of getting stone up to a railhead at which it could be off-loaded without holding up Q.'s work (food and ammunition), securing transport to take it where it was badly wanted, and getting a working party from a resting (and consequently tired) division, to lay it on a road congested with traffic. On one occasion I saw a man stooping down to spread stone between the feet of a team of horses whilst traffic was at a standstill, but as a rule congestion of traffic meant cessation of work. The formation of a large station yards, such as those at Heilly, Acheux, Contay, and Belle Eglise,* swallowed up a lot of stone: at Maricourt Plateau we had in the end to lay down sleepers.

* Belle Eglise not shown on the map.

An enormous amount of R.E. stores and material were received during the last weeks of June, and every demand was urgent. At the very end of the month a train of 50 trucks arrived at No. 6 Park, Mericourt, at the inconvenient hour of 9.30 p.m., and the R.T.O. asked that it should be off-loaded at once, as the trucks were urgently wanted at the Base to refill. Honeywill, whom nothing daunted, dashed off to Ribemont and got the O.C. of a Cyclist Battalion, who found the daily working party, to turn out 60 men. By 10 p.m. they were at the Park, and worked till 6 a.m., singing whilst they off-loaded and sorted 600 tons of stores. Not a bad effort!

THE ATTACK OF THE 1ST JULY, 1916.

The attack took place in the early morning of the 1st July, after several days' preliminary bombardment: its success on our right and failure on our left are well known, and need not be referred to here. On the 4th July, Gen. Sir Hubert Gough, commanding the Reserve Army (which at the moment consisted of the II Corps only), took over the northern part of our area, together with the VIII and X Corps, but for a short space we continued to look after their water supply and roads, as Maj. Gen. R. Lee, the C.E., had not yet had time to acquire a staff.† Lt.-Col. Preedy became C. of M. for both areas, but moved over to Acheux in the Reserve Army area, as on the right we had overrun the mining area, and the Tunnelling Coys. were employed on roads and dug-outs.

One remarkable piece of work was done in the III Corps. General Pulteney asked that Canadian lumberers might be sent up to improve the communications in Mametz Wood. On the 21st July, a party of 300 arrived, and in a few days had cleared and corduroyed a wagon road right through it.

Our water scheme was only partially carried out, but a water point was established in Fricourt on the first day, and a main laid into the village on the tenth day. Our great trouble was the vulnerability of the 4 in. mains laid on, or just below, the surface, and the difficulty of replacing damaged lengths of piping. The advance was slow, but at every possible opportunity fresh sources of water supply were developed, and Maj. Rogers got out new schemes for distribution to areas in which troops were massed. Some very successful work was done at Carnoy, which before the 1st July had been fed by a main from springs at Suzanne. In September, these springs showed sings of failing, so they were supplemented by Somme water pumped up from a sterilizing barge on the Somme canal, through a main a mile long, crossing the river Somme by means of a road bridge built by the French. To obviate having to rely on the Suzanne water, bores were now sunk by Capt. Gill at Carnoy*,

† Water supply was not taken over by Capt. Briggs until the 22nd August.

* The pumps erected here having proved inadequate, the first air compressor plant was installed in their place, with excellent results.

and a 6 in. rising main laid to a large reservoir constructed at Montauban—afterwards extended, 4 in., to Guillemont. Later, when winter came on, we had hard work to get our mains buried before the frosts of a very severe winter set in. 465 A.T. Coy.† especially, made a great effort, and it was owing to their work that we were able to give water to the Reserve Army and to the Railways at Trones Wood.‡

At the end of July, we were finding it extremely difficult to provide engine-drivers to man the pumping stations, which had largely increased in numbers, and tried to get our rear stations taken over by the D. of W., but the E. in C. ruled against us, as the D. of W. had no personnel for the work. It is to be remembered that E. and M. Coys. had not yet been formed, and our engine-drivers were a scratch pack, collected by Rogers and the C.E. of Corps from many R.E. companies, Infantry, and A.S.C. The latter now asked to have their men back, but the Army Commander decided that they could not be spared until R.E. could be sent up from the Base to replace them.

During the fighting it had become evident that the C.E. of Corps had more work to do than they could satisfactorily carry out, and on the 2nd August I put up a letter to the D.A. and Q.M.G. asking that C.R.E.'s and Adjutants of R.E. Corps troops might be appointed, to relieve C.E.'s of much of their less important work. It was some time before anything came of the proposal, and possibly it had already been put forward by someone else, but the C.E.'s must have been thankful when these officers eventually arrived.

As this had been the first big scheme of water supply in an attack worked out by the R.E. in France, we had many visitors who came to see the result. Amongst them were Maj. Gen. Glubb, C.E. Second Army; Maj.-Gen. Kenyon, C.E. Third Army; Brig.-Gen. Tanner, C.E. VII Corps; Capt. Jarvis, Water Officer First Army; a G.S.O. of the French Army on our right; and, later, Capt. Picquard from Verdun.

The chief source of anxiety from the 1st July onwards was the deplorable state of the roads. Maj. P. E. Hodgson was appointed Roads Officer on the 14th September, and, having provided him with a telephone, I handed over to him everything connected with roads, stone, arrival of stone trains, personnel, transport, rollers, tools, water carts, and Prisoner of War companies. In spite of all Hodgson's efforts the same old troubles went on, and the diary for this period is a continuous record of complaints about stone trains not arriving, working parties going astray, etc., but the C.E.'s played the game

† Originally known as 1/1 Wilts A.T. Coy.

‡ Between Montauban and Guillemont.

so well that there was not a single instance of one Corps seizing stone destined for another. One day a D.A.A.G. at A.H.Q. carried off a party of 300 German prisoners working on the road at Dernancourt to dig graves and carry stretchers, but he did it by mistake and quickly put things right again. Everyone did what they could to help. Q. stirred up Q.'s of Corps, and the Army Commander impressed on Corps Commanders the necessity of concentrating on the most important roads, and letting the others slide. It was not that labour was deficient, the XIV Corps alone at this time had one R.E. and three Infantry Labour battalions, but the battalions were short of officers, and very few of the officers or men of the Infantry battalions knew anything about road-making. German prisoners were employed in the back areas, and worked well, but their employment necessitated guards and wired camps.

In September, the newly-invented Directorate of Transportation began to take shape, and, on the 7th, Sir Eric Geddes, accompanied by Sir Ernest Moir, paid his first visit to the Somme, and I was ordered to take them round. It was a great pleasure showing them our worst roads, and the stone sidings at the rail-heads, and they quickly realized the difficulties under which we were labouring. They saw that only companies of road-men, commanded by officers who had had experience of road work in civil life, could cope with such work, and that it would be necessary for them to have their own transport of a suitable pattern, and not to have to depend on what could be obtained from formations.

On the 2nd November, Lt.-Col. S. Stallard* was appointed Assistant Director of Roads, Fourth Army, and came to work with Hodgson, to gain experience, before taking over charge of the roads in our area, under the direct orders of the Roads Directorate, a sub-branch of the Transportation Directorate at G.H.Q. This he did on the 1st January, 1917, becoming a member of the *Sous Commission d'Armée* in my place, and O'Brien consequently came under his orders. Under the new arrangement Stallard was responsible for all the roads, and for making the new station yards in our area, up to what was called the "D.G.T. Line." This line was laid down, in the first instance, at G.H.Q., but was pushed forward by A.H.Q. as we advanced. It was supposed to represent the limit up to which work could be done in daylight, and, in front of this, Corps arranged that Divisions should make temporary repairs with such debris as they could find. Stallard had D.A.D.R.'s with each corps, who worked under his orders, and C.E.'s were able on urgent occasions to get a certain amount of road material through them.

At first Stallard's difficulties were the same as we had already experienced, and we had many a laugh together over them, but

* A Territorial officer of the K.R.R., Road Surveyor of Oxfordshire.

eventually, when the companies of road-makers came up, and more rollers, he succeeded in getting the roads into order. He stuck to the Fourth Army until the end, accompanying the final advance in a gipsy-van, which, it was said, he kept a tame steam-roller to pull along!

On the conclusion of active operations in November, 1916, our front had advanced to Lesboeufs—Gueudecourt—Le Sars, and on this line we settled down to a period of trench warfare for the rest of the winter. I had seen the original Nissen hut at Hesdin on the 4th August, and, on the 15th, the E. in C. had informed me of the number of these and other huts that would be available for the Fourth Army during the coming winter, but the uncertainty of the situation prevented Q. from fixing the back areas of Corps, and getting out definite schemes of hutting until very late in the autumn. Consequently it was a rush to get the troops housed before the winter, but material came up well, and additional M.F.W.'s were allotted to Corps.

In December, Mackintosh was invalided to England, and Maj. V. E. Purcell took his place for a few weeks, and then went to the XV Corps as S.O. to the C.E. Maj. T. T. Behrens was my S.O. for three months, but then became C.R.E. 24th Division, and was replaced by Maj. A. P. W. Wedd, who remained with me to the end. Maj. Rogers was transferred to the Third Army on 22nd February, 1917, as water supply was likely to be of great importance during operations contemplated in that area, and Maj. Durham rejoined me from XIV Corps in his place.

During this winter we started to cut timber in Allonville Wood, two miles W. of Querrieu, where Lt. R. H. Ellis, with a few sappers and a company of German prisoners, built and ran a very efficient saw-mill. From this we sent up daily a supply of sawn timber to Corps, but soon afterwards a Forestry Department was started at G.H.Q., and they absorbed this small establishment into their big undertaking.

Life at A.H.Q. was never monotonous: a visit one day to the British Camouflage establishment at Amiens, on another to see that of the French, a tour with Q. and an Ordnance officer round a French rail-head and transhipping depot, a two-days' visit to Glubb at Cassel, to see his wonderful workshops, and an occasional E. in C.'s conference at G.H.Q., all helped to make life pleasant, and the time passed very quickly.

1917. The German Retirement.

In March, 1917, the Germans retired, and we advanced to a line running from Holnon Wood, just W. of St. Quentin, on our right, through Hargicourt to N. of Epéhy. This brought us our first experience of heavy bridging on a large scale, as numerous

crossings over the Somme had to be provided at Péronne, Eterpigny, Brie, St. Christ, and south of that place, the most important being that at Brie, which was carried out by the C.E. III Corps, Lt. R. Stephens, 574 (Cornwall) A.T. Coy. being in technical charge of the erection.

The 23rd and 409 (Lowland) Field Coys. of the 1st Division (C.R.E., Lt.-Col. C. Russell-Brown), and a detachment of an A.T. Coy., were employed, and the material was sent up by rail to La Flaque, 9½ miles from the bridge site, and brought on from there by road. There were six gaps to bridge on the one causeway, and the demolition had been thoroughly done, so that the first difficulty was to get to work on the further gaps. The critical point was the formation of the abutments at the far end of, I think, the second gap, as this necessitated driving sheeting, not only under the bridge, but also along the up-stream side of the island, to prevent water from getting behind the abutment, whilst the river was running at about four knots. This work was carried out by an officer of the Lowland Field Coy., and as the time of completion (for which I had had to give an estimate to G.H.Q.) depended largely on his efforts, I watched him and his men at work with considerable interest. Russell-Brown celebrated the completion of these bridges with a dinner in his camp alongside the site, to which I was invited, and I read them a telegram, received at A.H.Q. that day, from the C. in C., congratulating them on their successful work.* Unfortunately at breakfast next morning at A.H.Q. I mentioned the armies of rats that I had seen, on my way home, crossing the main road from the old French trenches near Estrées—and never heard the end of it!

At the beginning of April, A.H.Q. moved † forward to Villers-Carbonnel, south of the main Amiens—St. Quentin road, and a mile W. of Brie, where a hutted camp had been prepared for us by the 465 A.T. Coy. (III Corps). Afterwards we always kept this company at A.H.Q., and they also worked in the back areas under the C.R.E. Army Troops. 353 E. and M. Coy. moved from Albert to a field at La Flaque, on the north side of the main road, S.W. of Proyart, and built their shops, which quickly developed into a most efficient institution. Owen salved machinery in all directions, got a brass foundry started, and was soon able to carry out all but the very largest of the repairs of our engines and pumps. Many of his men were scattered over the country at pumping stations, but his system of inspection by Military Mechanists and senior

* Copy of telegram: "G.H.Q. to Fourth Army. F4018. 3 Apl. I heartily congratulate the Royal Engineers of the Fourth Army on the result of their recent efforts in restoring communications under difficult circumstances. From Sir D. Haig."

† For an amusing account of this move see *Punch* of 2nd May, 1917, letter from "Watch-dog," an officer in Q. branch.

N.C.O.'s on motor bicycles, kept them up to the high standard of work that he required of all.

The Coastal Area, 1917.

(See Map C, *Water Supply—France.*)

Our stay at Villers-Carbonnel was not a long one, as early in July, A.H.Q. moved to Malo, a seaside resort two miles E. of Dunkerque, where we were comfortably housed, offices and all, in a huge hotel on the sea shore. On moonlight nights we felt that we were an obvious target for the enemy bombers, who frequently passed on their way to Dunkerque, but only on one occasion had they an "egg" to spare for us. The sole casualty was the Army Commander's orderly, who had carried his flag throughout the war, and previously in South Africa.

The troops on the coast were the XV Corps (Lt.-Gen. Sir J. Du Cane, Brig.-Gen. C. W. Singer, C.E.), and the 1st Division, the latter being under the direct orders of the Army Commander, and undergoing special training in camp at Le Clippon, W. of Dunkerque. We had taken north with us a detachment of the 353 E. and M. Coy., under Capt. B. H. Peter, and the 465 A.T. Coy.,* under Maj. Wilson, who later established shops at Adinkerke, and his unit was re-named the 4th Army Workshop Company.

The most important piece of engineering carried out in this area was a pipe line from Rosendael, near Dunkerque, to the outskirts of Nieuport, for which Durham got out the scheme and the XV Corps carried it out. The Belgian Water Company's main was tapped at Rosendael, where they delivered from 100,000 to 150,000 gallons a day. From here the water was pumped forward through a 4 in. main to a point near Bray Dunes, where a second set of pumps sent it through a coastal main to Doornpans, and an inland main to Oost Dunquerque, between which two places the two mains were connected again. This main was about 16 miles long, and is said to have been one of the longest laid by the B.E.F. on the Western Front.† To supplement the supply at Bray Dunes, 10 barges brought up daily 50,000 gallons of water from a Barge Sterilizing Unit on the canal at Bergues, S. of Dunkerque.

The Tunnelling Companies were employed chiefly in making subways in the ruins of Nieuport, and a detachment provided dug-outs on the piers at Dunkerque, which were much appreciated by Commander Lines, R.N., and the Naval Signallers, who had to live there.

Half of No. 4 Siege Coy., R.A.R.E., were sent to the Army to

* A rather remarkable company, containing a high percentage of skilled men, as the O.C. and many of the N.C.O.'s and sappers came from the G.W.R. works at Swindon.

† See *Water Supply—France*, page 78, where the peculiar difficulties of work in the Dunes are also mentioned.

prepare a barge bridge in one of the basins of Dunkerque Harbour, to a design got out at G.H.Q. by, I think, Lt. Collins, who came specially to superintend the work. In the event of a successful advance along the coast this bridge was to have been towed out in column of rafts by the Navy, to the mouth of the Yser, and a bridge for all loads formed there, but these operations never took place. At the same time the field companies of the 66th Division (C.R.E., Lt.-Col. G. C. Williams) were given a course of pontooning, as it was realized that they had had no practice at such work.

The river Yser was a continual source of anxiety at A.H.Q. The demand for material for light foot-bridges across it at Nieuport was never ending, as they were continually being shelled and broken. The most enduring bridge was made of cork floats, but this lay so low in the water that in rough weather the roadway was covered with foam, and men crossing were unable to see what they were stepping on. A man falling off the bridge had little chance of regaining the shore. Then there were the locks at Nieuport, of which one pair of gates had already been destroyed. Every possible precaution was taken by the C.E. Corps to protect the remaining pair, and though frequently damaged they were always repaired at once, as their destruction would have caused all our footbridges down stream of them to be washed away, the water level above would have been permanently lowered, and an entirely new tactical situation created. The whole question of inundations, both what actually existed and what might possibly be created by the enemy or ourselves, had to be considered, not only on our immediate front but also, by the Army Commander's order, at the Ostend end of the Bruges—Ostend canal. Lt. Brown was sent from G.H.Q. to help in this matter, and together we had interviews with Gen. Bihin at Belgian A.H.Q., Col. Conard and M. Alleys at La Panne, and Commandants Dupont and Thys of the Belgian Engineers. We also consulted Admiral Ronarc'h, who had commanded the French sailors during the earlier fighting on the Yser, and was at the moment in command at Dunkerque, but it was impossible to get the accurate figures necessary to predict the results of all the possible courses of action that might be taken by either side, and especially to calculate the time required for such action to produce its maximum effect. The most reliable information was that produced by Col. Liddell from G.H.Q., as he had long been studying the question, but to my great relief nothing had to be done whilst we were on the coast.

In the back area a big steam laundry was installed in an existing building at Coudekerque, after much consultation with Q. and his laundry expert, Capt. Barrett, E. Wilts. Yeomanry, and Capt. Hogarth, laundry expert from G.H.Q. Maj. A. J. Graeme, C.R.E. Army Troops, had charge of the work, which was done chiefly by

the 4th Army Workshop Coy. and the detachment 353 E. and M. Coy., but it was not completed before we quitted the coast.

On the 31st July, the Second* and Fifth† Armies had begun the operations which culminated in the long-drawn-out fighting at Paschendaele, our attack in the coastal area depending on their gaining possession of this plateau, which was never accomplished. In November, Gen. Sir H. Plumer and the Second Army staff were ordered to Italy, and the Fourth Army took their place at Cassel, the coastal area being handed over to the French. At the same time the Fifth Army, which had been on the left of the Second, moved off to our old area south of the Somme.

Fourth Army H.Q. had moved from Malo to Rosendael in October, and on the 6th November were sent to Dury, S. of Amiens, so it looks as if we had at that time been destined for the Somme, but anyhow we hurried north again, and arrived at Cassel on the 9th November, finding comfortable offices in the casino, whilst the Army Commander's mess was in a small house on the same hill. At first we were called Second Army by G.H.Q., but the old name of Fourth Army, to which we had so long been accustomed, gradually came back again.

The Ypres Salient, Nov. 1917—March 1918.

Our new area stretched from N. of Armentières to just S. of Dixmude, and the Corps in line were, from right to left, the Australians, IX, XXII, VIII, II, and XIX, with X Corps in reserve. The Canadian and XVIII Corps were also with us for a short time, but lay right back preparatory to joining other armies. Q. told me that at one time our ration strength was over a million men. As regards Army units, our detachment, 353 E. and M. Coy., rejoined its H.Q. on the Somme, and we took over the Second Army Workshop Coy. (Maj. Richardson), who had shops at Hazebrouck, Bailleul, and Abeele, their 354 E. and M. Coy. (Capt. H. H. Bateman) at Arques, and No. 2 R.E. Park at Strazeele; also the Fifth Army Workshop Coy. (Maj. S. H. Ash) at Peselhook, alongside No. 10 R.E. Park, and their 351 E. and M. Coy. (Maj. Levine) at Proven, later Ouderdam.

The Second Army handed over Lt.-Col. S. C. Babington, C.R.E. Army Troops, whose assistant, Capt. Stow, also ran a concrete factory at Arques (subsequently taken over by the D. of W.), and Maj. Lees, Tramways Officer; the Fifth Army gave us Maj. Rugg, Tramways Officer, and Lt. Campbell, assistant Water officer. Lt.-Col. A. G. Stevenson, C. of M. Second Army, went off to G.H.Q., and was replaced by Lt.-Col. F. Preedy, who became our C. of M.

* Gen. Sir H. Plumer commanding, Maj.-Gen. F. M. Glubb, C.E.

† Gen. Sir H. Gough commanding, Maj.-Gen. P. G. Grant, C.E.

South, whilst Lt.-Col. L. E. Hill joined us as C. of M. North. We also inherited Musketry Schools at Nubecourt and Lumbres, whose Commandants asked for a lot of work to be done, and, of course, G. (Training) supported them in their demands.

In a new area it always takes some time to find out how things are going, and to what extent Army units are giving C.E. of Corps the assistance they require, but here we had the added difficulty of merging two distinct army organizations into one, on a battlefield encumbered with derelict tanks, guns, and disused dumps of ammunition and R.E. stores, and on which some of the roads had become impassable. It was also to be borne in mind that some of our newly-acquired army units might be called away to rejoin their own armies. All this time fighting was still going on at Paschendaele, where every endeavour was being made to construct a road to bring up ammunition and food to the troops in the front line, and at the same time the housing of the troops had to be considered, as winter was close upon us.

In so large an area the question of supply being obviously of importance, the Army Commander spent two days, accompanied by Q. and myself, going round to all rail-heads in a special train, and as I had just had time to visit all the C.E. of Corps, and learn their requirements, I was able to get most of the workshop sites and railway sidings they wanted.

The taking over from C.E.'s of Armies had been very simple, full records of water supply systems and stores having been prepared, so that Durham, who now had Lt. P. Waterhouse as an assistant, and Hargreaves were able to get to work straight away. The question of water was settled at a single conference at Abeele, held in a frightfully cold, disused school. C.E. of Corps were directed to send their Water officers, and invited to attend themselves if they wished and could find time. As I expected, no C.E. was able to turn up, so Durham took the chair, and propounded his scheme, whilst I sat over the fire and smoked, taking no part in the proceedings, but ready to decide anything that caused disagreement, as most of the schemes involved the work of two or more Corps. These Officers were, however, all experienced at their jobs, so that not a single difficulty was raised, but the way the work was subsequently carried out always struck me as a fine instance of the loyalty of the C.E.'s to their subordinates, and to higher authority. One big scheme, which had been begun by the Second Army, was based on the water in the moat E. of Ypres, and another on Zillebeke lake.

About this time Lt.-Gen. Sir T. Morland, commanding the X Corps, reconnoitred rear lines of defence across the whole of our area, and the Army Commander saw to it that these did not remain mere coloured lines on a map. One day he took me with

him round the works between Hooge and Friezenberg, and the tunnelled dug-outs in Glencorse wood, walking through the sticky mud as if he liked it, and showing particularly good form over the old barbed wire entanglements, in which the A.D.C. and I got stuck. Frequently the M.G.G.S. came round,and on other days I went with the C.E.'s of Corps, and sent in a report to G., so that the Army Commander always knew how things were going on. Corps were responsible for work in their areas, and material was used as quickly as it could be brought up to where it was required. German "pill-boxes" had proved hard nuts to crack during the recent offensive, and similar works now sprang up rapidly on these new defences. There was a good deal of controversy over the designs, and as to whether reinforced concrete, or reinforced concrete blocks, should be used, one important consideration being which system left fewest marks on the surface for hostile aeroplanes to photograph. Another point discussed was the effect of concussion in a closed pill-box, and whether it would not be better to leave them open to the rear. I was taken by the E. in C. to visit the G.H.Q. manufactory of concrete blocks at Aire, but was not convinced of their suitability to our site. I never heard whether these positions were used during the fighting of the following year.

The Tunnelling Companies were employed on mined dug-outs for H.Q.'s of formations, and machine gun emplacements, standard patterns having been prepared by the C. of M. and issued to Corps by G.

On the 9th November, we saw the first of our new American Allies, when Col. Black, Maj. Goetwalls, and Capt. Wickenshaw, of the American Engineers, arrived on a four-days' visit, and they did not waste their time. Goetwalls spent one night with the search-lights, and Wickenshaw made a special study of stores. Their thirst for information kept us all pretty busy.

In February, 1917, Gen. Sir Henry Rawlinson was ordered to Versailles, and the command of the Fourth Army was taken over temporarily by Gen. Sir W. Birdwood, but in March, Gen. Sir H. Plumer and his staff returned from Italy, and the old Fourth Army staff were withdrawn from Cassel, preparatory to being drafted to other appointments. Wedd and Hargreaves were taken over by the C.E. Second Army, as Staff Officer and Stores Officer respectively.

This state of things did not last long, as after the German advance on the Somme, Gen. Sir Henry Rawlinson was appointed to the command of the Fifth Army at Dury, three miles S. of Amiens, where all his old staff rushed to rejoin him. The taking over in this area was carried out on the 28th March. Shortly afterwards Sir H. Rawlinson's command became the Fourth Army.

THE SOMME, 1918, DEFENCE.

(See Map A.)

All my own staff turned up again on the 1st April, except Waterhouse, who remained with the C.E. Second Army. Lt. Allen joined as Inundations Officer, as the question of flooding the valley of the Somme, in case of further retirement, had to be considered, and it was possible that a dam at Camon, upstream of Amiens, might be destroyed by shell fire.

The tactical situation on Gen. Sir Henry Rawlinson's arrival, and during the subsequent four weeks, was of such a critical nature that it is worth while to narrate events in some detail. (See Map B.)

On the morning of the 29th March, our line, a very fluid one, ran from Moreuil on the right, which village was in the French area, E. of Moreuil Wood, E. of Demuin, Marcelcave, Tailloux Wood and Hamel, to the Somme, which was then the boundary of the Third Army (Gen. Sir J. Byng, commanding, Maj.-Gen. W. Liddell, C.E.).

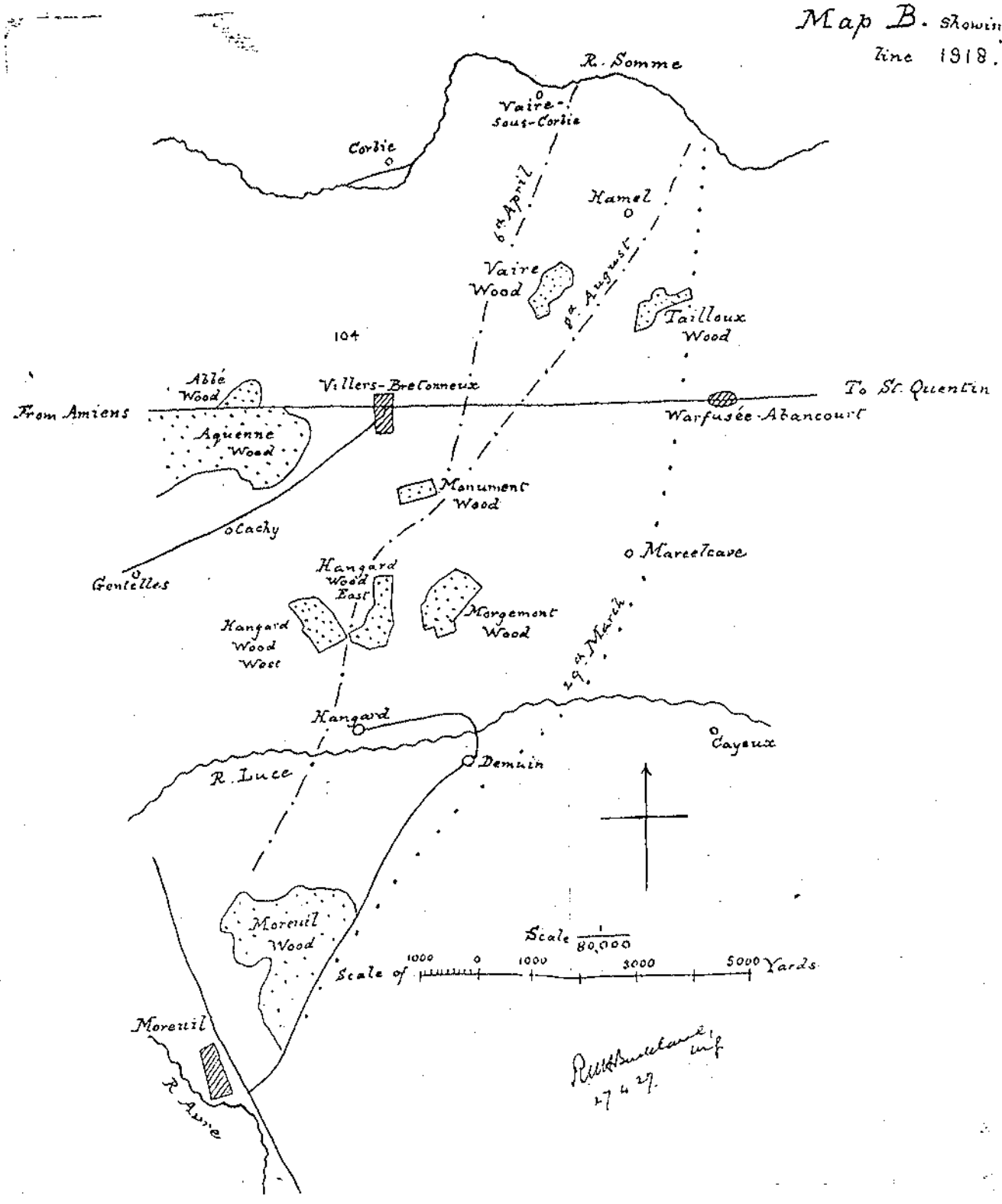
Our front was held at the XIX Corps (Lt.-Gen. H. E. Watts, Brig.-Gen. A. G. Bremner, C.E.) with nine exhausted divisions, Carey's Force,* and the 1st Cavalry Division. These were reinforced that day by the 2nd and 3rd Cavalry Divisions, and the 9th Australian Brigade. The Germans attacked again on the 4th and 5th April towards Villers-Bretonneux, with the result that our line was pushed still further back, and by the 6th April ran W. of Hangard, and Hangard Wood East, E. of Monument Wood, and Villers-Bretonneux, and W. of Vaire Wood and Hamel. Four more Australian brigades arrived as reinforcements during the battle, and the German advance was stopped by them and the 3rd Cavalry Division. The III Corps H.Q. then relieved the XIX Corps H.Q., who went back to Pont Remy to refit.

On April 7th, the Australian Corps, less their 1st Division,† were transferred from the Third to the Fourth Army, and the Fourth Army front was extended northwards to Aveluy Wood, near Albert. The III Corps, under whom were placed temporarily four Australian Brigades, held from Hangard (exclusive) to the Somme, the Australian Corps from the Somme to Aveluy Wood. The Cavalry Corps, XIX, and XVIII Corps were in Army Reserve, but the two latter corps contained only very exhausted divisions, most of which soon went to other armies, as also did the Corps H.Q.

* Among the numerous and varied units which comprised Carey's Force were 353 E. and M. Coy., 144, 213, 216, and 217 A.T. Coys., 253 Tunnelling Coy., 4th Army Workshop Coy., Fifth Army Field Survey Coy., and two Coys. 6th Bn. U.S. Engineers, collected by Maj.-Gen. P. G. Grant, C.E. Fifth Army, during the retreat. (The 4th Army Workshop Coy. had joined the Fifth Army when we left the coastal area.)

† The 1st Australian Division did not join its Corps until the first week in August, having been kept in the north, fighting in the Second Army-area.

Map B. Showing approximate front line 1918.



On the 20th April the Australian Corps took over from the III Corps as far south as Hill 104, N.W. of Villers-Bretonneux, the III Corps holding the front thence to Hangard with the 8th and 58th Division, with the 18th Division in reserve.

On the 24th, the Germans made one more attempt to reach Amiens, and four of their divisions attacked between Hill 104 and the Luce, supported by 14 tanks, and assisted by demonstrations on each flank. Villers-Bretonneux and Hangard were lost, and the enemy reached the Bois d'Aquenne. The situation for twelve hours was very critical as the enemy were almost in behind Hill 104, and from that high ground and from Villers-Bretonneux the whole valley of the Somme could be commanded as far as Amiens, and part of the valley of the Hallue. A brilliant counter-attack by the 13th and 15th Australian brigades, the 54th brigade (18th Division), and two battalions of the 8th Division—on which division the brunt of the attack had fallen—was carried out at 10 p.m. the same evening, and met with immediate success. Villers-Bretonneux was recaptured, 800 prisoners taken, and the situation was restored. The French, against Gen. Sir Henry Rawlinson's advice, postponed their attack on Hangard till the next morning, when it failed with severe losses.

After a short rest, during which the Australian Corps held the whole Fourth Army front, the III Corps came into the line again between Aveluy Wood and the Ancre near Dernancourt, while the Australian Corps held from the Ancre to Monument Wood (exclusive) just S. of Villers-Bretonneux. In this somewhat uncomfortable position, with very little depth of defence, our line remained for many weeks, but before the great advance in August took place, the Australians had improved the line considerably as the result of minor enterprises.

After a very short stay at Dury, Fourth Army H.Q. moved to Flixecourt, 12 miles W. of Amiens, taking over there the comfortable quarters of the Fourth Army School, for which we had to build a hutted camp at Ault, somewhere miles away by the sea. The 4th Army Workshop Coy. took on all the R.E. work at A.H.Q. and at the schools in the back areas, pending the erection of workshops, but as the situation was never sufficiently settled to render this possible, they were sent temporarily to the L. of C. at Abancourt, and their place at A.H.Q. was taken by 213 A.T. Coy., under Capt. C. Bisley.

From the Fifth Army we took over 135, 239, 281, 283, 284, 288, 567 and 568 A.T. Coys., Nos. 1 and 4 Siege Coys., R.A.R.E., 172, 173, 182 and 258 Tunnelling Coys., and No. 6 Foreways Coy., who were distributed to Corps; also 144, 213, 216 and 217 A.T. Coys., 253 Tunnelling Coy., 353 E. and M. Coy., No. 3 Boring Section, and Nos. 6 and 12 R.E. Parks, who came under the orders of the C.E.

Army. The Australian Corps, on their arrival, had 146, 221, 238 and 574 A.T. Coys., and 177, 178, 180 and the 2nd Australian, Coys.

The R.E. units with Carey's Force were assembled at Picquigny and La Chaussée Belloy, W. of Amiens, to refit, but soon returned to work on bridging, 353 E. and M. Coy. at Cagny, 216 A. T. Coy. at Boves, the U.S. Engineers at Camon, 144 A.T. Coy. at Vecquemont, whilst 217 A.T. Coy. went to fix up the huge R.A. Reforming Camp,* at Poix, S.W. of Amiens. Three Labour Coys. arrived, and each was sent to help an R.E. Coy. at bridging, but they were taken later by Q. to work under the A.D. Roads.

Our first work was to improve the communications over the Somme E. of Amiens, and the Ancre, also, in case of retreat, across the Avre, and the Somme W. of Amiens. Brig.-Gen. C. Armstrong, of the Canadian Engineers (formerly C.R.E. 1st Canadian Division) took charge of this work, with 353 E. and M. Coy. (relieved later by 239 A.T. Coy.), 216 and 574 A.T. Coys., and two Coys. 6th Bn. U.S. Engineers, under Lt.-Col. Hodges. Capt. Hopkins came down from G.H.Q. to help, and to arrange for sending up bridges from the Base. There was no delay: 45 truck-loads arrived on the 10th April at Longeau, a suburb on the E. side of Amiens, near the junction of the Somme and the Avre, and more than half the contents were issued from railhead on the same day.

The programme included duplicating existing bridges at Corbie, Longeau, and Boves, triplicating those at Daours, and making new crossings at Blangy-Tronville, Glisy, Cagny (two), Fort Manoir farm† (two), and N. of Boves (two). Owing to the width of the valley of the Somme, plank road approaches 700 yards long had to be made across the marshes at Glisy and Blangy-Tronville, also for the bridges near Boves. At Blangy-Tronville we erected our first Inglis bridge (84 ft.), and quickly learning to appreciate its merits, replaced it by a pile bridge, and at once re-erected it at Daours. Our work was much facilitated by the careful loading of the trains at the Base, and the good liaison between Base and the erecting unit. The organization at railhead, and at the depot, was very good, and included getting off-loading parties and transport, and ensuring that every convoy went to its correct destination, and did not block the traffic on arriving there. There is a great deal in bridging besides erection: the unit employed will see to that part of the work.

For the bridges W. of Amiens a small depot was formed at Argoeuves, just W. of that city, and manned, first by the 239 A.T. Coy., and later, when they were sent to the III Corps, by the two

* Specially formed for reorganizing and re-equipping the batteries that had been involved in the March retreat.

† Between Cagny and Boves.

Coys. U.S. Engineers. Their D Coy. had a nasty accident at Hangest, when erecting an 85 ft. Hopkins bridge on a site close to the railway. The back guys of the launching derrick were carried across the railway line sufficiently high to allow trains to pass underneath, and four trains passed all right. One truck of the following train had been carelessly loaded, and a projecting piece of timber struck the temporary supports of the guys, which consequently fell on the train. Much damage was done to our tackle, and launching delayed 24 hours, but not content with this the Railway branch of Transportation at G.H.Q. attacked me, and tried to lay on me the blame for the delay caused to their traffic. It took some time and correspondence to convince them that the fault was theirs.

Armstrong left us in May, and his place was taken by Capt. E. O. Pearce, who stayed with us to the end, and was responsible for all heavy bridging during the final advance. 353 E. and M. Coy. was withdrawn from bridging at the end of April, and set up temporary shops at Ailly-le-Haut-Clocher, 18 miles W. of Amiens.* Capt. E. G. Cohen, formerly 23rd Field Coy., came from R.E. Instructor, Fourth Army School, to take charge of stores in the place of Hargreaves, whose considerable experience in this line was placed at the disposal of American G.H.Q.

During the first few weeks the possibility of another big German push against Amiens, the junction of the French and British armies, was never lost sight of, and whilst the lock gates of the town were being protected from shell fire by a detachment of the I.W.T., under Capt. Gibson, the Tunnelling Companies prepared them, and all the bridges in the neighbourhood, for demolition. Maps and sketch plans of each charge were sent in to G., who undertook the responsibility of their being blown up in time, if the course of events necessitated it.

In the meanwhile rear defences went on gaily. G.H.Q. laid out lines to be generally superintended by the G.O.C. XIX Corps, who lay somewhere back in reserve, but we were responsible for the portion in our area, and Lt.-Col. W. Garforth took charge of our sector with such labour as we could get for him. Some of it was Chinese, who worked well except for their numerous holidays. A detachment of the Ports Construction Coy., under Maj. Macdonald, constructed concrete pill-boxes for him in the low-lying meadows near Argoeuves, and the 3rd Field Squadron, under Maj. Carsons, also worked on these defences. G.H.Q. carried off three of our A.T. Coys. to work on sectors outside our area.

A switch line, from near St. Gratien to Longeau, protecting Amiens from the N.E., was undertaken by the 10th French Army.† Among

* No suitable place could be found nearer the front, as we were all cramped for room.

† This army was in reserve on our right.

those whom I had to see about this matter were, Col. Hergot, Chief of the Staff, and Col. Soeur, C.E. 10th Army, the C.E. XX Corps, and Commandant Tartarin, *Commandant du génie 153rd Division*, and several of their staff officers. Eventually a company of engineers and a battalion of infantry were sent, and, later, a battalion of pioneers, but progress was slow, which was awkward for me, as our Army Commander was very keen to get the work done. It was noticed that they usually put up the wire of an entanglement before digging the trench which it was to protect.

All our dealings with the French were most satisfactory, and there was never any difficulty about handing over, or taking over, stores. On one occasion, in July 1918, I had to hand over to Col. Lesage, C.E. 1st French Army, several back lines of defences. We met at some small village, I showed him a bundle of plans, and said that I had much pleasure in handing over to him a large portion of France, which we had very greatly improved. His reply was, "Mon général, je l'accepte avec beaucoup de plaisir," and the interview was over.

The first offensive operation undertaken by our army resulted in the capture of Hamel by the Australians on the 4th July. This day, the anniversary of the American Independence Day, had been fixed for the Army Commander to present decorations and medals to certain officers and men of 12th Regiment of U.S. Railway Engineers, who were in camp in our back area preparatory to going off to join their own Army in the south. As our Army Commander could not be away from H.Q. during the fight, he sent me, with the acting Military Secretary, to represent him. After inspection of the Regiment, and presentation of the decorations, customary procedure required that I, as senior officer present, should take command of the parade to salute "Old Glory," the American national flag, an officer being detailed to prompt me in the necessary words of command. After that, March Past, speech, and home to A.H.Q. to hear the successful result of the morning's fight.

I had a similar excursion on the 7th July, when I was sent down to Senlis, 50 miles S. of Amiens, to present military crosses and medals to the 5th Company 8th Regiment of the French Engineers. The Military Secretary came too, and we thoroughly enjoyed our day in the country.

The work of the C.R.E. Army Troops (Lt.-Col. F. M. Westropp) was spread over an immense area, and, besides the work at A.H.Q., included the Army School at Ault, the Army Rest Camp at Bois de Cise, the Army Convalescent Depot and Rest Camp at Mesnil Val, the R.A. School at Sailly Fliebeaucourt, the R.A. Calibration Camp at Vaux, the 4th Guards Brigade Training Camp at Criel Plage, and various other establishments, whose unlimited requirements had to be cut down to a minimum.

Preparations for the Advance.

By this time preparations for offensive operations on a large scale were going on rapidly. Bridging in the back areas was nearly completed. The American Engineers, who were just beginning a series of bridges at Long, were recalled to their own Army on the 6th June, and the work there was done by the 574 A.T. Coy., the steel-work being off-loaded at Longpré-les-Corps-Saints by Indian labour. On this occasion a mechanical pile-driver was used for the first time, but the apparatus was not altogether satisfactory.

Water supply* was in an unexpectedly satisfactory condition, largely owing to the efforts of No. 3 Boring Section, under Lt. G. Hindson, who had come to us from the Fifth Army. Maj.-Gen. Grant, naturally enough, had been able to hand over very little in the shape of pumping stations or stores, but he gave us three air compressors, of which full use was made. These were mounted on lorries, which moved from one borehole to another, and filled the local reservoir with water for the days consumption. Our fleet of such lorries gradually increased from three to nine, and I never knew how Durham got hold of so many, but he thoroughly understood how to deal with Q. Everything possible was done to work to standard patterns: engine-houses were built to Maj. Owen's design, all boreholes were fitted with standard air heads, and a certain boring head, which was better than ours, was set aside because it required special fittings of its own. The C.E. Second Army gave us three of the special deep well pumps made in his workshop at Hazebrouck. We used the Fifth Army pattern of framed canvas water trough, a VI Corps design for sectional water troughs, and our own pattern of sheet iron troughing for more permanent installations. Col. Rogers' water-bottle filler, used in 1916, was supplied from the Base as a standard pattern, but was now fitted with brass bib-cocks.

To give some idea of the quantity of work done, it may be recorded that during the period 1st April—30th June :—

88 pumping stations were erected.
35 miles of 4 in. pipe were laid.
36 boreholes with a total depth of 10,000 ft. were sunk.
60 water points and 6,000 feet of horse troughs were put up, the total estimated capacity of which was between 1.5 and 1.75 million gallons for a 12-hour day.

During this period the mobile compressor plants lifted 1.4 million and No. 1 Water Tank Coy. sterilized 1.75 million gallons. A quick piece of work done was a 4 in. pipe line 8,400 yards in length, from two high-lift centrifugal sets erected over some springs at Boves,

* For map showing development of Water Supply in this area, April—Nov. 1918, see *Water Supply—France*, map G.

to water points on the Amiens—Villers-Bretonneux road, and the Bois de Gentelles by-road, which was laid in seven days. The Australian Engineers, assisted by the 238 A.T. Coy., did most of the work, but the Engineers of the Canadian Corps, on their arrival, helped to finish it. Each reservoir contained 36,000 gallons.

On the 1st August we took over an additional 7,000 yards on our right from the 1st French Army, and Corps areas were readjusted. No sooner had the C.E. Australian Corps completed taking over the French dumps, and handed over some of his own to the III Corps, than the Canadian Corps (Lt.-Gen. Sir A. W. Currie commanding, Maj.-Gen. W. B. Lindsay, C.E.) arrived to take over the extreme right of the line from the Australians. This seriously complicated the supply of R.E. stores for the attack, but the C.E. Canadian Corps had such a large force of engineers and transport at his disposal, that he was able to cope with the situation.* He also had allotted to him 144 A.T. Coy., No. 4 Siege Coy. R.A.R.E., 182 Tunnelling Coy., and No. 8 Pontoon Park. The whole Australian Corps (Lt.-Gen. Sir J. Monash, Brig.-Gen. C. H. Foot, C.E.) was now present, and had 648 Field Coy., 146, 238, 567 and 1st Australian A.T. Coys., 1st and 2nd Australian Tunnelling Coys., and No. 11 Pontoon Park. The III Corps (Lt.-Gen. Sir R. H. K. Butler commanding,† Brig.-Gen. A. Rolland, C.E.) had No. 1 Siege Coy. R.A.R.E., 216 and 574 A.T. Coys., 180, 253 and 256 Tunnelling Coys., whilst with A.H.Q. we had 213 A.T. Coy., 254 Tunnelling Coy., 353 E. and M. Coy., No. 6 Pontoon Park, and No. 3 Boring Section. The Cavalry Corps (Lt.-Gen. Sir C. Kavanagh commanding, Lt.-Col. W. H. Evans, C.R.E.) had their Field Squadrons, but no Army Units.

That this concentration had been effected without raising the enemy's suspicions was a wonderful achievement, but the secret was well kept, and the arrival of the Canadians took most of us by surprise. The 1st French Army, under Gen. Debeney, was to attack simultaneously on our right, and, to ensure co-ordination, was placed by Gen. Foch under the direct orders of Sir Douglas Haig for the occasion. How the arrangements for maintaining secrecy during the final preparations were devised, and carried out, is well told in Gen. Montgomery's *The Story of the Fourth Army*, page 18, *et seq.*

THE FINAL ADVANCE, 8TH AUGUST—11TH NOVEMBER, 1918.

(The Third Army joined in the fighting on our left on the 21st, and the First Army on their left on the 26th August.)

The best account of the attack of the 8th August, and of all the subsequent fighting, is given in Gen. Montgomery's book referred

* Each Canadian Division had three battalions of Engineers and a Pontoon Transport unit, and the Corps had an Infantry Works battalion.

† From 11th August to 11th September, Lt.-Gen. Sir A. Godley took his place.

to above; here I can tell only of the R.E. work involved, so far as it was planned at A.H.Q. I hope that some C.E. of a Corps will take up the story where I leave off, and describe the splendid achievements of the R.E. of Divisions, especially the numerous river crossings which they carried out so successfully.

One smart piece of work was performed by the Foreways Coy. A large German dump at Wiencourt l'Equipée having been captured on the 8th August, Capt. Figgis, on the 10th, ran out four of his tractors and 25 trucks on lorries, and proceeded to repair and work the German narrow-gauge railways the same day, so that we were at once able to make use of the masses of engineering stores that were found there.

A very satisfactory feature of the rapid advance was the number of pumping stations, previously erected by the Fourth and Fifth Armies, which were recovered, many of them intact, or requiring only minor repairs, or new engines. In one case the boilers were found under steam. Maps had been issued beforehand showing all these known sources of supply, so that Water Officers of Corps knew where to look for them.

Before this first advance it was not possible for C.E. of Corps to forecast accurately their requirements of bridging material, so each was supplied with a number of R.S.J.'s, and a quantity of heavy timber, but 15 spans of Inglis bridge were specially demanded from the Base, and delivered at Poulainville,* with a view to providing rapidly a crossing over the Somme in the neighbourhood of Vaire-sous-Corbie. On the 13th, Longeau, which had already proved convenient, was chosen as the railhead for bridging material, and here Capt. Upton, lent by G.H.Q., with three staff sergeants from the Bridging School, took charge, and had up to 300 Chinese labour at his disposal. Shortly afterwards a forward bridging depot was formed at the junction of the Amiens—Roye and Amiens—Boves roads S.E. of Longeau. It was first manned by the 548 Field Coy. (B category), and afterwards by the 224 (Transportation) Works Coy., with Lt. Carr Gomm in charge. With the continuous rush of receiving and issuing material, it was essential to have skilled men at a depot to ensure correct sorting and loading. The Pontoon Parks worked, as a rule, under the Army Bridging Officer, but were allotted to C.E.'s of Corps for special occasions. An advanced bridging depot was formed on the 16th September at Vraignes, E. of the Somme on the Amiens—St. Quentin road, the railheads used being Brie, La Chapellette, and Roisel, and to this place the Pontoon Parks brought up all the material remaining at Longeau, and the bridges dismantled at Daours. Later on, in October, the rear depot leap-frogged forward to Honnechy (captured on the 8th October), some six miles S.W. of Le Cateau, but we had no sooner

* Near Australian Corps H.Q. at Bertangles.

installed 224 (T) Works Coy. here, and got up 70 tons of materials, than it was found that our railway siding was required for ammunition, and we had to move to Bohain, five miles further south, where Pearce discovered a convenient German pioneer Park, of which he got sole possession. For the final bridging operations over the Selle (17th October), and the Sambre—Oise canal (4th November), the Base sent up what was required by train to Roisel, where it arrived on the 13th October, and was brought on to Bohain by lorry and light railway. The detachment at Vraignes salved bridges and material wherever they could (Monchy-Lagache, St. Christ, Brie, Péronne, etc.), sending it up to Bohain, and heavy timber was provided by the Forestry Department at St. Ouen.

The first important series of bridges to be made was that over the Somme at Brie. The bridges that we had made here in 1917 seem to have been left practically intact during the retreat in 1918, but the Germans had now made a pretty thorough wreck of them, though as reports speak of only five bridges being now made, whereas in 1917 we had made six, it is to be presumed that one span was found intact. The speed with which these bridges were made was so remarkable that the main facts are worth recording.

Early on the morning of the 5th September, the 32nd Division got their first patrols across, and their R.E. and Pioneers (Lt.-Col. G. C. Pollard, C.R.E.) had temporary bridges for wheeled traffic completed by noon on the 6th. On that day Pearce made a reconnaissance for heavy bridges in company with the C.E. Australian Corps, but, owing to a change of boundaries, the work was at the last moment handed over to the IX Corps (Lt.-Gen. Sir W. Braithwaite commanding, Brig.-Gen. G. S. Cartwright,* C.E.), who had just joined the Fourth Army. For the first series, two 60 ft., two 21 ft. 6 in., and one 30 ft. spans were required: these bridges were delivered on the site on the 6th and 7th, and erection was completed on the 9th. The 60 ft. bridges had to be erected as deck spans to allow tanks to cross with their sponsons out, and this necessitated 4 ft. ramps being made to each, and gave the completed bridge an unpleasant switch-back appearance. The second series was built alongside the first: material was delivered on the 14th, and the bridge completed on the 18th. It comprised one new 60 ft. span, one new 60 ft. span shortened, one 60 ft. salved (two bays repaired), and two spans of R.S.J.'s made up on the site.

Meanwhile the III Corps made six bridges, in Albert and Dernancourt, and the Australians (Bridging Officer, Capt. Christian†) had been bridging the Somme at Vaire, Cérisy-Gailly, Chipilly, Morcourt,

* On 27th October, Brig.-Gen. R. A. Gillam became C.E.

† This officer had been made a prisoner by the Germans at the very beginning of the war on an island in the Pacific Ocean, but was released on the arrival of an Australian man-of-war.

Bray, Cappy, and Hem—a comprehensive programme. The Inglis bridge erected by them at Vaire was taken down and re-erected at Bray, on a high-level site, for which it was eminently suitable, by the 216 A.T. Coy. At Chipilly there had existed two high-level steel lattice girder bridges, both of which the Germans had blown at one end only. One of these bridges was a few feet longer than the other. I was in Gen. Foott's office when a telegram came in from the O.C. 3rd Australian Pioneers, who reported the damage done, and stated that the longer girder could be mended and re-erected across the smaller gap, after the removal of the debris. His wire ended, "What about it?" Foot's reply was equally laconic, "Carry on." and the Pioneers completed the bridge in four days, using German tackle found on the spot.*

On the 2nd September, the Army and Australian Corps Bridging Officers reconnoitred the bridges in Péronne, whilst fighting was still going on in the suburbs of La Chapellette, and Flamicourt. Two were found intact, but others had to be made. Temporary bridges of R.S.J.'s were ready by the 5th, and two large spans completed by the 14th and 16th respectively.

On our right, bridges were made by 567 A.T. Coy. and No. 4 Siege Coy. R.A.R.E. over the Cologne and the Omignon in several places. One simple but original bridge was made for tanks at Monchy-Lagache, where there was a wide ditch of just such a section that a tank might get stuck in it. R.S.J.'s were placed across the stream at the bottom of the ditch, and 9 in. and 12 in. logs piled up over them until just below the level of the water.

The essential point thoroughout this bridging was that every site was inspected early by the Army Bridging Officer, so that he could allot the material available where it was most urgently required, and get it sent out in time: this he could do because Q. saw to it that he always got a car, and he had the Pontoon Parks at his disposal. Such was the confidence of the Army Commander, that he never once asked if we were ready: he told us what he was going to do, and left it at that. Pearce never let him down, but the job required a lot of forethought.

During the advance the Tunnelling Companies were first employed on roads, and in searching for German booby-traps, and, later, for delayed-action mines, which caused frequent interruptions on the railways. In Albert alone they found 105 booby-traps, which they removed without accident. Two companies (258 and 1st Australian) were lent to the Railways for constructional work, and others were employed on bridging. Though at first regarded throughout the army as tunnellers only, they were engineers to the backbone, and could tackle any engineering job.

* All the officers of the Australian Pioneer Battalions were engineers by profession, and their ranks contained many skilled tradesmen.

On the 30th August, A.H.Q. had moved to Bertangles, five miles N. of Amiens, taking over the hutted camp previously occupied by the Australian Corps H.Q., and on the 18th September, we moved again to a new camp on open ground between Eterpigny and Villers-Carbonnel, W. of the Somme at Brie. This site was chosen and the general lay-out of the camp arranged by the Army Commander himself, and it was all to be camouflaged as it was built. Needless to say it was wanted at once. The Camp Commandant, Capt. Houghton, the Camouflage Officer, and the C.R.E. A.T. worked wonders, with the result that when, immediately after occupation, a Flying Corps officer was sent up specially to photograph it, he could not find our camp, and photographed a wrong site.*

After the battle of Mont St. Quentin (Péronne) on the 4th Sept., our advance pushed steadily on, with incessant fighting, until the outer defences of the Hindenburg Line were captured on the 18th September, when the C. in C. had to decide what to do with regard to that formidable position. Orders promptly came out for a combined attack by three British Armies, the First and Third Armies to start the battle on the 27th September, whilst the main attack, on Vendhuille to Bellenglise inclusive, a front of 12 miles, was to be carried out by the Fourth Army on the 29th. The 1st French Army on our right was to attack at the same time as ours, on a front of 6 miles. The Fourth Army was reinforced, and on the 29th consisted of the III, IX, Australian, and II American Corps (Maj.-Gen. G. W. Read commanding, Col. Ferguson, C.E.) with the XIII Corps (Lt.-Gen. Sir T. Morland commanding, Brig.-Gen. C. A. Elliott, C.E.) in reserve.†

Preparations were made for crossing the St. Quentin canal (heavy bridges) at Vendhuille (III Corps), Pont de Riqueval, Bellenglise, and Lehaucourt (IX Corps).

For Vendhuille, 15 bays of Inglis bridge were loaded up on 36 pontoon wagons, and conducted by an officer of the 283 A.T. Coy., which was to build the bridge, to Lieramont, seven miles W. of Vendhuille, where the convoy was parked awaiting developments. Owing to our want of success in this vicinity on the 29th, Vendhuille was not captured till the 30th, and even then little progress was made, so that this bridge was not brought up till the 5th October, and opened for traffic on the 6th. To set this bridge free again, a 60 ft. span, on steel cube piers, with subsidiary bays of R.S.J.'s, was brought up on the 7th, but owing to the difficulties of the site was not completed until the 21st. The Inglis bridge was dismantled next day. A light Inglis bridge had been sent up from the Base

* See photograph of this camp in Gen. Montgomery's book, page 146.

† The Canadian Corps had left our Army on the 28th August.

for use at Pont de Riqueval, but the stone bridge there was rushed by a company of the 1/6th North Staffords and a detachment of R.E. just as the German pioneers were lighting the fuse to blow it up.

At Bellenglise the first bridge, of R.S.J.'s, was made by the R.E. of the 32nd Division, and was open for traffic on the 30th. It having been reported to the depot at Vraignes on the evening of the 29th September that an 84 ft. Inglis bridge was required at once at Bellenglise, the material was promptly loaded up, and despatched at midnight on pontoon wagons. This bridge was erected by the 216 A.T. Coy., and was ready for traffic at 3 p.m. on the 1st October. On the 27th, it was dismantled for moving forward, having been replaced by a 60 ft., class A, standard span, one end of which was supported on a wooden trestle, and two spans of R.S.J.'s, with a steel cube pier between them. This bridge took three weeks to build. The bridge at Lehaucourt was found intact.

During this time the 283 A.T. Coy. bridged the railway at Maurois, and 567 A.T. Coy. at Busigny, both girder bridges with R.S.J. shore spans.

The E. in C. now called on us to dismantle and send toot her Armies some of the bridges which we had left behind us, and no longer required. This necessitated sending back 574 A.T. Coy., half to Bray to replace the Inglis bridge there with one of R.S.J.'s on piles, half to Hangest to dismantle the Hopkins bridge at that place. A Hopkins at Daours had already been taken down and sent off.

The next phase of bridging was the crossing of the Selle on the 17th October. On the 1st October, the XIII Corps had relieved the III Corps (transferred to the Fifth Army) on our left, the IX Corps was on our right, and the II American Corps in the centre, the Australians having been taken out of the line on 5th October for a well-earned rest.*

The XIII Corps formed a small bridging depot at Reumont, four miles S.W. of Le Cateau, and had pontoon wagons allotted to them. Between the 18th and 21st October they made in all six bridges at Le Cateau, and St. Benin, of which one was a trestle bridge 100 ft. long, consisting of 14 spans of R.S.J.'s. The IX Corps made four bridges at Molains, St. Martin, and St. Souplet, using R.S.J.'s and timber. We gave the C.E. Third Army one 30 ft. class A span, to bridge the Selle at Montay.

The II American Corps went off to join their own Army on the 20th October, leaving us the IX and XIII Corps with which to

* By invitation of Brig.-Gen. C. H. Foott, Chief Engineer, I inspected the Engineers of the 1st and 2nd Australian Divisions on the 1st November, and those of the 3rd and 5th on the 8th. The 4th Division was out of reach, somewhere down by the sea. I shall never forget the compliment, nor the fine body of men that I saw on each occasion.

force the line of the Sambre and Oise canal on the 4th November The advance had been so rapid and the distances from our bridging depots had become so enormous, that it was now impossible to await reconnaissance reports before issuing bridges and material. What remained was therefore allotted to C.E. of Corps in the depot, according to what they might be expected to require; transport was provided there from the Pontoon Parks, so that C.E.'s could draw on their allotments as became necessary. The XIII Corps formed a small depot at Pommereuil, two miles from Le Cateau on the Landrecies road: the IX Corps drew direct from Bohain.

The remarkable feats of bridging in this battle carried out by the Divisional R.E. are well told by Gen. Montgomery, and he gives a good description of the peculiar obstacle formed by the canal, its reservoirs, and the adjacent marshes. As regards heavy bridging, the IX Corps put up a 21 ft. 6 in. span at Ors (567 A.T. Coy.), a 30 ft. bridge on steel cube piers at Cantillon (254 Tunnelling Coy.), duplicated later by a 60 ft. Warren girder salved at Monchy-Lagache, and a 30 ft. class A bridge on timber trestles, with R.S.J. shore spans, at Cambresis (No. 4 Siege Coy. R.A.R.E.). Over the Petite Helpe at Maroilles 283 A.T. Coy. erected the Inglis bridge last seen at Bellenglise, and 574 A.T. Coy. (who had reappeared from Bray and Hangest) duplicated this with a 60 ft. deck span, but their bridge was not completed until the 15th November, after the Armistice. An Inglis bridge of seven spans (last seen at Vendhuille) was erected at Cartignies, as soon as the launching gear and tail-piece used at Maroilles became available. The 256 Tunnelling Coy. (Maj. Wilson) bridged the Grande Helpe at Avesnes, by means of a 60 ft. span, completed after Armistice day, whilst trestle bridges of R.S.J.'s at Noyelles, Taisnières, and Dompierre were finished on the 10th November.

This ended our heavy bridging. It is interesting to note that our $2\frac{1}{2}$ units of Inglis bridge were used on no less than ten crossings, beginning at Blangy-Tronville and Glisy, and ending at Maroilles and Cartignies. Glisy to Cartignies in a straight line is about 66 miles. The total amount of bridging material used must have been something astounding, and the provision of it beforehand was an act of great foresight on the part of someone at G.H.Q.

To turn to water supply, the arrangements during the advance were usually of a temporary character, but Lieut. Hindson brought along No. 3 Boring Section, cumbrous though their drill was to move, and ten bores were put down during the period 1st October—11th November, totalling 1,186 ft. in depth. The town supplies of Fresnoy-le-Grand and Le Cateau were found in working order, except that new magnetos were required.

The most important work was the development of the supply from the St. Quentin canal. Two large high-lift centrifugal pumps were erected at the S. end of the tunnel at Bellicourt by the 238 and 221 (Isle of Wight) A.T. Coys., and a smaller installation was put up by another company at the north end. The water was lifted to storage tanks, from which it was drawn off by the sterilizing lorries, or fed horse troughs by gravitation. To cope with the supply of water for horses until the lakes near Busigny and the river Selle were reached, twelve lorries were fitted with canvas tanks, in addition to our existing fleet of 17 lorries fitted with two 400-gallon tanks each. During the period of 42 days, 1.7 million gallons of water were sterilized, and over three millions carried.

In October, the 4th Army Workshop Coy. rejoined us, and opened its shops at Bray Tourbières,* moving later to Roisel, but events moved too fast to permit of their being fully employed.

About the middle of September, Q. had begun to get busy on a train for the Army Commander, as it had become evident that, if the advance was going to continue at the same pace, a movable Advanced Head Quarters would soon be necessary. Railways promised a train of ten coaches, but Q. had much larger ideas, and having salved a dozen derelict German wagons in various places, and got them pushed round by hand to La Flaque, he called on us to fit them up as additional offices, with sleeping bunks and electric light. The C.R.E. A.T. and the O.C. E. and M. Coy. got on to the job, and Houghton fitted camouflage nets, which rolled up on to the roof for travelling. Railways, however, stood firm, and the train was limited to its ten coaches, in one of which an office was provided for the C.E., his Staff Officer, Bridging, and Water Officers, and we all lived very comfortably on the train. Cohen stayed with the main body of A.H.Q., as by this time the supply of stores had lost its importance. On the 14th October, A.H.Q. made its first train journey to Montigny Farm, and on the 3rd November went on by rail to Honnechy, where the armistice found us. On the 16th November we moved by road to Avesnes, on the 24th to Ham-sur-Heure, and finally to Namur, where the Fourth Army eventually came to an end.

Such is the story, in briefest outline, of the R.E. work done in the back areas of the Fourth Army. What has struck me most, in going over the whole period, is the co-operation, and the willing way in which Corps helped one another. The Chief Engineers of Corps, and those who worked under them, may well be proud of their achievements.

* Not marked on the map.

THE KABUL RIVER RAILWAY SURVEY.

By BRIGR.-GEN. H. H. AUSTIN, C.B., C.M.G., D.S.O.

IN the later 'eighties and early 'nineties of the last century considerable activity prevailed in India concerning its existing defence arrangements, in view of the menace of a Russian invasion across the North-West Frontier, some indications of which seemed disclosed by the Penjdeh affair of 1885. The Russian bogey was perhaps then at its height; and it was thought that the likely lines of advance of the Russian hosts were three in number: by the Khyber Pass from the direction of Kabul towards Peshawur and Rawalpindi; from Kandahar through Chaman, with Quetta as its immediate objective; and thirdly, by a central route from the direction of Ghazni, via the Peiwar Kotal and Kurram Valley towards the Indus.

Comparatively little was then known about the features of the Tochi Valley and Gomal routes; but minor excursions were regarded as possible from the Pamirs through Chitral, Gilgit and the mountainous country to the north of the Peshawur district. The difficulties of these latter regions were, however, enormous; and no invading force could there operate with much chance of success beyond, perhaps, creating diversions in the hope of drawing columns of defence away from the main theatres threatened.

Elaborate field fortification schemes had accordingly been drawn up for the protection of the Attock bridge, and the defence of the military arsenals and cantonments of Rawalpindi and Quetta; and also for that of the Sukkur bridge, then nearing completion. These works were later put in hand and their construction carried out by a distinguished band of R.E. officers during a period of several years.

Still, a glance at the map of the N.W. Frontier will show how wide was the front on which an invasion of India, on a large scale, might have to be met. The existing railway facilities were totally inadequate to enable the rapid transference of troops from one threatened quarter to another which might develop into the main line of invasion. The course of the Indus was nowhere spanned by a railway bridge between Attock—roughly mid-way between Rawalpindi and Peshawur—and Sukkur in Sind, a distance of over 500 miles of river front. Between Attock and Sukkur there were no railway communications west of the Indus; while bridges of boats and ferries across the great river were only established at rare intervals.

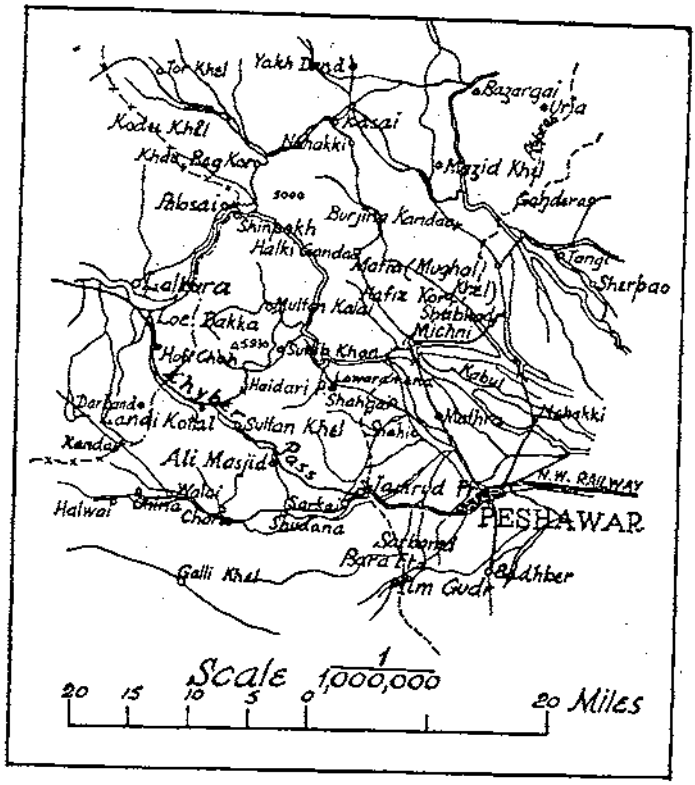
Moreover, the single line of railway connecting Peshawur with Quetta, both of which places were termini in 1889, followed a circuitous inland route, far from the Indus, through Rawalpindi, Lahore, Multan and so to Sukkur. Here the Indus was crossed by a fine cantilever bridge opened to traffic in April, 1889; and a line from Ruk, near by, branched off via Sibi and the Harnai on its northerly course of more than 200 miles to the Quetta plateau. This entailed many stiff gradients and a devious route through a treacherous region subject to wash-outs and land-slides.

No one in India was probably more alive to the unsatisfactory condition of communications along the N.W. Frontier at this time than General Sir James Browne, the Quartermaster-General in India when Sir Frederick Roberts was Commander-in-Chief. Sir James Browne was a very distinguished Royal Engineer, and had carried out the construction of the Harnai Railway under great difficulties, only a few years before, as its Chief Engineer. He thus appreciated, better perhaps than anyone, the slender nature of the thread by which Quetta had been brought into communication with India proper. He was, too, an officer with an unrivalled experience of the frontier, and possessed an intimate knowledge of the language and idiosyncrasies of the wild tribesmen who come under the term "Pathan and Baluch." He had spent much of his life in their midst during very stirring times; and had often extricated himself by his courage and ready wit from extremely awkward situations, caused by their far from friendly attitude towards him on occasion. Many were the yarns prevalent in those days, therefore, concerning "Buster" Browne's earlier adventures; particularly in the Ambela Campaign of 1863, when credited with meeting, and slaying in single combat, chosen champion swordsmen of the Bonerwals, during the protracted and sanguinary struggles for the possession of the Crag Picquet.

Hence the question of railway communications along the N.W. Frontier was pushed with perception and energy by Sir James Browne when Q.M.G. in India. The existing road from Peshawur up the Khyber Pass to Landi Kotal was judged incapable of dealing efficiently with the heavy up-and-down traffic essential to maintain a large field force operating in Afghanistan against a potentially well-equipped Russian Army advancing from the direction of Kabul. The likely congestion about the Ali Masjid defile might well prove disastrous to British forces, on a great emergency arising; whilst the idea of constructing a railway up the Khyber was ruled out, at that time, by reason of the stiff gradients imposed by the restricted space through which a line would have to climb to the Landi Kotal plateau beyond. The most promising alternative appeared to be an extension of the railway across the Peshawur plain to the mouth of the Kabul River, and thence to follow its

right bank through the gorges which terminate shortly before the Jellalabad Plain is reached, some miles down-stream of Dakka.

Thus, early in 1890, a trans-frontier railway survey expedition was despatched by Sir James Browne up the gorge of the Kabul River, under the command of Lieut. (the late Major-General Sir) J. R. L. Macdonald, R.E., with a view to ascertaining its practicability for a railway. The survey was to be carried out to a point as near Dakka as the Political Officer, Colonel Robert Warburton, of Khyber fame, considered safe; and Macdonald was assisted in this task by two R.E. subalterns and two infantry officers, with a subordinate staff of about 100 *khalassies* (chainmen, etc.) and workmen, and an escort of 200 men of the Khyber Rifles.



Kabul River Railway Survey.

It was my good fortune to be stationed at Peshawur when Macdonald arrived there towards the end of January to organise this important expedition. An old Aberdonian with a brilliant record at the Royal Military Academy, Woolwich, out of which he easily passed first into the Royal Engineers, Macdonald was still a subaltern with less than eight years' service, though he was promoted to captain a few months later. He had, nevertheless, already gained considerable experience of the frontier during the construction of the

Harnai Railway under Sir James Browne; on the Black Mountain Expedition; and in connection with the defensible post at Landi Kotal, designed by him for the headquarters of the Khyber Rifles, and lately completed by his friend, Lieut. J. W. Pringle, R.E. Macdonald's reputation stood high, therefore, at Army Headquarters, and he was early selected for the command of the difficult undertaking decided upon.

Lieut. P. G. Twining, R.E., also formed a member of his staff, but as Macdonald considered the services of a second R.E. subaltern desirable, he kindly applied for mine; and in due course I was appointed to the expedition, as were also Macdonald's younger brother in the 6th Warwicks, and Lieut. W. Gloster, of the 18th Royal Irish. Of this small band I, alas, am alone alive to-day; for Macdonald has passed away since this article was written, his brother was killed in Uganda in 1897, and Gloster in the South African War; while Major-General Sir Geoffrey Twining, K.C.M.G., etc., died in harness a few years ago when Director of Fortifications and Works at the War Office.

The expedition took the field on February 5th, and by the 21st had surveyed a route for the railway from Peshawur Station to Ursak, at the entrance to the Kabul River gorge—a distance of 16 miles. The country between these two places being open plain was found easy from a railway point of view; but the progress of the detailed survey up the gorge proved a very different matter, and it was May 4th before the remaining 31 miles from Ursak to Samsai were completed. Beyond Samsai both banks of the river were in the territory of the Amir of Afghanistan, into which the survey party were forbidden to go. It was possible, however, from the hills thereabouts to view the country as far as Dakka, only some eight miles distant, and to form a fair idea as to its nature.

Macdonald was thus able to report that the country between Peshawur and Dakka, a length of 55 miles, might conveniently be divided into three well-marked sections. The first, from Peshawur to Ursak, was chiefly open clay-land, partially under cultivation, low lying and irrigated from the Kabul River, but presenting no engineering difficulties. In the second section from Ursak to Narai, 21 miles, the river was confined to a narrow gorge, varying in width from 30 to 100 yards. The river bed was fairly free from rocks and obstructions, but awkward rapids occurred in places when the river was low. The third section from Narai to Dakka, 18 miles, though still in the gorge of the river, was much easier than the second. The river continued to be bound on one side or the other by steep rocky banks, but flowed generally in a narrow valley from a half to one mile in width. As Dakka was approached the valley opened out still more; whilst it assumed a broad, plain-

like aspect in the 50 miles intervening between that place and Jellalabad.

The first section enumerated above is all in British territory, save for a few miles at the end. The inhabitants of the right bank in the second section are Mullagoris, and certain divisions of the Tarakzai and Halimzai Mohmands. These were all under the political control of Col. Warburton, and friendly; whilst the Tarakzai and Halimzai Mohmands on the left bank were under the Amir of Afghanistan, and did not welcome the work of the survey party. The third section is occupied by Mohmands on both banks, those on the right bank as far as Samsai being friendly, and then under the control of Col. Warburton; whereas those on the left bank were subjects of the Amir, and at first resented any suggestion of a railway being carried up the Kabul River, as will presently be related.

Since some of the tributaries of the Kabul River have their source in the Hindu Kush range, a considerable rise in its level takes place in the summer, as the result of melting snows; but exceptionally high floods only occur during the combination of heavy rains with melting snow. Though the river is 500 to 600 feet wide at Ursak and fordable in winter, its width rapidly decreases as the gorge is ascended. For 20 miles or more the river is then only 100 to 250 feet wide, and nowhere fordable until near Dakka, where it widens again to 600 feet or over. Between Ursak and Dakka many short rapids exist when the river is low, with intervening stretches of comparatively smooth flowing water; whilst a few eddies and whirlpools, though not dangerous, certainly add excitement to *mussak* raft journeys down the river.

Before entering the gorge Macdonald engaged a boat capable of carrying 60 or 70 men, which accompanied us throughout the the survey. Skins were also procured from Lalpura and other places; and these when inflated and joined together with baulks formed extremely buoyant rafts. They were frequently utilised by us for returning to camp at the end of the day's work, when possibly several miles up-stream of it; and for dropping down the river to complete back work. The moral effect of the boat and rafts on the inhabitants of the left bank was by no means negligible therefore.

Numerous indications showed that the river was liable to heavy floods in its lower reaches; and though the highest ordinary rise above the cold weather level was found to be about 20 feet in the gorge, at long intervals, and in very abrupt bends, the water had apparently been banked up on occasion as much as 45 feet above winter level. Thus the proposed, and carefully demarcated, alignment for the railway was carried well up the hill slopes, to provide a good margin of safety. In spite of this, however, there was little

difficulty in obtaining a gradient which nowhere exceeded 1 in 200 as far as Samsai.

Owing to the sharp bends alluded to, and the often precipitous nature of the cliffs confining the river to its course, a certain amount of tunnelling is unavoidable in the central section. It was estimated that some fifteen tunnels in all, but with a total length of little over 1¼ miles, would be necessary in the 47 miles surveyed between Peshawur and Samsai. A good deal of cross drainage from the numerous nullahs that enter the right bank from the mountainous country through which the river flows had also to be provided for; so Macdonald allowed for the construction of some forty major bridges (with spans of 40 feet and over), and many minor openings and culverts.

It will thus probably be realised that, before we could move camp from one spot to another as the work progressed, mule roads had in nearly every case to be made on ahead to intended camping-grounds. An old caravan road through the Mullagori and Shilman territories was used as much as possible for bringing up our supplies from Peshawur, and branch mule roads constructed to the various camps and down to the river. Altogether some 42 miles of fair mule road were made, in addition to repairing about 10 miles of the old "*kafila*" road. These all ran inland from the river bank, along which it was frequently impossible to take loaded mules owing to its steep and broken nature. Some 25 miles of footpath were, however, made beside the stream to facilitate the survey work as we advanced up the gorge.

Traversing parts of this path was not without thrills. There was one precipitous cliff in particular, along the face of which it was not possible to cut a path; and here the natives cleverly let into the side of the precipice a temporary rustic bridge, consisting of stout boughs. As this primitive platform was less than two feet wide, rickety at that, and with nothing between it and the river beneath, it was well named the "*pul surat*," or Bridge of Paradise, for he who fell from it was surely bound for Paradise in the seething waters far below. In some other places, however, the skill of our path-makers was baffled, and the track had to be carried several hundred feet up the slopes to pass over the summits of precipices along whose faces no "*pul surats*" could be constructed.

In view of the likelihood of being fired into at night by evilly-disposed Mohmands on the left bank of the river, our camps were pitched in sheltered positions well removed from the range of that bank, and thus little annoyance was experienced in that respect. Our camp on a high plateau at Gutta Gudar was, nevertheless, sniped one night, towards the end of March, by a gang of Halimzai *budmáshes*, who appear to have crossed the river and opened fire from a knoll some 700 or 800 yards inland of us, and 200 feet above

us. Although it was bright moonlight at the time, the bullets passed harmlessly over our tents and landed in the mule lines without touching a single animal. The fire was promptly returned by our alert Khyber Rifles, and the rogues decamped when they realised our men were not to be caught napping.

During the greater part of the period the expedition was in the field the Mohmands on the left bank displayed a hostile attitude towards the railway project. Scarcely had the survey party reached Ursak when rumours became current that an inflammatory priest, Mullah Khalil by name, intended to give trouble. The old gentleman had previously beeen somewhat of a thorn in the flesh during the Afghan Campaign of 1878-80; and now, at our camp in the gorge of the river, up a branch nullah known as Shahid Miana, or "The Place of the Condemned," a letter was received from that turbulent individual. In it he demanded to be informed if Macdonald thought he was dead, that he should thus dare to survey for a railway past "his territory," as he called it, without first obtaining his sanction! The enraged priest went on to say that under no circumstances would he permit the survey to be carried out; and that his banner was being joined by 4,000 adherents who were ready to die in the cause.

Mullah Khalil received in reply a courteous communication, which sometimes turneth away wrath, whereby he was informed that the Government of India had arranged with the Amir of Afghanistan for this survey to be made; and that his threats would certainly not deter the expedition from carrying out its orders.

Hostilities actually broke out two or three days after we had been sniped at Gutta Gudar, when the survey had reached the Halimzai border. Whilst working in the gorge of the river on April 2nd, our parties were fired on from the left bank; and this annoyance continued almost daily during the next ten days. Though from a military point of view the opposition never became serious, yet it was a matter of considerable inconvenience to those entrusted with the survey. The escort of Khyber Rifles was, therefore, increased by another fifty men from Landi Kotal, and admirable work these irregular troops performed.

Born and bred amid the wild Afridi hills, they were thoroughly at home in these rugged gorges; and when accompanying us for the day's work they intuitively split up into small groups, as we approached the scene of our labours, and crowned the heights on our bank, whence they could obtain a good view of us and the opposite hill-sides. As a rule about half the Khyber Rifles came out with us, while the remainder attended to the safety of the camp, provided escorts for convoys, and so forth. At night they furnished guards, and picquets on hills near by that overlooked the camp. Their duties were onerous, but never once did they

complain ; on the contrary, the prospects of a scrap appealed forcibly to their warlike instincts, and kept them in perpetual good humour. Thus during the troubles with the *mullah* they proved themselves peculiarly alert sharp-shooters, and effectively kept the hostile *budmashes* across the river under observation and fire, so affording material protection to those carrying on the survey. We learnt later that five of our opponents had fallen to the rifles of our faithful watch-dogs ; whereas we sustained no loss whatever. But we British officers early took the precaution of adopting the Khyber Rifle head-dress in order to become less conspicuous.

It gradually began to dawn on Mullah Khalil and his adherents, apparently, that such opposition as they were able to offer was not likely to prevent the survey being proceeded with ; for his reputed army of 4,000 dwindled to 400 in reality when we reached the neighbourhood of Chamcha. This dominating bluff, rising some 600 feet sheer out of the river on the left bank, lent itself admirably to denying progress along the opposite slopes ; and here Mullah Khalil had established his headquarters some time previously. As the survey party was debarred from crossing the river, it seemed as though a slogging match across the narrow stream could alone decide the issue. Fortunately, thanks to the friendly services of certain *maliks* of the right bank who were accompanying us, Mullah Khalil was ultimately persuaded to come to terms ; and on April 13th he returned to his home at Palosai, higher up the river, with his following. Thenceforward he and the Khwaizai Mohmands faithfully adhered to their agreement, and the expedition was subjected to no further opposition during the remaining three weeks occupied in completing the survey to Samsai.

As we felt by no means sure, however, that Mullah Khalil would not play us false, and because the heat, too, had now become great, we still further increased our working hours, to push through the dangerous Shinaili gorge with all speed. We dressed by candlelight at 5 a.m. as we thought—on return to civilisation we found it had been 4 a.m.—and were off to work before sunrise. Since we never reached camp again until close on 7 p.m., the days proved long and fatiguing throughout the rest of the survey.

We bivouacked that night in the vicinity of Chamcha, and Twining was sleeping next to me on the bare hard ground. It came on to rain sometime in the small hours, so I ventured to rouse him that he might draw his ground-sheet over his bedding. In an instant he gripped my wrist as though in a vice, and looking at me in a dazed manner began to feel for his revolver under his pillow with the other hand. This was certainly not what I had bargained for, and having no desire to be shot by my friend in the darkness for performing an act of imagined charity, I hastily protested that it was "only me." That appeared to reassure him, and he slowly relaxed

his hold of me and got out his sheet, when conscious of my solicitude on his behalf. But the incident served to indicate how recent events had created an atmosphere of suspicion and alertness among us; and I did not wake him again that night.

The intelligence gained of the likely attitude of the Mohmands towards the projected railway naturally called for the provision of some measures for its defence, in the event of its ever being constructed. It was obvious that these tribesmen could not damage the line without crossing the river; and though this in itself would be no difficult feat, yet the risks involved are not lightly to be incurred. Failing the passage of the river, the tribesmen could do little more probably than hope to retard traffic by firing at the trains. Macdonald's scheme of defence, therefore, lay in the construction of watch-towers, to be held by four or five men, and spaced about a mile apart on commanding ground. These were to be in sight of each other, the railway and the opposite bank. Further, three defensible barracks for the headquarters of three companies of the Khyber Rifles were designed at suitable points for the protection of the line. They were to be supplied with trollies, on which reinforcements could be hurried to any watch-tower signalling for assistance. Stations were to be located approximately seven miles apart, made defensible, and provided with their own small guard of eight to ten men.

Such defence arrangements were deemed sufficient in normal circumstances; but if the Mohmands were bent on crossing the river in great numbers to attack the railway, it was judged their intentions could not be kept secret; and time would thus be given in which to assemble additional Khyber Rifles on the spot. It must be remembered that few boats are available in the gorge of the river, and that its passage is usually accomplished on inflated skins, the tribesmen lying on these and paddling themselves across with their hands and feet; whilst their garments, weapons and ammunition are done up in a bundle secured to the head by their *pagris*.

The rapidly increasing heat towards the end of April was somewhat alleviated by several heavy downpours of rain. One such storm broke over us shortly after dawn at our camp on the bank of the dry Ugde Khwar nullah, leading into the Kabul River. Attracted presently by the sound of a distinct roar we looked out of our tents to behold a wall of water, some two feet in height, rushing down the nullah bed. Five minutes later a tremendous torrent, ten feet deep and twenty yards wide, was flowing with immense velocity past our tents, and lashing itself into a fury of milky foam against a large rock obstructing the fairway. The hard-pressed boulder nobly stood its ground, but in resisting the shock emitted reports at intervals like the distant crack of rifles. The hills around, too, had suddenly become alive with white serpentine streaks coursing

and tearing down their stony slopes to mingle with others, thus forming splendid cascades and feathery waterfalls that plunged headlong into the angry torrent. It was a moving spectacle. An hour later the avalanche of water had abated greatly; and soon after mid-day the nullah was quite dry save for a few small pools.

The field work of the survey was at length completed on May 4th. Here at Samsai we constructed our last, and most imposing, pillar of stone and cement to indicate the spot where the survey ceased. Only a few days before, whilst at work near Shinpokh village, at a great bend of the river opposite Mullah Khalil's home at Palosai, one of our friendly *maliks*, who had accompanied us throughout, remarked to Macdonald, "*Sahib*, you have but to say the word, and I will cross the river and slay Mullah Khalil in his house. Otherwise, you will only have all this trouble over again when you return to these parts to make the railway, should he remain alive."

This, too, from one of the men who had negotiated terms of peace with the priest. He appeared quite unable to understand Macdonald's prompt repudiation of such a treacherous proposal, and yet was regarded by his fellow-tribesmen as more than a shining light for honesty of purpose!

The heat in the gorge of the Kabul had by this time become very great; so it was with distinct relief that the expedition set forth for Tor Sappar, a lofty mountain overlooking the upper portion of the Khyber. From its summit we obtained an extensive view of the snows of the Afghan Safed Koh range, the distant Jellalabad plains beyond Dakka and the river meandering across them, before entering the winding gorges which we had lately traversed and which lay far beneath our isolated position. Our march from the river had led through the Loi Shilman, a comparatively expansive and well-cultivated valley, in which we camped for one night beside a friendly village, the property of the would-be murderer of Mullah Khalil. We continued up the valley to the foot of Mt. Tor Sappar next day, and then commenced the ascent by a zig-zag track which had been made to the top from a beautiful spring and pool at its base, during the Afghan War, when the hill had been used as a sanatorium for the troops.

Here, amid cool and pleasant surroundings at an altitude of nearly 6,000 feet above sea level, we were joined later in the afternoon by General Sir James Browne and Colonel Warburton from Landi Kotal. As I had been stationed at Peshawur, the latter was well known to me, but it had not been my privilege to meet Sir James before. The contrast between the two men was striking. Col. Warburton small, spare and dark of complexion; while the Q.M.G. was sturdy of build, obviously still possessed of great physical strength, and with the glow of health radiating from his cheerful

countenance. Very entertaining, too, did his conversation prove at dinner that night and the next; for he recounted many amusing frontier episodes of his younger days to us. Col. Warburton was likewise an admirable raconteur, whose experiences were of intense interest to us youngsters; so the two days spent with those notables on the summit of lone Tor Sappar live in the memory.

On May 7th, Sir James Browne, Col. Warburton and Macdonald went into the results of the field work; and in the afternoon a largely attended durbar was held, at which the various *maliks* who had rendered good service during the survey were suitably rewarded.

At the close of the durbar Col. Warburton conducted us to the top of a precipice facing the Khyber and nearly 2,000 feet high: and there we might have been seen launching huge rocks and boulders with schoolboy enthusiasm from the summit. It was a grand game watching these rocks rolling and bounding down the face of this magnificent cliff with ever-increasing momentum. If not broken to fragments before the bottom was reached, they disappeared like thunderbolts into the bed of a nullah at its base, or were pulled up short by some luckless tree with a terrific crash. The pastime certainly gave one a vivid conception of the feelings of troops when encountering this form of defence by tribesmen holding heights in process of being assailed.

Sir James Browne and Macdonald marched next day with 100 Khyber Rifles down to the Kabul River at Gutta Gudar, where they embarked on *mussak* rafts the following morning. Thus as they floated down to Michni, and thence travelled by road to Peshawur, the Q.M.G. was able himself to see some of the most difficult problems of the gorge from a railway point of view.

Col. Warburton and the remainder of us marched the eight miles to the Landi Kotal defensible *serai*, where we spent the night. Outside, there assembled that evening the *kafila* from Kabul, for whom the Khyber Pass would be opened next day. Amongst the heterogeneous throng of traders and travellers from all parts of Central Asia were twenty Khokandis, who were quite different in appearance from all the rest. Their faces were of a dull brick-red colour, and their features Mongolian. Clad in rough skins and blanket coats, their trousers were tucked into high-top Russian boots. They seemed to speak only a Persian patois, and the money they carried for their distant pilgrimage to Mecca consisted of gold coins, bearing the stamp of Russian eagles.

The whole multitude moved off down the Khyber early next morning, as did we, to traverse the 22 miles to Jamrud at the lower end of the Pass; but we pushed on the remaining 10 miles into Peshawur Cantonment, to find that General Browne and Macdonald had arrived shortly before us. The scene along the road had been

an animated one, and interested as I have always been in strange types of humanity, I found much scope for scrutiny among the motley beings proceeding up and down this historical highway to India. In the gorge below the precipitous crags of Ali Masjid—the scene of many a fierce conflict in the past—the up-and-down traffic was greatly congested, and as we threaded our way through it we were able to view from close quarters as varied a pageant of wild Asiatic wanderers as can be seen probably anywhere along the N.W. Frontier of India.

By some strange chance I ran, four-and-a-half months later, across a party of the same Khokandis seen in the Khyber, and they had only then arrived at the Lahore stage of their journey. They seemed utterly lost in the turmoil of the railway station, but recognised me almost as soon as I them, and gathered round me; so I was able to put them into the right train for Karachi. Bewildered as they appeared, one wondered how they could ever hope to reach the tomb of the Prophet; and their enthusiasm must have been great indeed to embark on so hazardous an undertaking, so ill-equipped were they for the venture that lay before them.

Plans, reports and estimates for the projected railway were drawn up by Macdonald, Twining and me in Lahore; and later in Col. Warburton's camp on Tor Sappar. These were submitted to the Government of India in August through the usual channels; and in due course Macdonald and his staff received the special commendation of the Government for the work accomplished. Meanwhile the entire personnel of the Kabul River Survey was ordered to hold itself in readiness to take part in the Zhob Valley Railway Survey in September; and of our experiences then I hope to say something in a subsequent article.

A considerable number of years elapsed before any further steps were taken by the Government of India to carry out the construction of the Kabul River Railway. A start was eventually made in 1905, when Lord Kitchener was Commander-in-Chief in India. Lord Kitchener at first formed the opinion that a somewhat shorter route, and one less exposed to hostile sharp-shooters on the left bank of the river, might be obtained by leaving the Kabul where the Loi Shilman entered its right bank. He desired the line to follow that valley to near its head, and then to descend again into the Kabul River in the neighbourhood of Samsai. This possible alternative had already been considered by Macdonald in 1890; but he found that it would involve gradients of about 1 in 50; that work for the most part would be as heavy as in the route he recommended; and that there would be at least one long costly tunnel necessary, to descend again to the level of the Kabul River alignment about Samsai.

Macdonald actually accompanied Lord Kitchener in an examination of the Loi Shilman alternative in 1903, and then convinced the Commander-in-Chief, somewhat against Lord Kitchener's will, of the advantage to be gained by adhering to the Kabul River route throughout.

All work on the Kabul River alignment was abandoned, however, for financial reasons, in 1908, when the railway had already been carried for several miles up the gorge of the river. Nothing more was done to extend the railway from Peshawur in the direction of Dakka, beyond Jamrud, until 1920. Then it was decided to construct the shorter line up the Khyber Pass to Landi Kotal, and the Afghan frontier about Landi Khana, whence there is a steep descent from the plateau to the valley of the Kabul and Dakka. This railway has recently been completed, but the difficulties of gradients and terrain by this route have already been referred to in the earlier part of this article. The problem of protection by following the Khyber is doubtless simplified; but such a railway is never likely to prove of much utility in a commercial sense in the years to come, though it possibly fulfils the more pressing strategic requirements of the present.

Although the Kabul River Railway has now been placed in the background by the authorities in India, I believe that hereafter, when public opinion has become more enlightened in Afghanistan, and roads, motors and railways develop into a common feature of that conservative country, the main line of railway communication between India and Afghanistan will be by the Kabul River, and that the Khyber route will ultimately give way in its favour.

I am strengthened in this belief to some extent, perhaps, though the case is not quite on all fours, by recent developments of the railway policy in Kenya Colony. Nearly thirty-five years ago, when Macdonald had carried out the preliminary survey for the Uganda Railway, he advocated, with rare prescience, the adoption of a route from Lake Nakuru over the Uasin Gishu plateau to Lake Victoria, near the mouth of the Nzoia River. His recommendation was turned down when the line came to be built some years later; and a shorter, but more difficult, route was constructed from Nakuru to the present terminus of the railway on Lake Victoria at Kisumu. Time has shewn that Macdonald's advocacy of the Uasin Gishu route, in view of the likely traffic from Uganda and the lake, and the future development of British East Africa generally, was thoroughly sound. After an interval of nearly thirty years, the Uasin Gishu line is now being pushed forward with energy to meet the crying needs of that fertile region, which should have been opened out long years before, had the railway but traversed it.

CONSTRUCTION OF BRIDGES FOR PILGRIM TRAFFIC AT THE KUMBH MELA, HARDWAR, 1927.

By MAJOR AND BREVET LIEUT.-COL. P. NEAME, V.C., D.S.O., R.E.

GENERAL.

1. No. 3 Field Company, K.G.O. Bengal Sappers and Miners, was allotted the task of the construction of the following bridges across the main canal supply branch of the River Ganges at Hardwar :

(i) Two bridges at Lalta Rao, each with a 10ft. wide roadway, primarily required for cart traffic (length 370ft.).

(ii) A group of three bridges at Gao Ghat ; two each with an 8ft. wide roadway, and the third with a 10ft. wide roadway. These three were to be constructed for crowded foot traffic (length 350-ft.).

The original proposals of the Officer-in-Command Kumbh Mela had been for a single 20ft. wide bridge at Lalta Rao, with a division down the centre for to and fro traffic, and for one 15ft. and one 10ft. wide bridge at Gao Ghat.

A study of the materials available, the difficult conditions for launching trestles, and the uneven nature of the boulder-strewn bed of the river, forced the conclusion that such wide roadways, with the very heavy loads involved, were impracticable in the time available.

The Gao Ghat bridges were required for the principal religious processions of the festival. As one of these processions has two deities on broad palanquins, which have to be carried exactly abreast, a 15ft. bridge was considered very desirable by the officer in charge, but finally a compromise was made for two 8ft. bridges, to be joined into one 16ft. wide bay at each shore bay, and also into 16ft. wide bays for that portion of the bridge carried on barges.

STRENGTH OF COMPANY AND HOURS OF WORK.

2. As the Company was firing its musketry casuals during February, the total strength at Hardwar from 24th January to 9th February, was 105 all ranks. From 10th February to 16th February this was increased to 160 all ranks.

Eighty-five coolies were employed daily in addition.

Eight hours' actual work were carried out daily, excluding Sundays.

LALTA RAO BRIDGES.

3. (i) The length was 370 feet, with 34 trestles, including two four-legged trestles filled with boulders, on each side of a 15ft. clear

waterway for boats and timber rafts. This waterway was required near the right bank. The remaining bays were 10ft. span. A section of the river with trestle positions is given in *Plan* "A."

(ii) A standard trestle was used throughout, design is shown in *Plan* "B." The trestle comprised a long leg and a short leg on each side, spiked together top and bottom with $\frac{3}{4}$in. square twisted iron spikes, and also lashed with wire. The ledger was held between the legs by the bottom spike. Diagonal braces were spiked with $\frac{1}{2}$in. square spikes and lashed with wire. Longitudinal braces were bolted on at the foot of each leg so that they could be dropped into position directly the trestle was launched. The transom consisted of four 10in. by 5in. sleepers, 14ft. long, the two centre sleepers on edge spiked together, the top and bottom ones flat, and the whole bound with three wire lashings. The actual transom load was 10 tons, and for this 14in. by 10in. timber would have sufficed, but as only sleepers were available and time and labour to key them together into one beam was not available, a very bulky 20in. by 10in. transom had to be employed.

(iii) Road bearers, normal 10ft. span :—seven 40lb. rails, going over two bays, as the rails were 24ft. long. For the 15ft. waterway 13 rails were used.

(iv) Roadway :—a double layer of bamboos, each bamboo lashed down in four places with *moonje*. Ten-ft. sal *tors* as ribands, were lashed down in three places with *moonje*. Bundles of thatching grass were laid on the bamboos, and over this 3in. of sand and shingle.

(v) Handrails :—two rows of 18-lb. rails, joined into continuous rails by fishplates, were fixed into notches in the long legs of the trestles by wire lashings.

(vi) The load allowed for was 175 lbs. per foot super for pilgrims crowded in a disorganised mass. Another 50 lbs. per ft. super for weight of sand, bamboos, and rail roadway gives a transom load of 225 lbs. per ft. super or 10 tons on the transom. Actually the bridge designed would carry heavy motor lorries or light tanks, but it cannot be considered unduly massive when it is remembered that some of the processions consist of massed religious fanatics who proceed in a series of jumps or bounds, and that a total of possibly one million pilgrims would cross the bridges in one day on their way to the "Sacred Pool." Moreover, in the last Kumbh Mela, in 1915, it was reported that some of the trestle transoms broke under the strain.

(vii) List "C" attached gives all the materials actually incorporated in the two Lalta Rao bridges.

(viii) The two Lalta Rao bridges were built concurrently, the derrick boat launching a trestle in each alternately.

The progress was as follows :—

	Trestles made.	Trestles launched.
1st day's work.	10	1 No derrick boat.
2nd ,, ,,	16	6 Derrick boat arrived in evening.
3rd ,, ,,	17	12
4th ,, ,,	7	16
5th ,, ,,	2, 4—legged.	15
6th ,, ,,	2, 4—legged. 6 ordinary.	2
7th ,, ,,	8	3 4—legged.
8th ,, ,,	—	1 4—legged.
		12 2—legged.
9th ,, ,,	Completion of roadway	and shore end.

(ix) The four-legged trestles were very cumbersome and awkward to launch in the very swift current near the right bank, and without this 15ft. waterway the bridges could have been completed two days quicker. A bamboo lattice lining was put in these trestles to contain stones and boulders and thus make a massive pier to stand the shock of impact of timber rafts.

(x) The only serious hitch in construction occurred when launching the first four-legged trestle. The current swept this too far down, and when the derrick boat was picking it up again one leg of the derrick, or rather sheers, snapped at the bottom and the whole sheer legs fell off the boat into the water. The trestle then began to go down stream and broke the foot-rope by which it had been anchored to the head of the bridge. This trestle had to be abandoned, as it went down over shallow rapids with a rocky bottom, over which the derrick boat could not go.

(xi) Photos of the construction of Lalta Rao bridges are attached.

Gao Ghat Bridges.

See Plan D, Section of 10ft. Bridge. Plan E, Section of 8ft. Bridges.

4. (i) The length was 350ft. Of the three bridges at this place, the downstream one, 10ft. wide, was constructed entirely of trestles, 34 trestles. The two upstream bridges were made of large country boats and trestles. Commencing from the left bank, a broad 16ft. roadway ran over a single wide trestle and thence over four 85ft.-long country barges, so that the first 106 feet of the bridge had a single wide roadway. From this point on to the right bank the roadway was divided into two 8ft.-wide tracks carried on pairs of trestles. The trestles comprising each pair were slightly staggered so as to fit as close together as possible. Extra road bearers and bamboos were laid between the two bridges so that the two roadways were joined, hand rails on the inner side of each being omitted. The inner legs and bracing had to be left for constructional reasons.

(ii) The design of trestle was similar to that already described for Lalta Rao bridge, the width being varied for 8ft. roadways. The 16ft.-wide trestle for the first bay on the left bank had central legs added to support the transom.

(iii) Road bearers, 10ft. span, five sleepers on flat for the 10ft. bridge, and four sleepers on flat for the 8ft. bridges. Sleepers were used on the flat because although one less sleeper might have been used on edge, the spaces between would have been too great for the bamboo roadway.

(iv) The four 85ft. boats were anchored by a 3½in. steel wire cable passing from an anchorage 240ft. above the centre line of the bridge on the right bank to an anchorage 70ft. above on the left bank. This was calculated so that the cable could lie on the river bed and be lifted up and pass in a correct curve over the bows of the four boats where it was lashed to the thwarts by wire lashings. The boats were kept in place by distance pieces at bow and stern, consisting of sleepers with 15in. spikes driven through to fit over the gunnels. Sleeper roadbearers were also fitted with these spikes to fit each side of the gunnels. The boats were also connected bow and stern by two diagonal wire braces (1¼ inch steel wire cable) which were tightened up and secured by bulldog clips after the boats had taken their final position. The roadway over the boats, 14ft. span, was carried by 10 sleepers on edge, notched to fit on the gunnels flush with the other sleeper roadbearers which were on flat.

(v) List "G" attached gives all the materials incorporated in the 10ft. Gao Ghat bridge and in the two 8ft. bridges.

(vi) *Progress.* The 10ft. trestle bridge was completed first and then the two 8ft. bridges, concurrently, as follows:—

	Trestles made.	Trestles launched.	Remark.
1st day's work.	20	9	
2nd " "	14	2	Derrick boat sunk.
3rd " "	—	5	New derrick boat at work.
4th " "	—	2	Derrick boat guys breaking and failure to manœuvre it correctly.
5th " "	—	1	
6th " "	23	7	Completion of 10ft. bridge.
7th " "	23	10	
8th " "	2	12 By boat.	
		3 By hand.	
9th " "	—	20 By boat.	
		4 By hand.	
10th " "	—	7 By boat.	
11th " "	Completion of roadway of two 8ft. bridges		

(vii) The launching of trestles at Gao Ghat was very much more difficult than at Lalta Rao owing to the fierce current, the nature of the bed of the river, loose stones and boulders, which

shifted about under the influence of scour, produced by any obstruction to the current, and the fact that there was a shoal in the middle of the river on which the derrick boat frequently went aground.

To start with, two bow and two stern guy ropes to the shore were necessary, as well as guy ropes to the traveller on the cable way. Even so the boat frequently remained immovable in the grip of the current. A further difficulty to navigation was the fact that the current at this place set diagonally across the river, and the boat would not move along the cable way at a normal angle to the stream.

A set-back occurred on the second day when the main cable across the river broke under the strain of holding the derrick boat. Actually a 4½in. hemp rope was in use, but being slightly too short, it had to be connected to its anchorage by a double 3in. hemp rope. The two 3in. ropes snapped and in a moment the derrick boat had been swept broadside on to the bridge. The force of the water at once pushed the upstream gunnel under water and the boat filled, sank, and soon began to bulge and break up. A new boat was obtained and a new derrick made and fitted. Fortunately, the Canal Department was able to provide a new 6in. hemp hawser and suitable blocks. This was used as the cable way for the derrick boat to run on and stood the strain.

Further trouble ensued from guy ropes breaking when hauling the boat in shore; 3in. hemp rope being inadequate, 1½in. steel wire cable was used for bow and stern guys.

After some days' work and some changes in personnel, the derrick boat crew became acquainted with the vagaries of the current, and really learnt how to run the boat to and fro without using guy ropes, but simply depending on the angle the boat was held from the traveller. The speed of the current enabled the boat to travel far faster than at Lalta Rao, and actually 20 trestles were launched in one day of nine working hours. Most of these trestles were on the far side of the river, involving a 300ft. or more run to and fro to fetch each trestle.

In these bridges the big four-legged trestles on each side of the 15ft. clear water-way were dispensed with, and, instead, two ordinary trestles were placed 6ft. apart each side of the big span and strongly braced. It had been intended to fill these 6ft. bays with boulders, but it was decided not to, owing to fear of such a big obstruction setting up bad scour. The sunken derrick showed what scour could do in causing trestles to sink, for before the boat was broken up by explosive and removed, it caused trestles at each end of it to sink as much as 2ft. One had to be replaced, and the others had their transoms raised and blocked up.

(viii) Photos of Gao Ghat bridges are attached.

NOTES ON DESIGN.

5. (i) The ordinary type of double-legged trestle used was very stable, and it appears unnecessary to try to add to stability by using cumbersome four-legged trestles or boulder crates, as these latter waste time in launching.

(ii) As the bed of the river is of a shifting nature, it was invaluable to be able to raise or lower transoms after launching. They were only wire-lashed on to the legs and could easily be released and raised or lowered by block and tackle.

NOTES ON ORGANISATION AND CONSTRUCTION.

6. (i) In the first instance tasks were allotted to the three sections of the Company as follows :—

B Section (Mussalman) to man the derrick boat and launch and fix all trestles.

C Section (Sikhs) to construct trestles on shore. The unit trestle construction party was one N.C.O. and seven men.

A Section (Hindus) : (i) to receive trestles from C Section, to fix the transoms when the trestles were by the water's edge, and to fix sling, head ropes and foot ropes ready for the derrick boat. (ii) To lay the roadway and fix handrails, ribands, etc. For the construction of Gao Ghat bridges sections were changed round, so that C Section launched trestles, A Section made them and B Section laid the roadway, etc.

(ii) Eighty-five Coolies were employed daily, approximately allotted as follows :—

Thirty-five to C Section for fetching timber to the trestle parties and for carrying completed trestles to the shore.

Fifty to A Section for fetching rails for the roadway, for laying and binding bamboos and ribands, and for pitching stones into the four-legged trestles.

(iii) The organisation was varied slightly from day to day by transferring some of A Section from roadway to trestle making and vice versa, according to daily progress.

(iv) The derrick boat was invaluable and the bridges could hardly have been constructed without it, for the placing of heavy trestles in a 10-mile-an-hour current and in up to 5½ft. of water would have been a task of extreme difficulty without it.

(v) The following materials were used during construction :—

Grass rope (2in. and 3in.).

Hemp rope (2in., 3in., 4½in., 6in.). The 4½in. and 6in. hemp rope formed the cable way across the river for the derrick boat to run along by means of a snatch-block.

Steel wire rope (1¼in.) for boat guy ropes.

Blocks, single and double.

Two pontoons and superstructure and anchors.

One dinghy.

Steel and ordinary tape measures.

A few picks and shovels.

Artificers' tools, hand saws, adzes, augurs, chisels, claw-hammers, rivetting hammers, miners' hammers, sledge hammers.

Wire cutters and pliers.

Chalk and black paint for marks on trestles, etc.

Augurs are very easily blunted and broken in the sal timber, which comprised all the spars, and a supply of about 30 1in. and 30 ¾in. was only just adequate.

(vi) The dinghy with a crew of three and a lifebuoy stood by all the time during work, in case of accidents.

(vii) The contract made for the construction of the bridges enabled every man to receive his ordinary day's engineer pay plus a proportion extra. This extra was issued in the form of bonuses for rapid work. A daily competition amongst the trestle making parties, and a graduated bonus for the number of trestles launched daily ensured rapid work.

LIST C.

STORES INCORPORATED IN THE TWO LALTA RAO BRIDGES.

	Average length.	Average diameter.	Quantity.	Remarks.
Sal Ballas.	25 ft.	7 inch	164	For trestle legs each balla made 2, 3, or 4 legs.
Sal Ballies.	20 ft.	4 inch	504	Bracing.
Sal Tors.	11 ft.	4 inch.	150	Ribands.
Deodar Sleepers.	14 ft.	10" x 5"	308	Transom.
Rails 40lb.	24 ft.		278	Road bearers.
Rails 20lb. with fish plates	20 ft.		150	Handrails.
Bamboos	10 ft.		9,000 approx.	Roadway.
Twisted spikes	15 inch 18 inch	¾ in. sq. ¾ in. sq.	172 172	
Spikes	9 inch	½ in. sq.	500	
Dog spikes for Rails			1,668	
Bolts and Nuts	15 inch	½ inch	280	For bottom of longitudinal bracing.
Nails	2 inch		6,000	In lieu of staples for fixing wire lashings.
Wire, 8 gauge, malleable			30 cwt.	
Moonje (Grass string)			A large quantity.	For fixing bamboos and ribands.

NOTE.—Instead of 15 inch bolts, 13 inch bolts threaded for 3 inches would be better, if the timber scantlings are as above.

LIST G.

STORES INCORPORATED IN THE THREE GAO GHAT BRIDGES.

	Average Length	Average Diameter	No. in 10ft. bridge	No. in double 8ft. bridge	Remarks.
Sal Ballas	25 ft.	7 inch	102	144	Trestle legs.
Sal Ballies	20 ft.	4 inch	238	336	Bracing.
Sal Tors	11 ft.	4 inch	70	70	Ribands.
Deodar Sleepers	12 ft.	10" x 5"	187	344	Road bearers and Transoms.
Deodar Sleepers	14 ft.	10" x 5"	136	115	
Rails 40 lbs.	24 ft.	—	13	26	Road bearers.
Rails 20 lbs.	20 ft.	—	62	60	Handrails.
Bamboos	10 ft.	—	5,000 approx.	14,000 approx.	Roadway.
Twisted Spikes	15 ft. 18 ft.	— —	68 69	96 96	
Spikes	9 ft.	—	595	976	
Dog spikes	—	—	52	104	
Bolts and Nuts	15 ft.	½ inch	136	192	For bottom of longitudinal bracing.
Nails	2½ ft.	—	3,000	5,000	In lieu of staples for fixing wire lashings
Wire 8 gauge	—	—	15 cwt.	15 cwt.	
Moonje (Grass string)	—	—	A large quantity	A large quantity	For fixing bamboos and ribands.
Country boats	85 ft.	—	—	4	

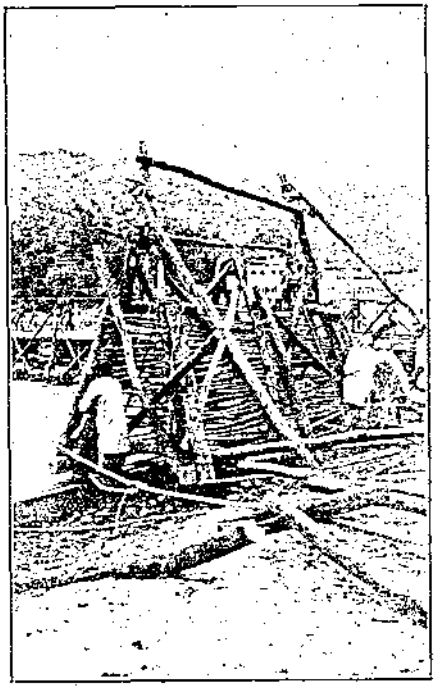


Photo 1.
Four-legged Trestle, Lalta Rao.

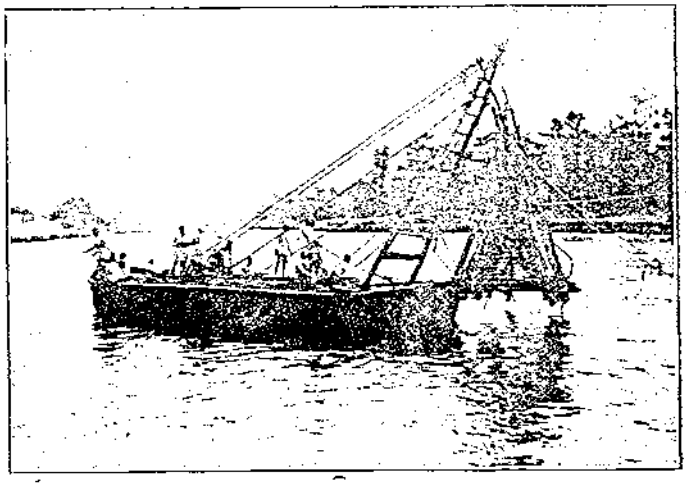


Photo 2.
Launching a Four-Legged Trestle.

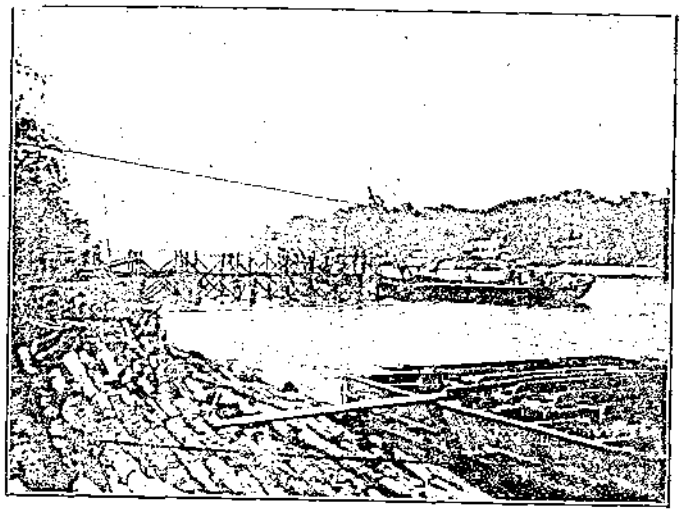


PHOTO 3.
Bridge Construction, Lalta Rao.

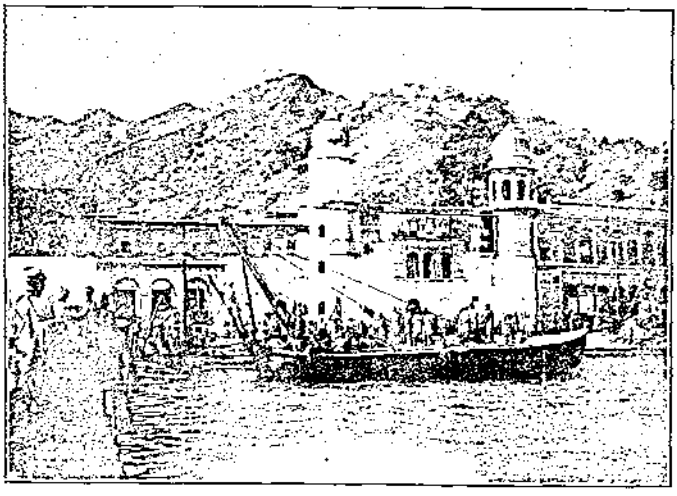


PHOTO 4.
Bridge Construction, Gao Ghat.

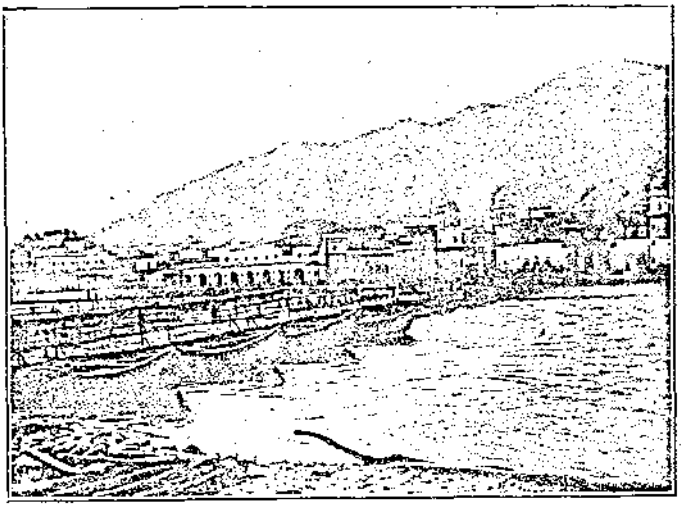


PHOTO 5.
Double Bridge, Gao Ghat.

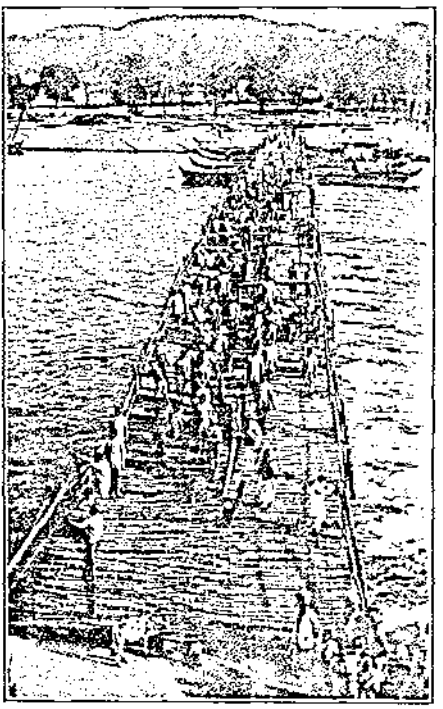
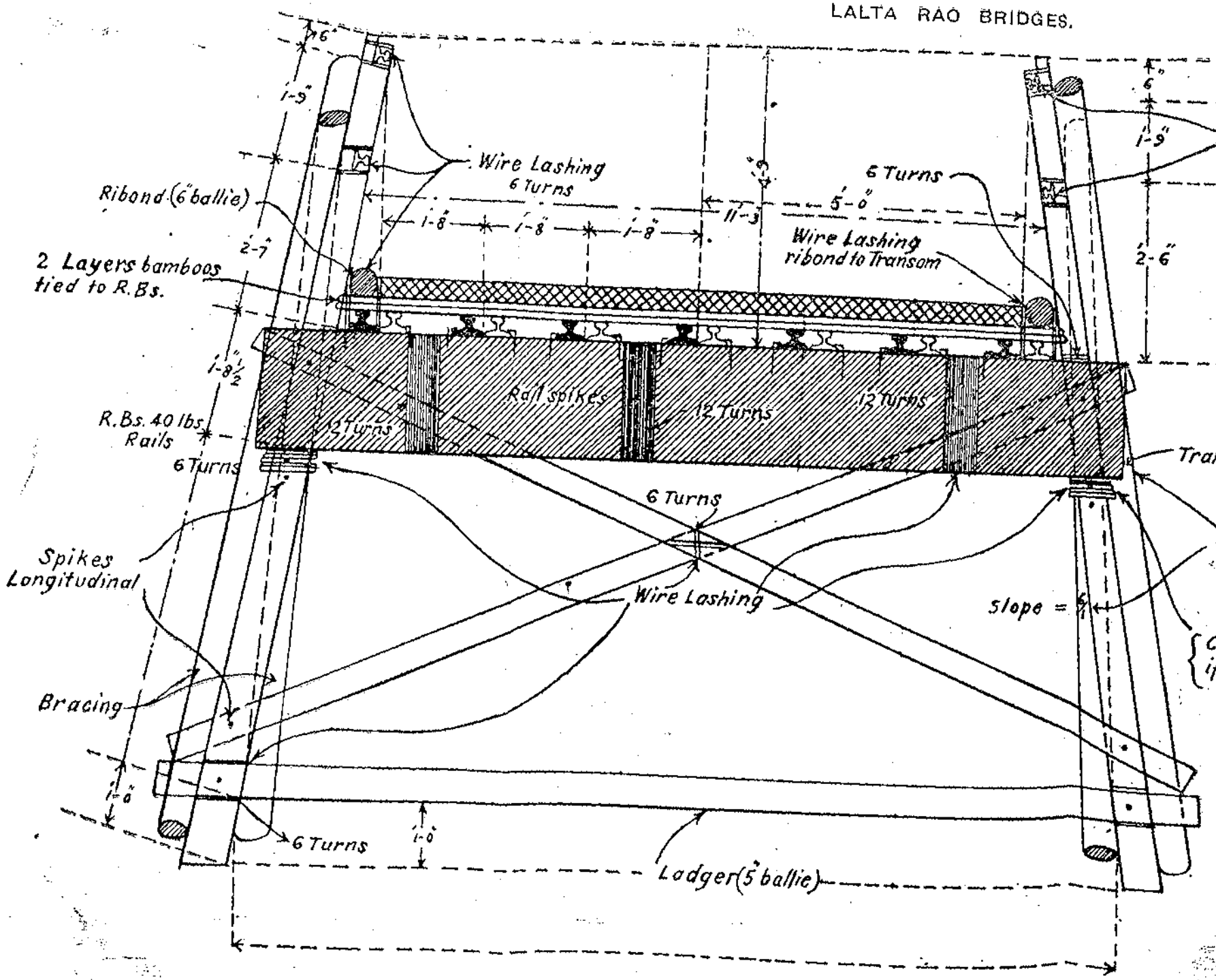


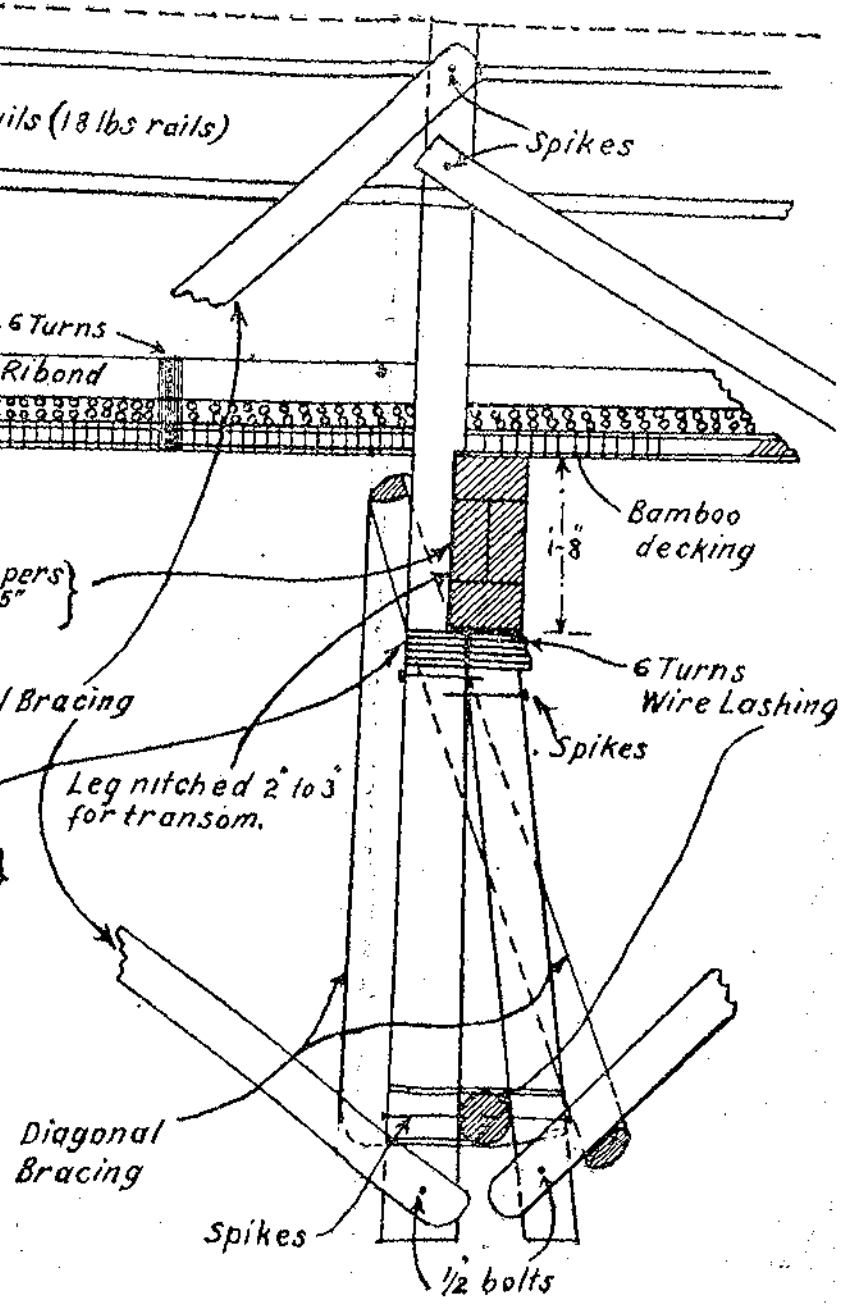
PHOTO 6.
Double Bridge, Gao Ghat.

LALTA RAO BRIDGES.

Plate 1



END ELEVATION

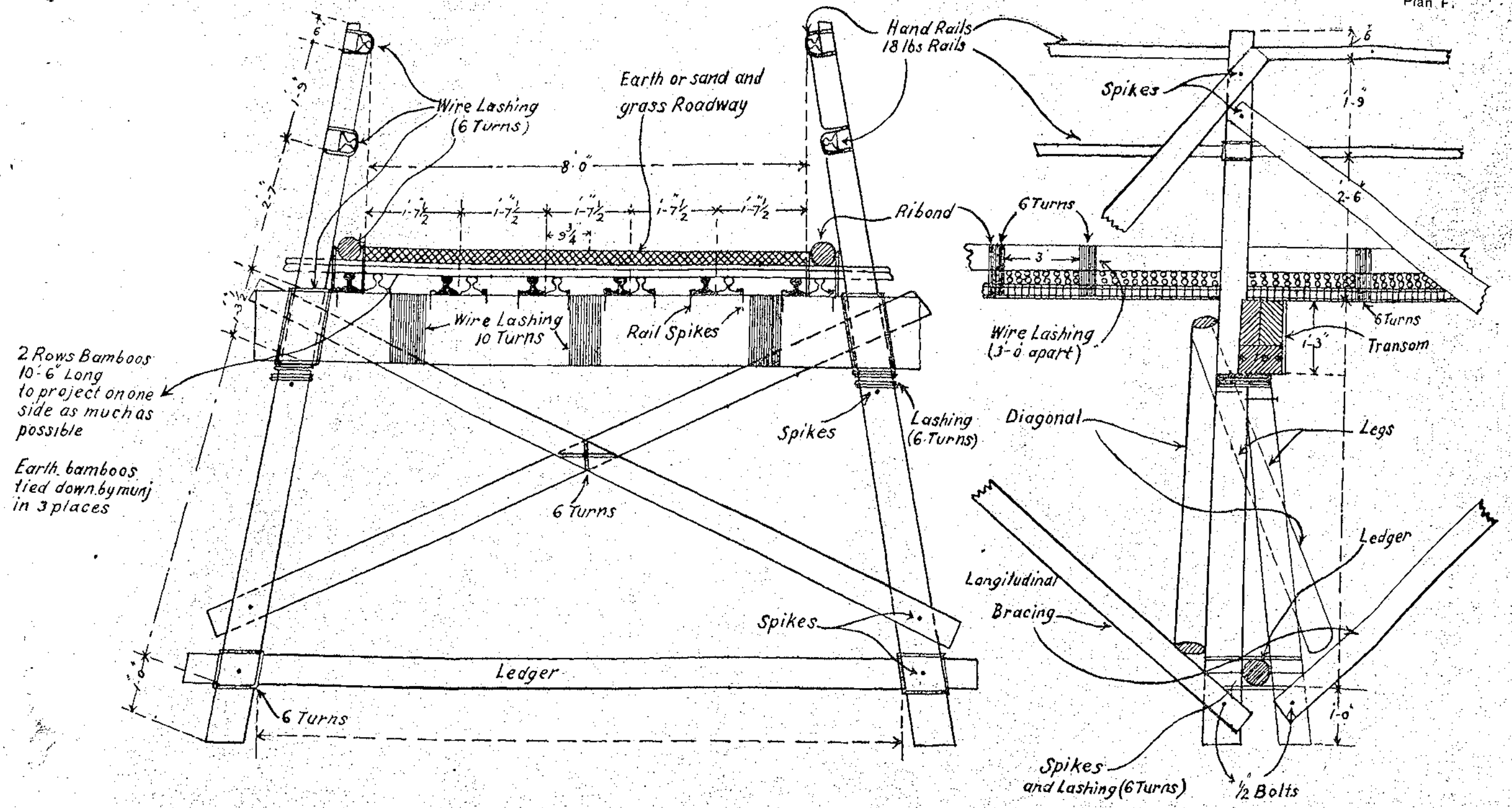


SIDE ELEVATION.

No 1405

GAO GHAT.

Plan F.



Sal Ballies used biggest for Legs remainder for diagonals etc (about 6 m.d.)

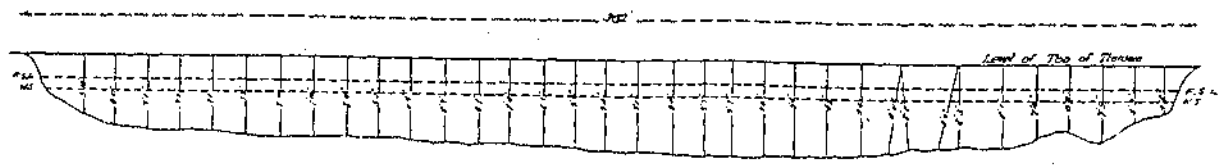
END ELEVATION

SIDE ELEVATION

No 1409

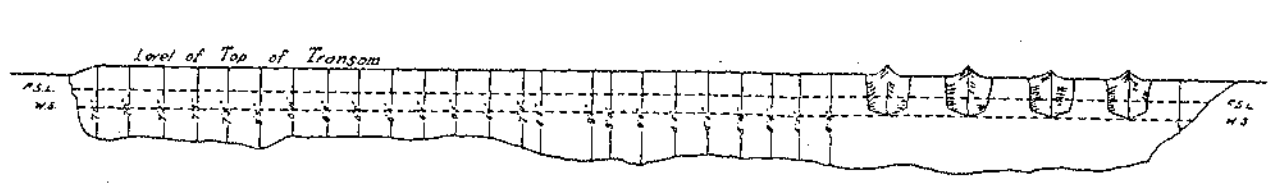
Lalta Rao Bridges

Two 10 ft Roadways – Span 362 feet

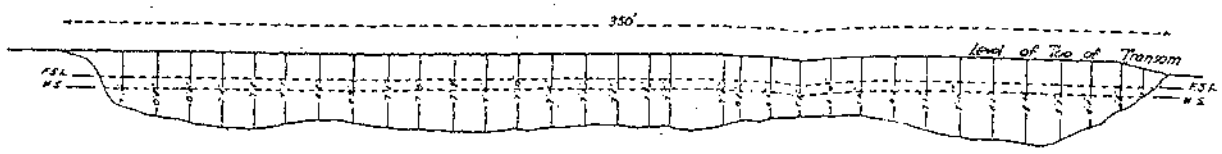


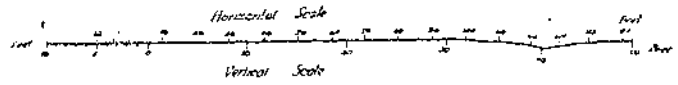
Gao Ghat Bridges

Double Bridge 15 ft Roadway Span 355 ft



10 ft Roadway Span 350 ft





INEXPENSIVE CONCRETE BUILDINGS.

By LIEUT.-COLONEL A. E. DAVIDSON, D.S.O., R.E.

IN the *Royal Engineers Journal* of June, 1926, there appeared an article on Housing Expedients, by Capt. G. Streeten, M.C., R.E. The last paragraph gives a hint of a type which it is proposed to describe in some detail. This system is one introduced by the Universal Housing Company, Ltd., of Rickmansworth.

The system had been brought to the writer's notice some time previously by one of the directors. It made a special appeal by appearing to be very cheap to construct, because it required the employment of very little skilled labour, and utilised for the most part materials easily obtainable locally, except for certain essentials which are detailed later.

An opportunity for trying out the system did not occur till the middle of 1926, when two small buildings were constructed at Shoeburyness.

The first was a section of a Stores building, 48ft. by 24ft. by 8ft. to the eaves, and the second a Stores Office. This latter was not started till after the first was completed, and experience in its construction had been obtained. The costs of construction worked out at 3¼d. per foot cube for the store and 8¾d. for the office. At Shoeburyness there should be no difficulty in erecting buildings similar to the store at or about 3d. per foot cube.

Buildings of this type can probably only be erected cheaply where directly employed labour is available. If put out to contract the prices are likely to be much higher, as contractors do not care to tender for buildings built to a special system. Further, the real economy comes in where the buildings are of a simple nature, such as stores. When there is a complicated interior, the saving on the outer shell is not so appreciable.

The description of the system is as follows :—

A concrete raft, or suitable foundation walls and surface concrete are first constructed. On this vertical pressed-steel channels or stanchions are erected, at 4ft. centres; to the required height of the eaves. These, together with horizontal steel re-inforcing bars (of 5/16th-in. round placed 6in. apart staggered) form the basis of a reinforced concrete structure. No shuttering is used. In its place the outside of the wall is formed by Poilite cement channel

pieces, 12ins. deep, while the inside is formed by asbestos cement sheets of a convenient size to handle—8ft. by 4ft. were used at Shoeburyness. The outer channels are put up one at a time and concrete is poured in layers between the Poilite channels and the asbestos sheets. The Poilite channels are held in place by wire ties at 2ft. intervals secured to inside vertical battens which are erected at 2ft. intervals in between the vertical steel channels.

The details are shown clearly by two plates, No. 1 being an isometric section and No. 2 a horizontal section through a wall.

Both buildings were finished off with asbestos cement tiles laid on battens 12ins. apart. The ceiling of the store was not lined, but that of the office was.

In the first building it was found that the weight of concrete made with Thames ballast was too great if the full depth of a channel were poured at a time, with the result that the interior asbestos sheeting bulged somewhat. The channels were, therefore, only half filled, and the bulging stopped. On the next building it was decided to try a lighter matrix, and breeze clinker was employed. With this material the full depth of the channel could be poured without any signs of unevenness or bulging on the interior lining. Even with a lighter matrix, however, only 12in. high should be concreted at one time, and after it is steady another 12in. can be put on, but a total of 4ft. in height should not be exceeded in any one day.

The concrete should not be too wet, but just moist enough to work in around the channels and bars.

The only skilled labour required is one carpenter for setting out and batten work, and one bricklayer to superintend and put in the concrete, but the latter can be omitted if a good skilled labourer is available.

Now to come to the special points which arose during the erection of the buildings at Shoeburyness.

Both were built up on concrete foundations 12in. wide by 12in. thick (but this thickness can be much less if the subsoil is rock or stiff soil) and under the floors breeze concrete 4ins. thick.

On this foundation a 2in. by $\frac{3}{4}$in. horizontal deal batten should be secured on edge right round the room to serve as a toe to secure the bottom edge of internal asbestos sheets, and behind this the vertical steel channels erected at 4ft. centres.

Great care should be taken with the internal horizontal ground batten to see that it is level and at the correct dimension of the room.

Before erecting channels a 2in. by $\frac{3}{4}$in. deal batten must be fixed to each so that internal asbestos sheets can be secured to it.

At midway between vertical channels another 2in. by ¾in. deal batten is fixed vertically, so that internal asbestos sheets can be secured at 2ft. intervals. The wall plate is fixed to the tops of steel channels, and roof timbers and covering put on in the usual way.

The firm recommend putting on roof tiles before walls are concreted, but this was found awkward if filling walls to wall plate is desired.

Doors and windows have to come between vertical channels, and this may in some cases act as a limitation on designs.

The appearance of the buildings is not unpleasant, bearing in mind that they are concrete structures. The system looks best when the length is long in proportion to the height, *i.e.*, a block of three two-storied houses looks far better than a pair of such buildings, and a single storied building looks better still.

Improvements recently made are :—

(*a*) Manufacture of corner Poilite blocks to avoid trouble or unsightliness at the corners of buildings.

(*b*) Provision of a lip on the Poilite channels, to prevent possibility of moisture penetrating through badly-made horizontal joints.

Enquiries made from inhabitants of dwelling houses made on this system elicited the information that leakage has only occurred at windows which were of steel-framed type. This was remedied without difficulty, but it is thought that the construction of door and window frames should be carefully watched. Where fully exposed, *i.e.*, lower storey windows and doors—zinc flashings should be used.

The system is applicable to two-storey houses.

Examples can be seen near London :—

(*a*) On Sidcup Bye-Pass Road, south end.

(*b*) Chatham Main Line, north of Bromley Station.

One house constructed on this principle was on view at the Ideal Home Exhibition, Olympia, 1927.

Details of dimensions and costs are as follows :—

R.E. Stores Office. Three Separate Rooms.

(*a*) *Outside Dimensions.*

Main Building	44.1 × 16.0 × 8.3	..	5819.0
Roof	½/44.1 × 16.0 × 5.8	..	1998.5
Floor and Founds.	44.7 × 16.6 × 1.0	..	735.7
Chimney	1.6 × 2.9 × 4.0	..	16.6
Ditto	1.6 × 1.6 × 8.0	..	18.0
			F.C. 8587.6

(*b*) *Total Cost.*

	£	s.	d.
Stores	165	10	2
Directly employed labour	145	15	8
	£311	5	10

(*c*) *Cost per F.C.* 8.70*d.*

R.E. STORES BUILDING.

(*a*) *Outside Dimensions.*

Main Building	25.1 × 48.3 × 8.2	.. 9883.9
Roof	½/25.1 × 48.3 × 6.6	.. 3933.5
Floors and Founds.	25.6 × 48.9 × 1.0	.. 1243.2
		F.C. 15060.4

(*b*) *Total Cost.*

	£	s.	d.
Stores	129	16	10
Directly employed labour	76	3	2
	£206	0	0

(*c*) *Cost per F.C.* 3.28*d.*

Acknowledgments are due to the Universal Housing Co., Ltd., for loan of two blocks and drawings from which others were made.

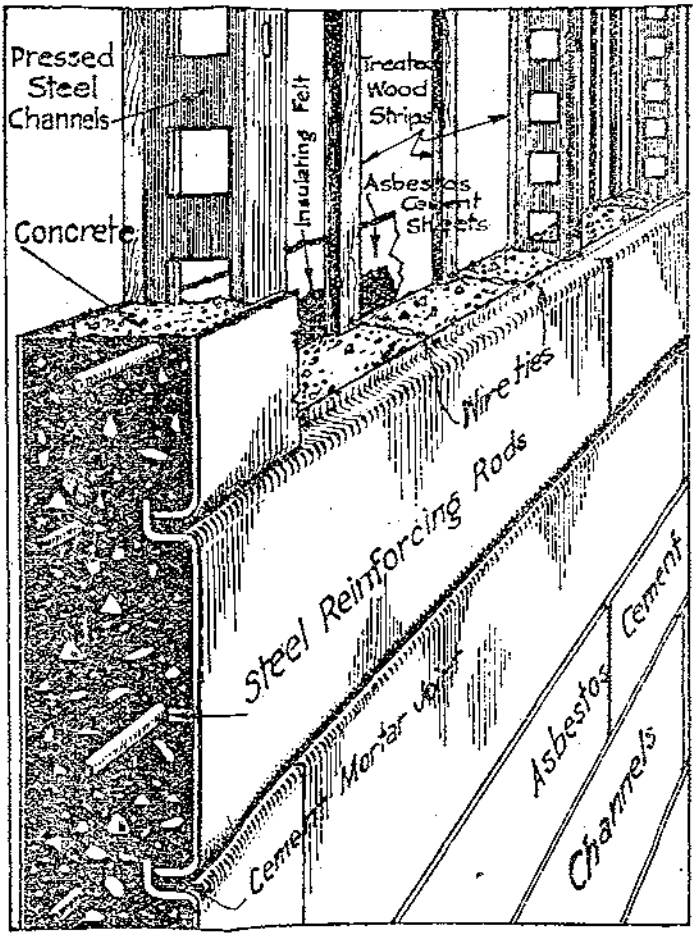
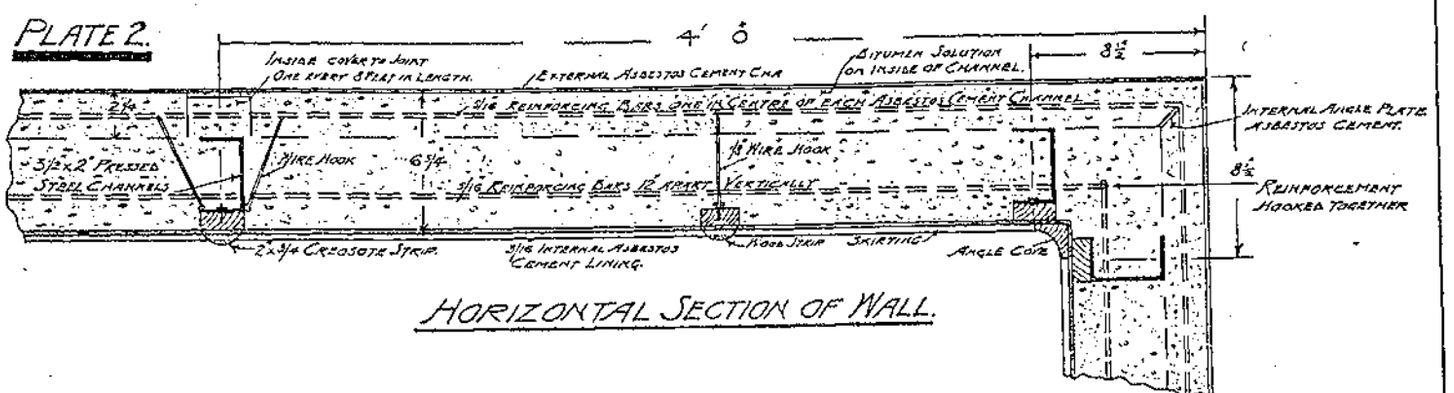

Pressed Steel Channels
Concrete
Insulating Felt
Treated Wood Strips
Asbestos Cement Sheets
Wire ties
Steel Reinforcing Rods
Cement Mortar Joint
Asbestos Cement Channels

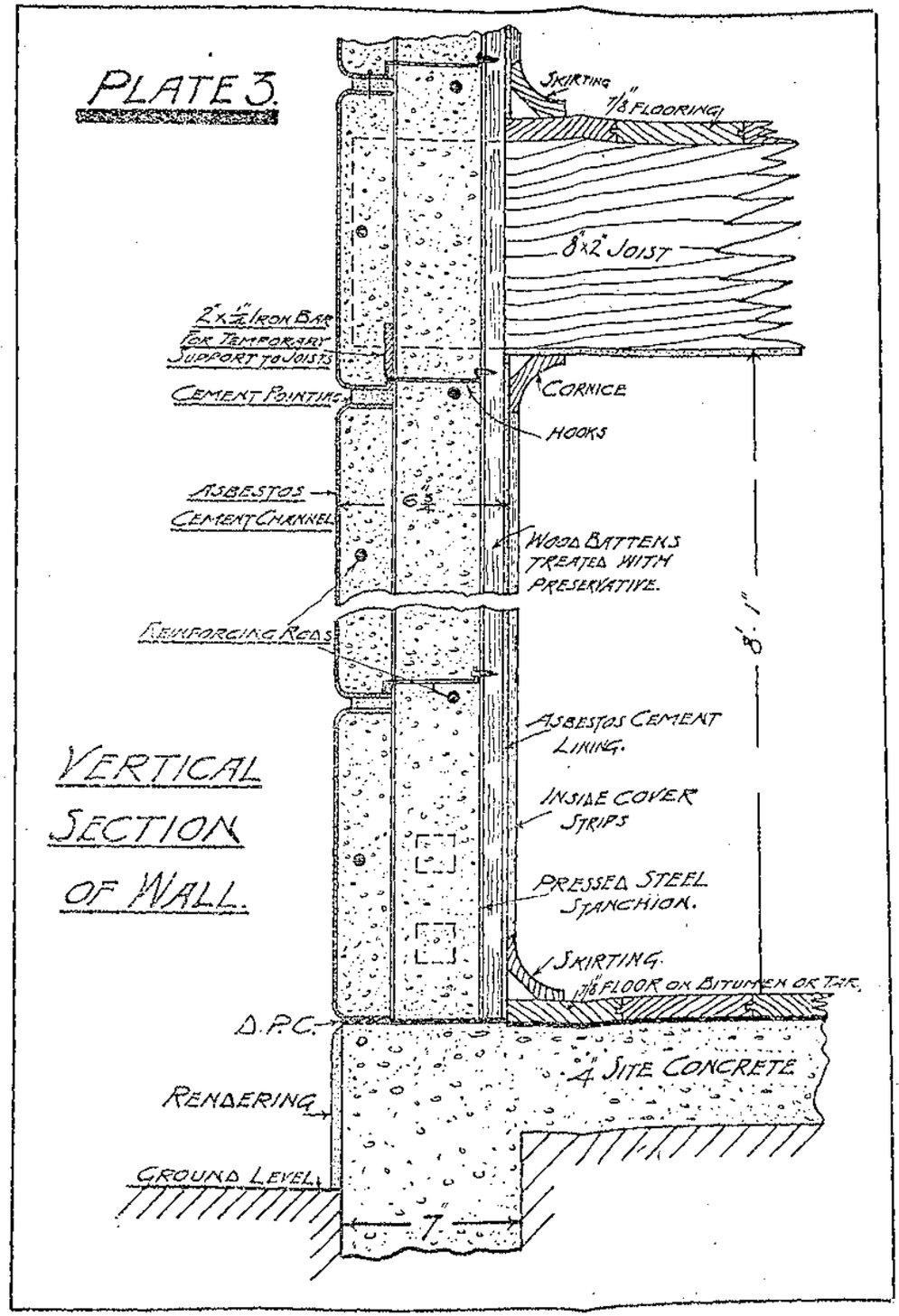
Plate 1.

PLATE 2.



HORIZONTAL SECTION OF WALL.

PLATE 3.



VERTICAL SECTION OF WALL.

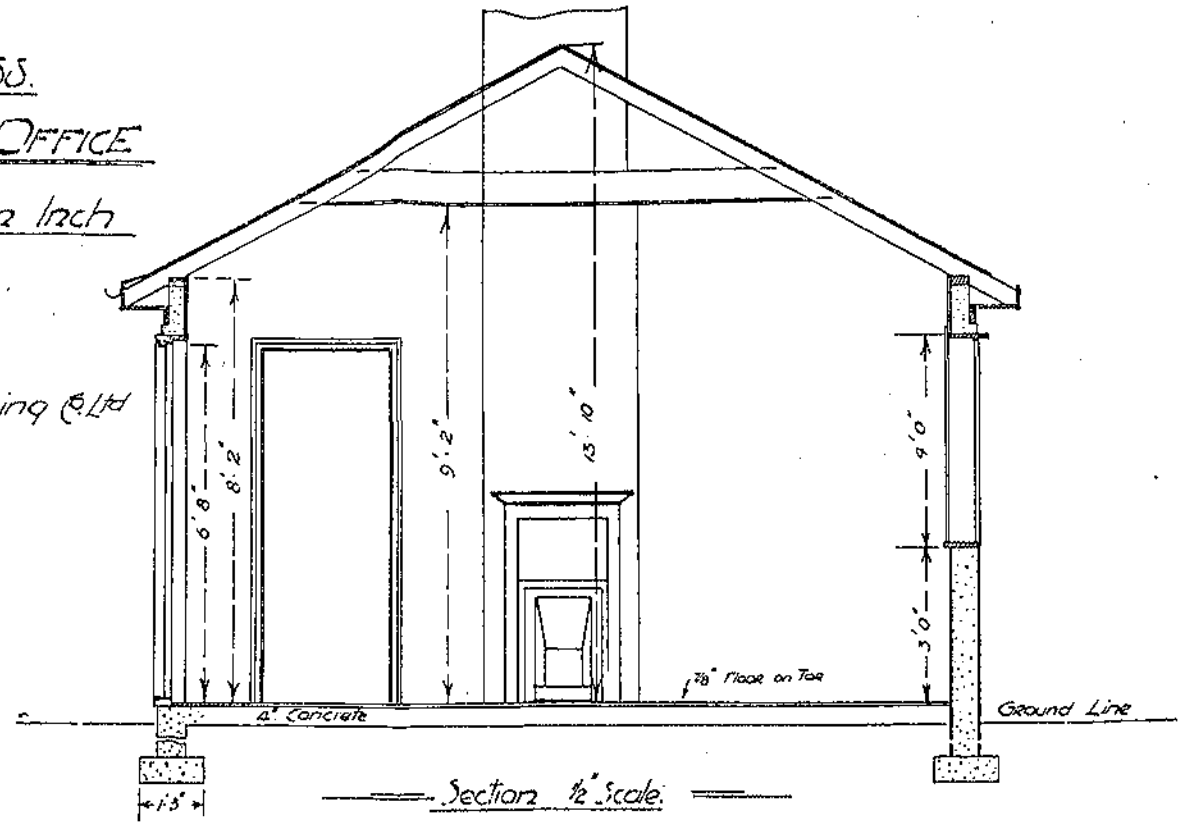
F 4/10

SHOEBURYNESS.

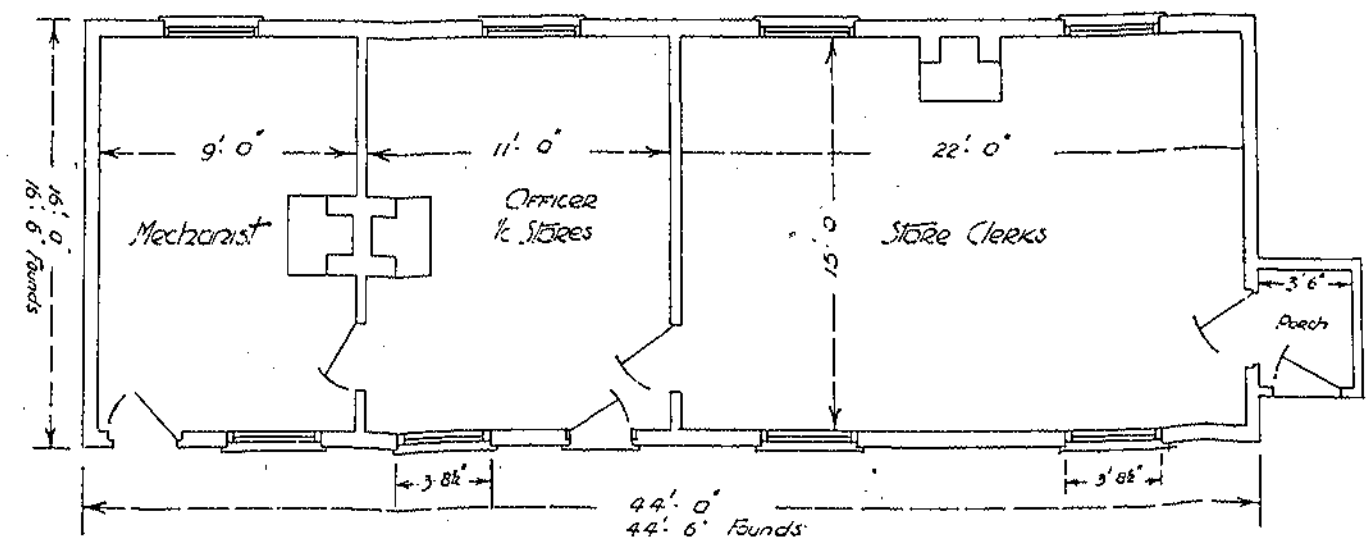
R.E. STORES OFFICE

Scale 4 feet to an Inch

Detail as plan from
The Universal Housing Co. Ltd



Section ½" Scale.



PLAN.

JB 2H 6 26

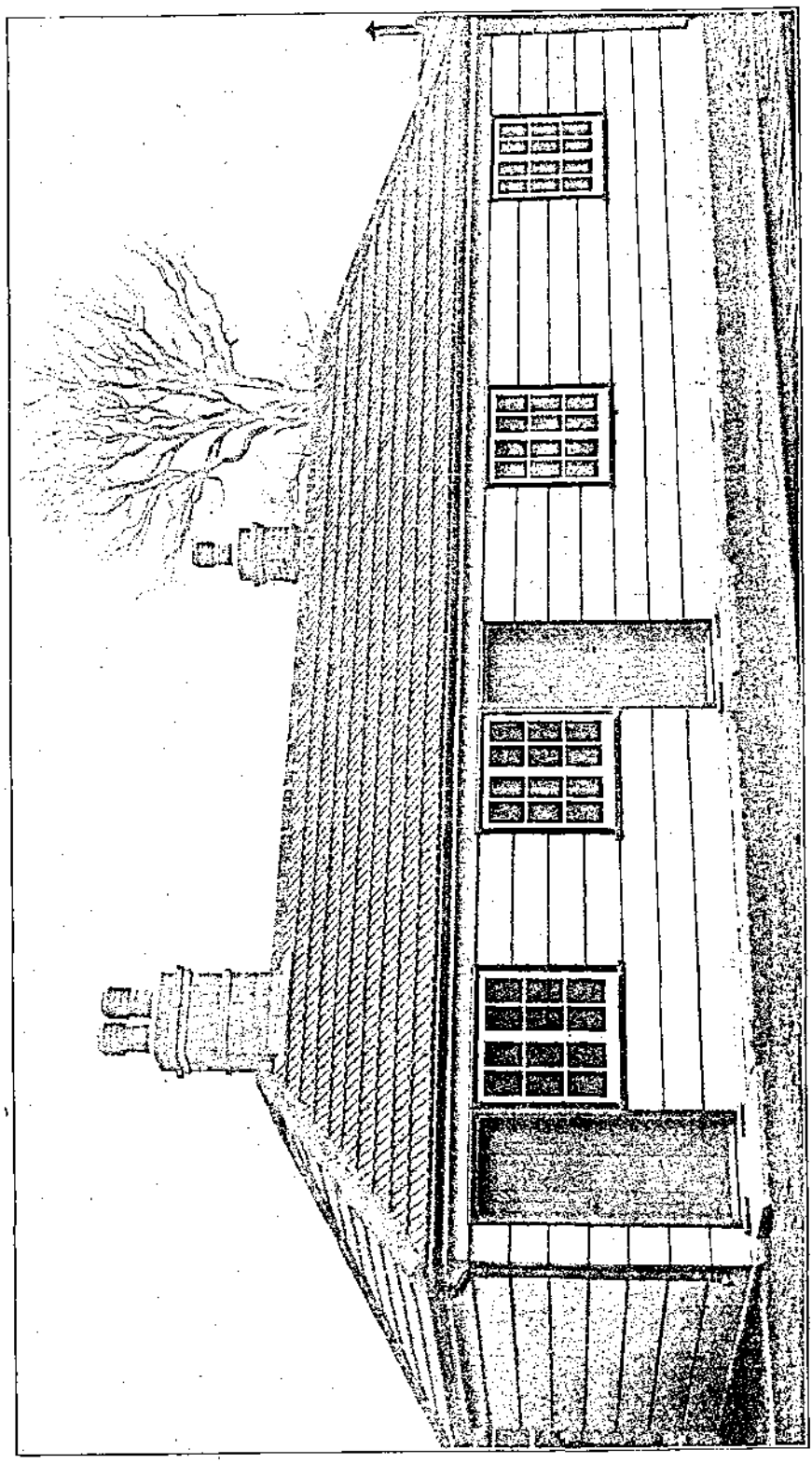


Plate 5. Stores Office Building, Shoeburyness.

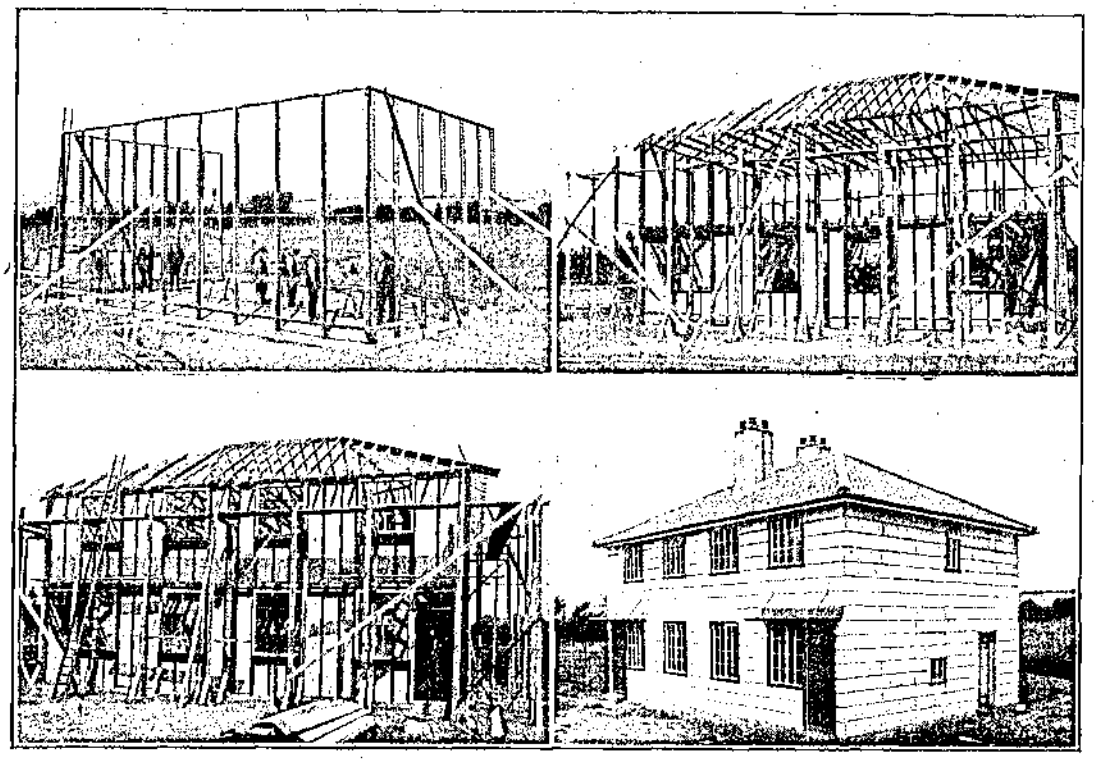


Plate 6. Method of erection of two-storied house.

SOME NOTES ON THE MAINTENANCE AND REPAIR OF MOTOR VEHICLES, WITH PARTICULAR REFERENCE TO COMMERCIAL PRACTICE.

By CAPTAIN J. H. DYER, M.C., A.M.I.MECH.E., R.E.

IN view of the increase in mechanisation, maintenance of motor vehicles will be an essential part of the work of most officers in the future.

"The repair of vehicles is a more difficult process, and calls for greater skill on the part of managers and men than the production of new vehicles."*.

1. MAINTENANCE.

Under this heading will be considered all work which should be carried out with the Unit.

(1) *Inspection.*

The main object is early detection of faults, before serious defects develop. For example :—

Fault.	Possible cause.	Effect of neglect.
Loss of compression.	Valve pitted.	Valve burnt out and valve seating badly pitted.
Knock.	Scoop broken off connecting rod big end (splash lubrication).	Bearing runs, crankshaft journal scored.
Spring clips loose.	Nuts require tightening.	Broken spring leaf.
Difficulty in starting, owing to weak spark from magneto.	Contact breaker points pitted or oily.	Contact breaker points burn away rapidly.

Absolute cleanliness is essential for efficient inspection, as well as preventing grit getting to working parts, and improving the appearance of the vehicle (*e.g.*, on L.G.O.C. omnibuses steering drop arms are kept polished, so that any incipient cracks may be readily detected).

A suggested method of inspecting is as follows :—

The preliminary inspection is carried out by an N.C.O., the driver being first asked to report any minor defects that he may not have had time to rectify. Should faults be detected, in the subsequent inspection, that he ought to have reported, it will be a matter for

* "The Maintenance of Commercial Vehicle Fleets," by E. G. Beaumont, *Prov. Inst. Auto. Eng.*, Vol. XIX.

censure. By this means time is saved, as faults which might not have been noticed are reported at once. (The driver should, of course, at all times immediately report any serious defect that he cannot himself rectify.)

The inspecting N.C.O. should prepare an Inspection report (keeping a carbon copy for reference at the next inspection), with defects noted on a 4-star basis, as follows :—

* Keep under observation.
** Requires attention by driver.
*** Requires attention by workshop staff.
**** Requires immediate attention by workshop staff.

The vehicle should then be inspected by an officer, who will note any additional defects observed, and initial the inspection report.

Each driver should normally be allowed at least one-half day a week preparing for inspection.

In cases where the drivers do no repairs or adjustments themselves a Driver's Report Book may be kept, with columns to be filled up by each driver, on return from work, under the following headings :—(1) Vehicle Number ; (2) Chassis Repairs Required ; (3) Body Repairs Required ; (4) Driver's Signature, Time and Date ; (5) Repairs Executed ; (6) Fitter's Signature, Time and Date. (Columns 5 and 6 being completed by Workshop Staff.) This system is usual with omnibus companies, as it enables vehicles to be at work on the road for the whole of the drivers' working hours, running adjustments being carried out by a special staff outside normal working hours.

(2) *Routine Attention.*

This greatly reduces breakdowns and should be adhered to as closely as possible. Examples (practice of the Southdown Motor Services Co.) :—

TABLE I.

Item.	Interval at which routine attention is carried out.
Lubrication of engine and chassis.	As per Makers' Instruction Pamphlet, giving daily, weekly, monthly, quarterly, and half-yearly items.
Test pneumatic tyre pressures.	Twice daily.
Examine valves, grind in and adjust tappets if required.	2,000 miles.
Inspect electrical equipment, top up battery with distilled water, test density of electrolyte, remove for special charging if necessary.	Monthly.
Overhaul and test magneto.	18,000 miles.
Complete overhaul of chassis and body.	30,000 to 40,000 miles, or annually.

N.B.—An annual overhaul is carried out by Motor Omnibus Companies (1) to satisfy Police Regulations; (2) to maintain the bodywork in smart condition; (3) on account of the annual mileage (usually 30,000 to 40,000 miles).

(3) *Method of Obtaining Fuel Consumption.*

Petrol tank is full, on starting work daily. On return from work driver refills tank, and enters the petrol drawn in a log book, together with particulars of journey, extra mileage due to deviations, etc. This method avoids the inaccuracies of petrol gauges, and insures that tanks are always full, in case vehicles are required at short notice. It may be mentioned that petrol consumption is far from being only affected by carburettor setting. Careful warming up of radiator, avoiding idling and low gear running, condition of the ignition (particularly running at all times with as full an advance as possible), valves, piston rings, etc., all have a large influence.

(4) *Records and Programmes of Work* (*Southdown Motor Services Co.*).

(*a*) *Petrol and Oil Consumption:* recorded for all vehicles. A minimum performance is laid down, *e.g.*, not less than 6 miles per gallon of petrol and 200 miles per gallon of engine lubricating oil, for 50-seater omnibuses. Any vehicle falling below these figures is at once withdrawn from service, for attention by maintenance staff.

(*b*) *Monthly Inspection of Electrical Equipment.* A chart as under is used. At the end of the month each horizontal space should have at least one entry.

ELECTRICAL EQUIPMENT INSPECTION CHART, JUNE, 1927

Registered Number of Vehicle.	Battery in use.	Month						
		1	2	3	4	5	etc.	31
1706	X 64		O					
1707	E 69			O%				
1720	O 71				XV451	+		
1732	H 72		O			*		

+ = gassing charge given.
X = battery changed. Number of new battery is given.
O = topped up.
% = switchbox changed.
* = dynamo changed.

Each battery has its number and distinguishing index letter, showing the Maker, viz.:—

X = Exide.
E = Edison.
O = Oldham.
H = Hart.
V = C.A.V.

(*c*) *Monthly Top Overhaul and Thorough Inspection.* Remove wheels and examine bearings, decarbonise, drain engine sump if

necessary, inspect magneto platinum points and trim if necessary, etc.

A chart similar to that for Electrical Equipment in 3 (*b*) above is kept.

(*d*) *Valve Grinding and Magneto Chart.* A chart on similar lines to that given in 3 (*b*) above is prepared. Mileage since last overhaul of valves and magneto is entered weekly, for each vehicle. When the mileage exceeds 2,000 for valves, and 18,000 for magneto, it is entered in red, to show attention is due.

(*e*) *Life of Units.* Chassis is divided up into six units, viz. :—

Engine.
Steering.
Front axle, wheels and springs.
Gearbox.
Differential.
Rear axle, wheels and springs.

Each of these units has its own registered number, and is normally sent for overhaul after 30,000 miles. A card index system is used, a card as per Fig. 1 being kept for each vehicle, and entered up monthly.

The term "chassis" means all units, except those separately shown on the card. It may happen that all the units were overhauled at the same time, in which case only one "curve" will be required on the card graph.

Magnetos are also shown on the graph, being sent for overhaul every 18,000 miles.

To save crowding "curves" together, they may start from either side of the card, where several units have been overhauled at different mileages. An arrow shows the direction in which the mileage "curve" is to be read.

In Fig. 1 the chassis (less gearbox) of Vehicle 1706 started the year with 6,000 miles use, since last overhaul. At the end of November it is sent for complete overhaul.

The magneto (No. 640) started with 10,000 miles and was exchanged for magneto No. 190 about May 15th.

Magneto 290 became due for overhaul at the end of November, and the chassis, after overhaul, was re-issued with magneto No. 720.

Gearbox No. 250 started in January with 21,000 miles since overhaul, and was sent for overhaul at the end of May, having completed 30,000 miles. Gearbox 200 was then fixed in the vehicle, and finished the year at 17,000 miles.

The card index enables mileage to next overhaul of any vehicle to be rapidly ascertained, and assists the repair depot manager to decide how much of the vehicle to strip down when it comes for complete overhaul. Usually, if all the units are nearing their 30,000 miles, it is best to recondition all of them thoroughly; the

VEHICLE 1706.

FIG. I. CARD SHOWING LIFE OF CHASSIS UNITS.

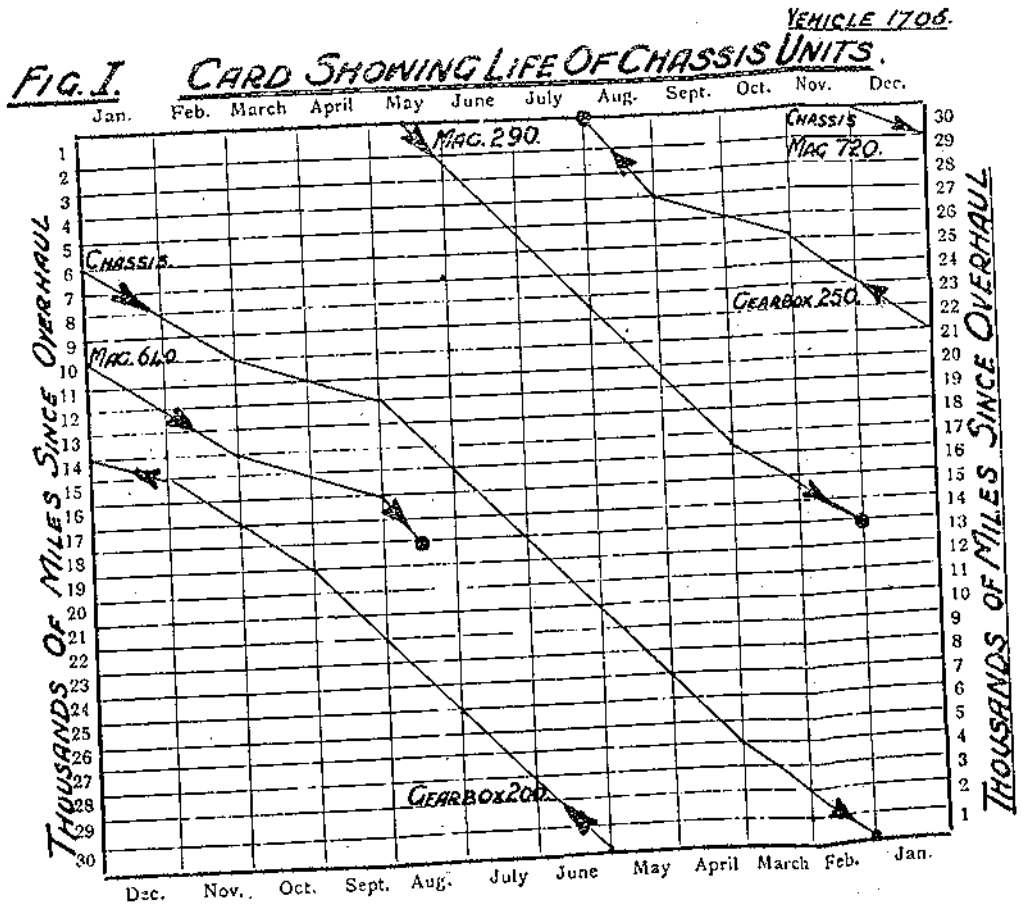
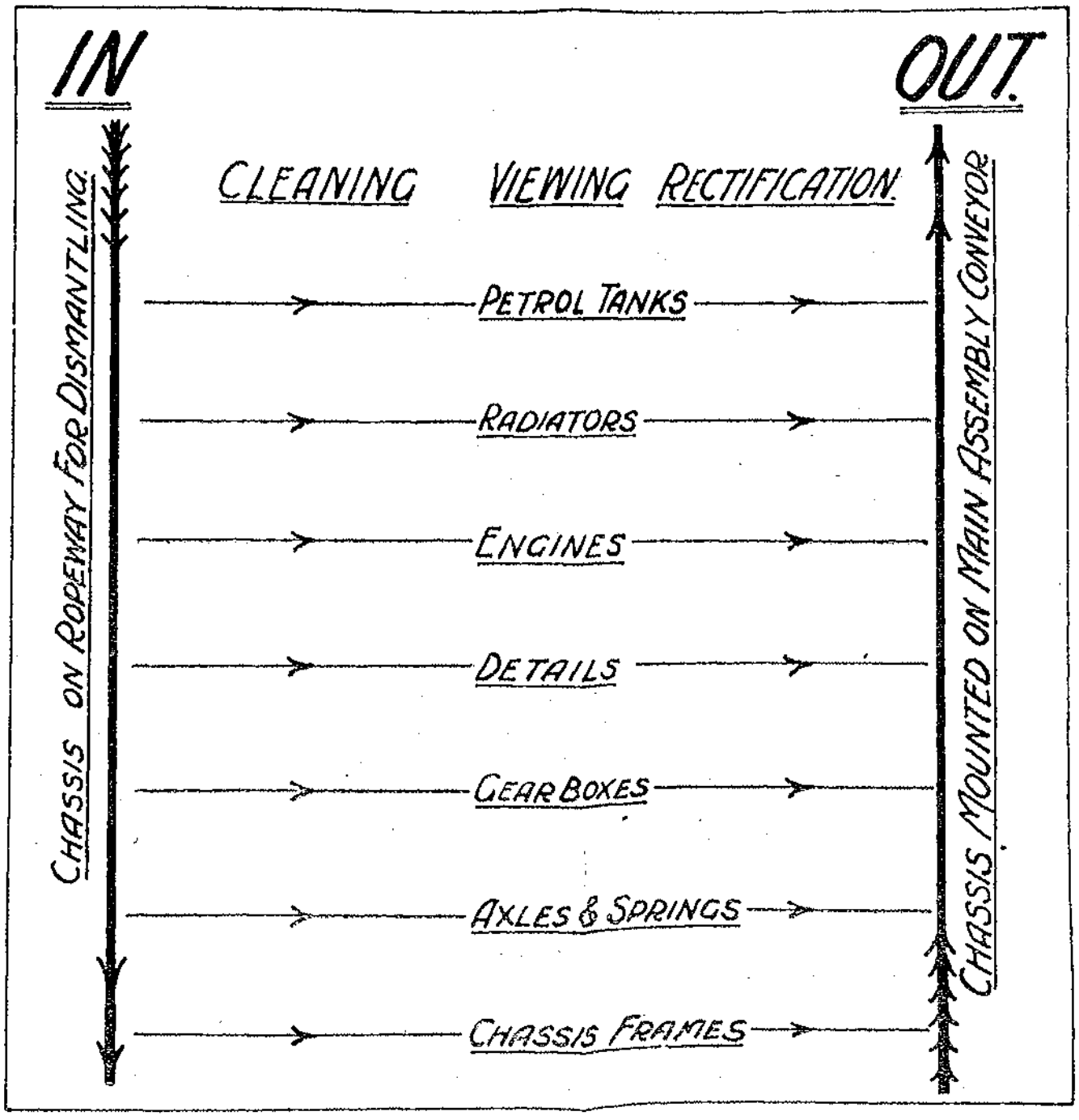


FIG. II.

PLAN OF REPAIR SHOP FOR PROGRESSIVE WORKING.



whole chassis can then start again with all units having the same probable life.

Comparatively little labour is required to prepare the various charts, which catch the eye much more readily than columns of figures.

(5) *Repairs by Replacement.*

Under this system no repairs requiring skilled fitting, or use of machine tools, are carried out by the local workshop. Defective components are removed and replaced by a complete new component. This saves keeping the vehicle out of action during repair, and enables repair of components to be carried out by central workshops equipped with special machines.

It is most suitable where labour is unskilled or expensive, spare parts are cheap and easily obtainable, and a high degree of standardisation exists.

(6) *Equipment for First Line Repairs.*

(*a*) An ample supply of hand tools, kept in good condition (*e.g.*, spanners are frequently almost useless, through being opened out by misuse).

(*b*) Jointing material and joints ready cut for inlet and exhaust manifolds, etc.

(*c*) Timber, jacks and lifting tackle.

(*d*) Cleaning material and valve grinding abrasive.

(*e*) Bins for small stores (expensive spare parts, not in constant demand, should not be held, as this means locking up capital).

(*f*) If top overhauls are to be carried out, a lathe, drilling machine and grinder are required. Battery charging equipment is also desirable.

2. Repair.

(1) *Design and Lay-out of Repair Shops.*

Progressive Working. "Pedestrianism" is not a paying occupation during working hours, to quote Henry Ford, but is, nevertheless, common in many shops.

The object should be to reduce movement of personnel and components under repair to the minimum. To this end, the plant may be arranged with machine tools in groups, each dealing with some component, such as engines, gearboxes, back axles, etc. Each group is, of course, arranged to suit the order of operations in the group.

This is preferable to grouping machines together by type, *i.e.*, lathes, drilling machines, milling machines, etc.

Overhead runways may be used for the transit of material, saving handling and floor space required for trucking.

Fig. 2 shows a diagrammatic plan of ideal lay-out for progressive working.

(2) *Advantages of Centralised Workshops.*

(*a*) The volume of work is sufficient to occupy continuously specialised machine tools and appliances, and individuals may be kept on one process.

(*b*) All repair work may be carried out in one building, saving the waste mileage entailed by repairing, say, bodies at a different repair shop to chassis, etc.

(*c*) The practice of the L.G.O.C. may be quoted. Formerly a number of garages carried out all repairs for between one and two hundred vehicles each, taking sixteen days for the complete overhaul of an omnibus. This has now been reduced to three days, by using a central repair depot.

Conditions are, of course, very favourable for centralisation in the case of the L.G.O.C., owing to the comparatively circumscribed operating area. In the case of military motor vehicles, the cost of transporting by road or rail in a scattered area might form a large proportion of the total cost of repair, and render some decentralisation advisable.

(3) *Specialised Machines and Appliances.*

With a large volume of work, specialised machines and tools are an economic proposition, *i.e.*, the interest on capital and depreciation of the machine is more than offset by the saving in labour cost and much greater accuracy and rapidity attained.

The following examples, mostly from L.G.O.C. works at Chiswick, may be of interest :—

(*a*) *Hydraulic Lift for Removing Bodies.* Operation takes two minutes, which formerly occupied three or four men for two hours.

(*b*) *Rotary Wire Brush for Decarbonising.* Cleans cylinder heads, pistons and valve ports in a fraction of the time required by hand scraping, and leaves a clean burnished surface. Driven by a portable electric motor, with trailing cable.

(*c*) *Cylinder Grinding Machine :* for worn or oval cylinders, for fitting of standard oversize pistons. Southdown Motor Services Co. fit pistons .020ins., .040ins. and .060ins. oversize for the vehicles of their fleet.

(*d*) *Die-casting Machine for re-metalling Bearings.* One man can reline in a day all the bearings for 36 engines.

(*e*) *Press* for trueing sprung crankshafts.

(*f*) *Crankshaft grinding machine* grinds down to nine standard sizes, as journals wear oval. Tolerance .0005ins.

(*g*) *Crankcase bearing Reamering and Running-in Machine.* Reamers crankshaft main bearings to a standard; crankshaft is then fitted and run in. Four men occupied on the machine complete the whole process in 20 minutes; formerly, when the bearings were scraped by hand, the process took one man two days.

(*h*) *Engine Running-in Machine.* Engine is "motored" for a certain time, until the power required to drive it drops to a safe figure (shown by ammeter). In some works, the engine is driven by a "dynamotor" and, when run in, is run under its own power on fuel (petrol, or town gas for cheapness) and supplies power back to the mains from the dynamotor for a period.

(*i*) *Valve re-seating.* Special cutters may be used on the cylinder block: (*a*) to remove a shoulder that may be formed on the valve seat by repeated grinding-in, thus shrouding the valve at the commencement of its lift; (*b*) to remove pitting in the valve seat. Fig. 3 shows two cutters used by hand at School of E.L. for Dennis lorry engines.

Pitting may be removed from the faces of the valves themselves by skimming up in a lathe, or by a special grinding machine.

(*j*) *Valve Grinding-in Machine.* Grinds in all four valves of a two-cylinder block in one operation, the valves being automatically rotated a few revolutions in one direction, lifted, and rotated in the opposite direction, alternately.

(*k*) *Gas Furnace for Springs.* For hardening, tampering and setting. Gives close control of temperature. Four sets of smiths do all the spring work for 4,000 buses annually. By ordinary smithing methods, at separate garages, at least 12 sets of smiths were required for the same fleet.

(*l*) *Pneumatically-operated Reamers for Shackle Pin Brushes.* Speed and accuracy of fitting.

(*m*) *Conveyors.* The work is moved on a travelling platform from one department to the next, at a speed just sufficient for the workers to complete their operations on it. This enables tools, appliances and components to be placed exactly where they are wanted, largely eliminating waste movements. It ensures that the departments feed one another, without the shop foremen having to hustle anyone, as nobody can drop below the standard pace of working.

(*n*) *Portable Engine Starter.* An air-cooled petrol engine drives a dog clutch through reduction gearing, the whole set being mounted on a small truck. The dog clutch can be made to engage the starting handle of a vehicle and turn the engine over rapidly. Used where an engine is stiff after overhaul, or for easy starting from cold in winter in large garages.

(*o*) *Sand Blast.* For cleaning plugs, enables the interior of a plug to be cleaned in a few seconds, without dismantling.

(4) Management.

(*a*) *Programme.*

The order of urgency, and amount of detail dismantling to be done, is decided from :—

(i) Mileage run by each unit of chassis since last overhaul.
(ii) Reports of inspection staff.
(iii) Road test.

The main cost of a general overhaul is generally labour, particularly where the economic balance in design is poor, *i.e.*, much dismantling of parts which are sound has to be done, to repair parts prematurely worn. Parts which are inaccessible should generally, if doubt arises, be replaced, instead of being repaired, to save risk of subsequent dismantling becoming again necessary at an early date.

Each vehicle in for repair should have a label attached, giving description of vehicle (Registered No., etc.), date received, works order No., defects and operations required, remarks (delivery date required, etc.). This label should be initialled by foreman on leaving each department, giving date.

Actually, at the L.G.O.C. main repair works, all vehicles are completely dismantled, as the works are laid out for a standard procedure, which is carried out so expeditiously that it is worth examining every component thoroughly, irrespective of its history.

(*b*) *Records.*

Where the chassis is divided into six units, as given in 1 (4) (*e*) six record books may be kept, each dealing with one type of unit only. Each individual unit has a page in the record book of its type, in which a complete history of mileage, defects and repairs is entered.

(*c*) *Control of Personnel.*

(i) Written instructions, giving duties and responsibilities of all subordinates, fix responsibility in case of complaints, and render reliefs simple in case of changes of staff. A routine book may be kept, with items to be initialled monthly by each member of the staff concerned, so that there may be no excuse for ignorance of any general routine instructions.

(ii) Individual workers should be kept on one job continuously as far as possible, but foremen are responsible that every man is continuously occupied. In the Ford industries, only two divisions of labour are recognised : office and shop. If there is no work for the moment at his usual job, a specialised worker is at once put on to any other work that is to hand, such as cleaning up.

(iii) Distribution by squads should maintain tactical unity as far as possible, *i.e.*, should fit in to the military organisation.

(iv) Returns of numbers on the works, distribution by trades to squads, etc., should enable the management to apply for reinforcements of the correct trades, and check the effect on output of alterations in the numbers employed in different departments.

(v) The management should be constantly on the watch to eliminate waste of time during working hours, such as waiting for tool grinding, issue of consumable stores, etc.

(vi) Best times for meals, intervals of rest, and motion study to eliminate unnecessary movements, should receive attention.

(vii) Unless a careful check is made on output and consumption of stores, pilfering, idling and carrying out of unauthorised work are very likely to develop.

(*d*) Further details as to Administration and Accounts are given in Chapter XXXVII, "Military Engineering," Vol. I (Mechanical Engineering), 1925.

(5) Execution of Work for Overhaul of Chassis.

The following details are mainly from the L.G.O.C. repair works at Chiswick, and illustrate up-to-date practice under the best conditions, *i.e.*, a very large fleet of standard vehicles :—

(*a*) *Progressive Dismantling.*

The chassis is attached to a ropeway moving at one foot per minute, and components are removed in the following sequence: Petrol tank, radiator, engine, steering, brake rods, cardan shafts, gearbox, front axle, springs and wheels, rear axle, springs and wheels.

(*b*) *Cleaning.*

The components, on moving conveyors, pass through sheet iron tunnels, where they are sprayed with hot soda-ash solution, and pass out to the viewing section.

(*c*) *Viewing.*

Special jigs and limit gauges greatly simplify inspection. Units are marked with green paint if fit for immediate use, blue if rectification is needed, and red for scrap.

(*d*) *Engine Repairs.*

(i) Main bearing shells of a standard size are fitted to the crankcase.

(ii) A crankshaft that has been straightened, centred, and has had the journals reground to a standard size, is fitted to the crankcase main-bearings, and run in by a machine.

(iii) The crankcase now begins a three-hours' journey on an assembly conveyor, moving at $7\frac{1}{2}$ inches a minute. After the reciprocating components and cylinder blocks have been fitted, the engine is removed from the conveyor by a pneumatic hoist on an overhead runway to a test stand, where it is run in by an electric motor.

(iv) If the running-in is satisfactory, the engine is replaced on the conveyor, where, at successive stages the carburettor, magneto and generator are fitted.

If any defects are revealed during running in, the engine is transferred to rectification benches, so that the regular flow of work shall not be disturbed.

(*e*) *Magnetos.*

(i) Armature insulation is tested by withdrawing armature and

energising the primary winding by a 4-volt battery and trembler. The secondary induced EMF should be sufficient to discharge across a test gap of 9.5 millimeters (corresponding to 12,000 volts). This test is kept on for half a minute.

(ii) Carbon brushes are examined for wear and broken springs, and should have a clean glazed bearing surface. The condition of the armature earthing brush, or brushes, which generally bear against the condenser end cap, is important, as they are frequently partially insulated by grease from the bearings. If the earth return is allowed to act through the armature ball bearings, corrosion will be set up; to obviate this, some makers actually insulate the outer races of the armature ball bearings with presspahn.

(iii) Contact breaker platinum points are trimmed, if necessary, with dead smooth jeweller's file, to give smooth contact. The break is adjusted to an accurate .012in. on both cams. Bell crank lever fibre bush should only be eased with a taper broach or reamer when necessary; a little light oil may be applied. Roadside methods of easing the fibre bush, such as using the tang of a file, are apt to allow play. The platinum points then get out of line, and burn away in much less than their normal life of 18,000 miles.

(iv) Distributor is lapped, if necessary, to bring the segments flush with the insulation. The distributor rubbing surface is left very slightly oily, to avoid rapid wear of carbon brush. Air gap distributors are not favoured, as two of the segments (in a 4-cylinder distributor) burn away, while the metal distributor arm burns away on the other two, thus ultimately tending to cause the magneto to discharge at its safety spark gap, and stressing the armature insulation severely.

(v) *Remagnetising.* No heating or retempering of the magnets is necessary.

At most repair works the magnets are remagnetized, after dismantling, on an electro-magnet having 5,000 ampere turns.

At the School of Electric Lighting, an electro magnet having 60,000 ampere turns is used; on it magnetos can be remagnetised with their armatures in position, saving the risk of loss of magnetism in assembling, and often enabling the performance of a magneto to be brought up to standard without dismantling. Construction is shown in Fig. IV.

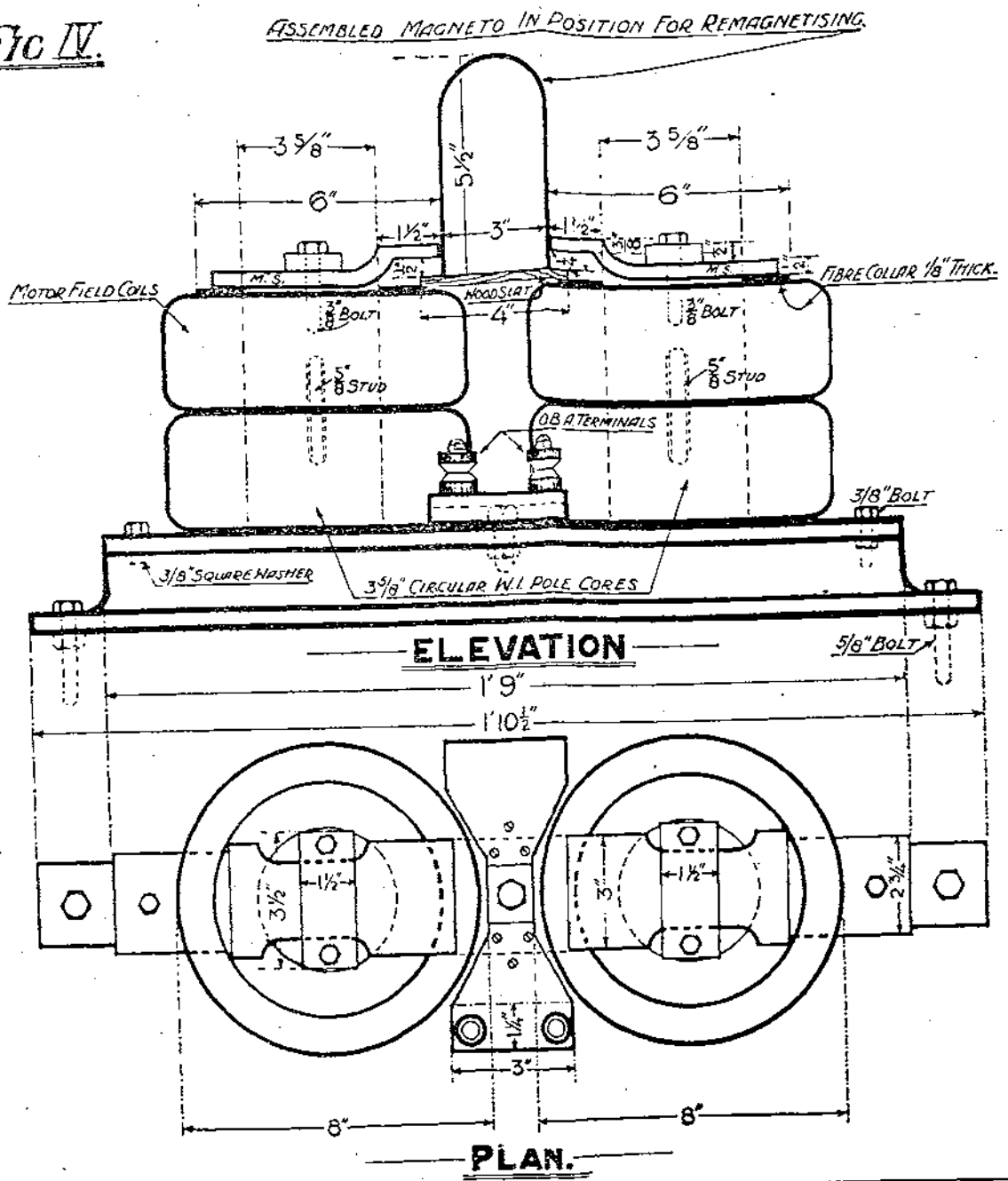
(vi) *Tests.* These are all carried out on a special three-point test gap set to 5.5 millimetres.

(*a*) Slow speed: 100 consecutive sparks, without missing, must be given at 100 r.p.m. on full advance and full retard.

(*b*) High speed: 4,000 r.p.m. for one minute: contact breaker is observed. Slight bluish flashing at the platinum points is permissible; white sparking shows a defective condenser.

(*c*) Endurance: Three hours at 2,000 r.p.m.

Fig IV.



PARTICULARS OF MAGNETISING JIG IMPROVISED FROM THE FIELD COILS OF A 3 HP, 80 VOLT WRIGHT & WOOD SW MOTOR.

No OF COILS 4	TURNS OF WIRE PER COIL 2750	TOTAL TURNS OF WIRE TO JIG 11.000.
GAUGE OF WIRE 28 S.W.G.	TOTAL AMP. TURNS REQ. 60000.	TOTAL CURRENT NECESSARY 2.2 AMPS
RESISTANCE OF EACH COIL 38 Ω VOLTS	VOLTAGE REQUIRED AT TERMINALS 215 VOLTS.	
HOW CONNECTED. 4 COILS IN LOOP ACROSS TERMINALS.		

(vii) Sparking plugs: by keeping gaps adjusted to .015ins. breakdowns of armature insulation from excessive voltage are largely reduced.

(*f*) *Re-erection.*

It is not proposed to describe rectification of remaining components. Each is dealt with in a separate section, and delivered opposite the particular stage of the main assembly conveyor at which it is required.

The main assembly conveyor is 220 feet long by 8 feet wide, and travels at floor level, at a speed of 15½ inches per minute. Each unit is erected by a squad of men, employed on that job only, in the following order :—

Front and rear axles placed in position on conveyor, and chassis frame is lowered from an overhead runway and bolted up.

Then follow gearbox and rear cardan shaft, pedal and brake gear, steering gear, engine and clutch, radiator, dash board and bonnet.

Final operations are: Coupling up of water pipes, adjustment of brakes and engine control, oiling up, filling of petrol tank and radiator, and starting of engine, by revolving drums at floor level engaging the back wheels.

(*g*) *Road Test*

is carried out and list of defects, if any, prepared by the Testing Department. After these have been rectified, a body is mounted and the vehicle is passed out for service.

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The writer is also indebted to the Southdown Motor Services Co. for much information used in this article.

PERMANENT FORTIFICATION IN MECHANISED WARFARE.

By MAJOR G. E. H. SIM, D.S.O., M.C., R.E.

IN an article entitled "The Effect of Mechanicalisation on Permanent Fortification," which was published in a recent number of *The Royal Tank Corps Journal*, Major-General Sir J. E. Capper, K.C.B., K.C.V.O., sets himself the task of examining the modifications which have become, or which will shortly become, necessary in our ideas on permanent fortification, in view of the advances in mechanisation of armies.

He starts by making certain assumptions as to what the mechanised warfare of the future will be like. From these he proceeds to deduce the need for permanent fortifications and the probable form of attack to which such fortresses would be liable at the hands of a mechanized enemy. He concludes by putting forward some ideas on the design and arrangement of such fortifications, by the adoption of which, he considers, such attacks could best be countered.

His main assumption is that the mechanised warfare of the future will be a struggle between two forces capable of extremely rapid movement in all directions. In fact, it would appear that the movements and actions of these forces are to resemble somewhat those of the navies of the present day. Each army will be capable of developing an attack on the other from any point of the compass, but will, whether successful or unsuccessful, have eventually to retire to a "reasonably safe refuge" to re-fuel, refit, and take in supplies. It is, therefore, these refuges or bases that will require to be fortified as strongly as possible, and it is here that the art of the military engineer will find its greatest scope.

He considers that the modern fortress, consisting of a ring of strong forts with field defences in the intervals, would be incapable of resisting an attack delivered suddenly and in strength by a mechanized enemy. The forts would be smothered by artillery fire and aerial bombardment, while mobile forces, assisted by light tanks, would rush the intervals, field defences being useless against tanks, and create havoc inside. On the other hand, he is of opinion that the old, deliberate method of attacking fortresses by investment and siege is obsolete, because of the danger to which the besieging

force, in hastily improvised defences, would be exposed from the mechanised forces of the defenders and from mobile relieving columns.

As the attack will be rapid, the attacker will not have time to bring up much heavy artillery, so exposed masonry and concrete may be used more freely than in the past.

He therefore suggests that the defences of a base should consist of "A ring of small forts, heavily bomb-proofed, armed with machine-guns and numerous Q.F. guns in casemates firing to the flanks . . . surrounded by a ditch . . . to keep out infantry and to ensure that debris . . . does not obscure the flanking guns." Outside the ditch would be a strong wire entanglement, and beyond that would be an anti-tank obstacle, consisting of concrete pillars interspersed with pill-boxes containing anti-tank machine guns and 3 pr. guns. Lateral communication between the forts would be by trenches or underground passages, and the intervals would be defended by concrete pill-boxes for machine guns and anti-tank guns, and blocked by belts of concrete pillars and minefields, enfiladed from the forts. Contact mines would be principally used, but observation mines would be used where lines of egress for the defender's tanks through the obstacle zone were required. Heavy artillery, "*if considered necessary*," would be in strong casemates at intervals inside the perimeter. Mobile anti-aircraft artillery would be provided.

The author claims that this arrangement of the defences would not tie up a large defending force of the field army, would make the base secure against sudden attack, and would enable a stout resistance to be offered, even against prolonged operations.

The article is admittedly written to promote thought and discussion on the relationship between permanent fortification and mechanised warfare, and the author does not claim to have completely solved the problem. This being so, it may, perhaps, be permissible to offer one or two comments upon his suggestions.

The first thing that strikes the reader is the assumption that the development of overwhelming fire of heavy artillery, as exemplified during the Great War, will be incompatible with the degree of mobility attained by a mechanised army, and the conclusion that fortresses of the future will therefore not be called upon to withstand such concentrations. But these concentrations of artillery are an accomplished fact, whilst the mobility envisaged has not yet been achieved. Is it then wise to ignore the substance for the shadow? Should we not rather envisage a state of affairs when the mobility of the heavy artillery will have increased proportionally with that of the rest of the army, allowing of an attack on a fortress by a mechanised army adequately supported by heavy artillery? The problem thus becomes more difficult, but more probable.

The second outstanding point is the way in which, in the defence of the fortress, the forts themselves are to become of minor importance, while the anti-tank obstacles—belts of pillars and mines—assume the first place. This idea, if not carried too far, is probably sound, but it must be remembered that an obstacle which ceases to be under the effective fire of the defenders ceases to be an effective obstacle. Unless, therefore, the forts can survive, the obstacles will be useless. It would appear, therefore, that the forts, if made at all, must be made strong enough to resist the bombardment of any concentration of artillery likely to be brought against them, and still retain their fighting value, while adequate heavy artillery must be provided within the fortress for counter-battery work.

A third assumption which requires further investigation is that field defences can offer no great difficulties to the progress of tanks. This is certainly true of field defences in the state of development at which they had arrived at the end of the Great War, but it is unwise to assume that this state of affairs will last indefinitely. The trench is the most effective cover that has yet been devised against modern artillery fire, and as long as the enemy have artillery, whether mechanised or no, so long will the defenders go to ground in trenches whenever they cease to move. But the old trench, coupled with the wire obstacle, is of little use against tanks, so the problem is to devise an efficient anti-tank obstacle which can be quickly made and which can be used in conjunction with the trench. So far as can be foreseen at present, the most likely solution is the anti-tank minefield, sited in conjunction with a really efficient anti-tank gun. Experiments along these lines would appear to offer more promising results than the suggested reversion to the old type of fort, with all its inherent disadvantages.

The fact is that mechanisation is still in such an embryonic state that nobody can predict with any certainty what form the warfare of the future will take. We have to make assumptions, and the solutions of our problems will be sound or unsound in direct proportion to the soundness or unsoundness of our assumptions. Unfortunately nobody can say whether our assumptions are true or false. Yet the problems are there, and solutions have to be found for them now if we do not wish to be caught napping when the test of war descends upon us. All we can do, therefore, as military engineers, is to go on thinking all the time and, by following carefully all the developments of mechanisation, ensure that our science of military engineering does not lag behind the developments which are taking place in the rest of the army. General Capper, therefore, has done us a great service in propounding this problem and in indicating the lines upon which its solution may lie.

BATTLE HONOURS OF ROYAL ENGINEER UNITS

(*Continued*).

N.B.—"HINDENBURG LINE" COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN ANY OF THE BATTLES FROM HAVRINCOURT TO CAMBRAI, 1918.

CANAL DU NORD. 27TH SEPTEMBER—1ST OCTOBER, 1918.

Unit.	Formation.	Remarks.
FIRST ARMY.		
ARMY TROOPS.		
Special Cos.	First Army	N.E.
25th Army Troops Co.	,,	,,
217th ,,	XXII Corps	,,
568th ,,	XXII ,,	,,
1st Can ,,	Can. ,,	,,
2nd Can ,,	Can. ,,	,,
3rd Can. ,,	Can. ,,	E.
4th Can. ,,	Can. ,,	,,
5th Can. ,,	Can. ,,	,,
172nd Tunnelling Co.	XXII ,,	,,
179th ,,	XXII ,,	D.
1st Tramway Co. C.E.	Can. ,,	E.
2nd ,,	Can. ,,	,,
No. 7 Foreway Co.	XXII ,,	D.
XXII CORPS.		
9th Field Co.	4th Div.	N.E.
406th ,,	,,	E.
526th ,,	,,	N.E.
416th ,,	56th Div.	E.
512th ,,	,,	,,
513th ,,	,,	,,
CANADIAN CORPS.		
67th Field Co.	11th Div.	E.
68th ,,	,,	,,
86th ,,	,,	,,
1st Bn. 1st Bde. C.E.	1st Can. Div.	,,
2nd ,,	,,	,,
3rd ,,	,,	,,
4th ,,	2nd Can. Div.	,,
5th ,,	,,	,,
6th ,,	,,	,,
7th ,,	3rd Can. Div.	,,
8th ,,	,,	,,
9th ,,	,,	,,
10th ,,	4th Can. Div.	,,
11th ,,	,,	,,
12th ,,	,,	,,
THIRD ARMY.		
ARMY TROOPS.		
J. Special (Proj.) Co.	VI Corps	N.E.
K. ,,	V ,,	D.
Q. ,,	IV ,,	E.
No. 3 Special (Mortar) Co.	IV ,,	D.
546th Field Co. (73rd Div.)	VI ,,	N.E.
547th ,,	V ,,	,,
549th ,,	VI & XVII Corps	,,

CANAL DU NORD. 27TH SEPTEMBER—1ST OCTOBER, 1918.

Unit.	Formation.	Remarks.
132nd Army Troops Co.	VI Corps	E.
142nd ,,	IV ,,	,,
149th ,,	IV ,,	,,
232nd ,,	XVII ,,	,,
565th ,,	VI ,,	,,
577th ,,	IV ,,	N.E.
7th R. Mon. ,,	IV ,,	,,
No. 2 Siege Co. R.A. R.E.	XVII ,,	E.
174th Tunnelling Co.	VI ,,	,,
177th ,,	XVII ,,	,,
178th ,,	XVII ,,	,,
252nd ,,	IV ,,	,,
258th ,,	IV ,,	N.E.
N.Z. ,,	IV ,,	E.
IV CORPS.		
59th Field Co.	5th Div.	E.
491st ,,	,,	,,
527th ,,	,,	,,
152nd ,,	37th Div.	,,
153rd ,,	,,	,,
154th ,,	,,	,,
427th ,,	42nd Div.	,,
428th ,,	,,	,,
429th ,,	,,	,,
1st N.Z. Field Co.	N.Z. Div.	,,
2nd N.Z. ,,	,,	,,
3rd N.Z. ,,	,,	,,
VI CORPS.		
55th Field Co.	Guards Div.	E.
75th ,,	,,	,,
76th ,,	,,	,,
5th ,,	2nd Div.	,,
226th ,,	,,	,,
483rd ,,	,,	,,
56th ,,	3rd Div.	,,
438th ,,	,,	,,
529th ,,	,,	,,
457th ,,	62nd Div.	,,
460th ,,	,,	,,
461st ,,	,,	,,
XVII CORPS.		
410th Field Co.	52nd Div.	E.
412th ,,	,,	,,
413th ,,	,,	,,
421st ,,	57th Div.	,,
502nd ,,	,,	,,
505th ,,	,,	,,
247th ,,	63rd Div.	,,
248th ,,	,,	,,
249th ,,	,,	,,

SIGNALS.

CANAL DU NORD. 27TH SEPTEMBER—1ST OCTOBER, 1918.

Unit.	Formation.	Remarks.
First Army Signal Co.		N.E.
Y Corps Signal Co.	XXII Corps	D.
4th Div. Signal Co.	,,	,,
56th ,,	,,	E.

SIGNALS.

CANAL DU NORD. 27TH SEPTEMBER—1ST OCTOBER, 1918.

Unit.	Formation.	Remarks.
Can. Corps Signal Co.	Can. Corps	E.
11th Div. Signal Co.	,,	,,
1st Can. ,,	,,	,,
2nd Can. ,,	,,	,,
3rd Can. ,,	,,	,,
4th ,,	,,	,,
Third Army Signal Co.		N.E.
D Corps Signal Co.	IV Corps	,,
5th Div. Signal Co.	,,	E.
37th ,,	,,	,,
42nd ,,	,,	,,
N.Z. ,,	,,	,,
E. Corps Signal Co.	VI Corps	,,
Guards Div. Signal Co.	,,	,,
2nd ,,	,,	,,
3rd ,,	,,	,,
62nd ,,	,,	,,
R Corps Signal Co.	XVII Corps	,,
52nd Div. Signal Co.	,,	,,
57th ,,	,,	,,
63rd ,,	,,	,,

ST. QUENTIN CANAL. 29TH SEPTEMBER—2ND OCTOBER, 1918.

Unit.	Formation.	Remarks.
THIRD ARMY.		
ARMY TROOPS.		
K. Special (Proj.) Co.	V Corps	D.
N. ,,	,,	N.E.
147th Army Troops Co.	,,	D.
280th ,,	,,	E.
559th ,,	,,	N.E.
4th Siege Co. R.M. R.E.	,,	E.
175th Tunnelling Co.	,,	N.E.
183rd ,,	,,	E.
V. CORPS		
77th Field Co.	17th Div.	N.E.
78th ,,	,,	,,
93rd ,,	,,	E.
97th Field Co.	21st Div.	,,
98th ,,	,,	,,
126th ,,	,,	,,
11th ,,	33rd Div.	,,
212th ,,	,,	,,
222nd ,,	,,	,,
123rd ,,	38th Div.	,,
124th ,,	,,	,,
151st ,,	,,	,,
FOURTH ARMY.		
ARMY TROOPS.		
D Special (Proj.) Co.	III Corps	N.E.
Z ,,	Aust. ,,	,,
No. 1 Special (Mortar) Co.	IX ,,	E.
648th Field Co.	IX ,,	N.E.
144th Army Troops Co.	Aust. ,,	E.
146th ,,	Aust.	N.E.
213th ,,	Fourth Army	,,
216th ,,	IX Corps	E.
221st ,,	IX ,,	D.

ST. QUENTIN CANAL. 29TH SEPTEMBER—2ND OCTOBER, 1918.

Unit.	Formation.	Remarks.
238th ,,	Aust. Corps	D.
283rd ,,	III & XIII Corps	N.E.
288th ,,	II Amern. & XIII Corps	E.
567th ,,	IX Corps	,,
574th ,,	IX ,,	,,
1st Aust. ,,	Aust. Corps	D.
1st Siege Co. R.A. R.E.	II Amern. & XIII Corps	E.
4th ,,	IX Corps	,,
180th Tunnelling Co.	IX ,,	,,
182nd ,,	III ,,	,,
253rd ,,	IX ,,	,,
254th ,,	IX ,,	,,
256th ,,	IX ,,	,,
1st Aust. ,,	Aust. ,,	N.E.
2nd Aust. ,,	Aust. ,,	E.
III CORPS.		
69th Field Co.	12th Div.	E.
70th ,,	,,	N.E.
87th ,,	,,	E.
79th ,,	18th Div.	,,
80th ,,	,,	,,
92nd ,,	,,	,,
IX CORPS.		
23rd Field Co.	1st Div.	E.
26th ,,	,,	,,
409th ,,	,,	,,
12th ,,	6th Div.	N.E.
459th ,,	,,	,,
509th ,,	,,	,,
206th ,,	32nd Div.	E.
218th ,,	,,	,,
219th ,,	,,	,,
465th ,,	46th Div.	,,
466th ,,	,,	,,
468th ,,	,,	,,
XIII CORPS.		
7th Field Co.	50th Div.	E.
446th ,,	,,	D.
447th ,,	,,	E.
AUSTRALIAN CORPS.		
5th Aust. Field Co.	2nd Aust. Div.	E.
6th Aust. ,,	,,	,,
7th Aust. ,,	,,	,,
9th Aust. ,,	3rd Aust. Div.	,,
10th Aust. ,,	,,	,,
11th Aust. ,,	,,	,,
8th Aust. ,,	5th Aust. Div.	,,
14th Aust. ,,	,,	,,
15th Aust. ,,	,,	,,
CAVALRY CORPS.		
1st Field Squadron	1st Cav. Div.	E.
2nd ,,	2nd ,,	N.E.
3rd ,,	3rd ,,	D.

SIGNALS.

ST. QUENTIN CANAL. 29TH SEPTEMBER—2ND OCTOBER, 1918.

Unit.	Formation.	Remarks.
Third Army Signal Co.		N.E.
O Corps Signal Co.	V Corps	D
21st Div. Signal Co.	,,	E.
33rd ,,	,,	,,
38th ,,	,,	,,
Fourth Army Signal Co.		N.E.
C Corps Signal Co.	III Corps	,,
12th Div. Signal Co.	,,	D.
18th ,,	,,	,,
E Corps Signal Co.	IX Corps	,,
1st Div. Signal Co.	,,	E.
6th ,,	,,	N.E.
32nd ,,	,,	E.
46th ,,	,,	,,
N. Corps Signal Co.	XIII Corps	D.
50th Div. Signal Co.	,,	,,
Aust. Corps Signal Co.	Aust. Corps	N.E.
2nd Aust. Div. Signal Co.	,,	E.
3rd ,,	,,	,,
5th ,,	,,	,,
Cavalry Corps Signal Sqn.	Cav. Corps	N.E.
1st Signal Squadron	1st Cav. Div.	D.
2nd ,,	2nd ,,	N.E.
3rd ,,	3rd ,,	E.

BEAUREVOIR. 3RD TO 5TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
THIRD ARMY.		
ARMY TROOPS.		
K Special (Proj.) Co.	V Corps	N.E.
N ,,	,,	,,
147th Army Troops Co.	,,	,,
280th ,,	,,	,,
559th ,,	,,	,,
4th Siege Co. R.M. R.E.	,,	,,
175th Tunnelling Co.	,,	,,
183rd ,,	,,	D.
V CORPS.		
123rd Field Co.	38th Div.	E.
124th ,,	,,	,,
151st ,,	,,	,,
FOURTH ARMY.		
ARMY TROOPS.		
N Special (Proj.) Co.	XIII Corps	N.E.
Z ,,	Aust ,,	,,
No. 1 Special (Mortar) Co.	IX ,,	,,
648th Field Co.	IX ,,	,,
144th Army Troops Co.	XIII ,,	,,
146th ,,	Aust. ,,	,,
216th ,,	IX ,,	E.
221st ,,	IX ,,	N.E.
238th ,,	Aust. ,,	,,
283rd ,,	XIII ,,	E.
288th ,,	XIII ,,	N.E.
567th ,,	IX ,,	E.
574th ,,	IX ,,	N.E.
1st Aust. ,,	Aust. ,,	D

BEAUREVOIR. 3RD TO 5TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
1st Siege Co. R.A. R.E.	XIII Corps	N.E.
4th ,,	IX ,,	,,
180th Tunnelling Co.	XIII ,,	E.
182nd ,,	III ,,	,,
253rd ,,	IX ,,	,,
254th ,,	IX ,,	,,
256th ,,	IX ,,	,,
1st Aust. ,,	Aust. ,,	,,
2nd Aust. ,,	Aust. ,,	,,
IX CORPS.		
23rd Field Co.	1st Div.	D.
26th ,,	,,	N.E.
409th ,,	,,	,,
12th ,,	6th Div.	E.
459th ,,	,,	,,
509th ,,	,,	,,
206th ,,	32nd Div.	,,
218th ,,	,,	,,
219th ,,	,,	,,
465th ,,	46th Div.	,,
466th ,,	,,	,,
468th ,,	,,	,,
XIII CORPS.		
105th Field Co.	25th Div.	E.
106th ,,	,,	,,
130th ,,	,,	N.E.
7th ,,	50th Div.	E.
446th ,,	,,	N.E.
447th ,,	,,	E.
AUSTRALIAN CORPS.		
5th Aust. Field Co.	2nd Aust. Div.	E.
6th ,,	,,	,,
7th ,,	,,	,,
CAVALRY CORPS.		
1st Field Sqn.	1st Cav. Div.	E.
2nd ,,	2nd ,,	,,
3rd ,,	3rd ,,	,,

SIGNALS.

BEAUREVOIR. 3RD TO 5TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
Third Army Signal Co.		N.E.
O Corps Signal Co.	V Corps	,,
38th Div. Signal Co.	,,	E.
Fourth Army Signal Co.		N.E.
E Corps Signal Co.	IX Corps	D.
1st Div. Signal Co.	,,	N.E.
6th ,,	,,	D.
32nd ,,	,,	E.
46th ,,	,,	,,
D Corps Signal Co.	XIII Corps	N.E.
25th Div. Signal Co.	,,	E.
50th ,,	,,	,,
Aust. Corps Signal Co.	Aust. Corps	N.E.
2nd Aust. Div. Signal Co.	,,	E.
Cavalry Corps Signal Sqn.	Cav. Corps	N.E.
1st Signal Sqn.	1st Cav. Div.	E.
2nd ,,	2nd ,,	N.E.
3rd ,,	3rd. ,,	E.

CAMBRAI, 1918. 8TH TO 9TH OCTOBER, 1918.

Unit.	Formation.		
FIRST ARMY.			
ARMY TROOPS.			
E Special (Proj. Co.)	Can. Corps	D.	
G ,,	,,	,,	
25th Army Troops Co.	XXII Corps	N.E.	
217th ,,		N.E.	
230th ,,		,,	
282nd ,,		,,	
568th ,,	XXII Corps	,,	
1st Can. ,,	Can. Corps	,,	
2nd Can. ,,	,,	,,	
3rd Can. ,,	,,	,,	
4th Can. ,,	,,	,,	
5th Can. ,,	,,	E.	
172nd Tunnelling Co.	XXII Corps	N.E.	
179th ,,	,,	,,	
1st Tramway Co. C.E.	Can. Corps	,,	
2nd ,,	,,	,,	
XXII CORPS			
416th Field Co.	56th Div.	D.	
512th ,,	,,	N.E	
513th ,,	,,	,,	
1st Bn. 1st Bde. C.E.	1st Can. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
CANADIAN CORPS.			
67th Field Co.	11th Div.	N.E.	
68th ,,	,,	D.	
86th ,,	,,	E.	
4th Bn. 2nd Bde. C.E.	2nd Can. Div.	E.	
5th ,,	,,	,,	
6th ,,	,,	,,	
7th Bn. 3rd. Bde. C.E.	3rd. Can. Div.	,,	
8th ,,	,,	,,	
9th ,,	,,	,,	
THIRD ARMY.			
ARMY TROOPS.			
Special Cos.	3rd Army	N.E.	
546th Field Co. (73rd Div.)	VI Corps	,,	
547th ,,	V ,,	,,	
549th ,,	VI ,,	E.	
132nd Army Troops Co.	VI ,,	,,	
142nd ,,	IV ,,	N.E	
147th ,,	V ,,	E.	
149th ,,	IV ,,	D.	
232nd ,,	XVII ,,	,,	No Diary.
280th ,,	V ,,	E.	
559th ,,	V ,,	,,	
565th ,,	VI ,,	D	No Diary.
577th ,,	IV ,,	E.	
7th R. Mon. ,,	IV Corps	N.E.	
2nd Siege Co. R.A.R.E.	XVII ,,	D.	No Diary.
4th Siege Co. R.M.R.E.	V ,,	E.	
174th Tunnelling Co.	VI ,,	,,	
175th ,,	V ,,	,,	No Diary.
177th ,,	XVII ,,	,,	
178th ,,	XVII ,,	,,	
181st ,,	VI ,,	,,	
183rd ,,	V ,,	,,	
252nd ,,	IV ,,	,,	
258th ,,	IV ,,	D.	
N.Z. ,,	IV ,,	E.	

CAMBRAI, 1918. 8TH TO 9TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
CAVALRY CORPS.		
2nd Field Sqn.	2nd Cav. Div.	N.E.
IV CORPS.		
59th Field Co.	5th Div.	D.
491st ,,	,,	E.
527th ,,	,,	,,
152nd Field Co.	37th Div.	,,
153rd ,,	,,	,,
154th ,,	,,	,,
427th ,,	42nd Div.	,,
428th ,,	,,	,,
429th ,,	,,	,,
1st N.Z. ,,	N.Z. Div.	,,
2nd N.Z. ,,	,,	,,
3rd N.Z. ,,	,,	,,
V CORPS.		
77th Field Co.	17th Div.	E.
78th ,,	,,	,,
93rd ,,	,,	,,
97th ,,	21st Div.	,,
98th ,,	,,	,,
126th ,,	,,	,,
11th ,,	33rd Div.	,,
212th ,,	,,	,,
222nd ,,	,,	,,
123rd ,,	38th Div.	,,
124th ,,	,,	,,
151st ,,	,,	,,
VI CORPS.		
55th Field Co.	Guards Div.	E.
75th ,,	,,	,,
76th ,,	,,	,,
5th ,,	2nd Div.	,,
226th ,,	,,	,,
483rd ,,	,,	,,
56th ,,	3rd Div.	,,
438th ,,	,,	,,
529th ,,	,,	,,
457th ,,	62nd Div.	,,
460th ,,	,,	,,
461st ,,	,,	,,
XVII CORPS.		
81st Field Co.	19th Div.	E.
82nd ,,	,,	,,
84th ,,	,,	,,
103rd ,,	24th Div.	,,
104th ,,	,,	,,
129th ,,	,,	,,
421st ,,	57th Div.	,,
502nd ,,	,,	,,
505th ,,	,,	,,
247th ,,	63rd Div.	,,
248th ,,	,,	,,
249th ,,	,,	,,
FOURTH ARMY.		
ARMY TROOPS.		
Special Cos.	4th Army	N.E.
648th Field Co.	IX Corps	,,
144th Army Troops Co.	XIII Corps	E.

CAMBRAI, 1918. 8TH TO 9TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
146th Army Troops Co.		N.E.
213th ,,		,,
216th ,,	IX Corps	E.
221st ,,	IX ,,	D.
238th ,,		,,
283rd ,,	XIII Corps	E.
288th ,,	XIII ,,	,,
567th ,,	IX ,,	D.
574th ,,	4th Army	N.E. No diary.
1st Aust. ,,	II Amer. Corps	E.
1st Siege Co. R.A.R.E.	XIII Corps	,,
4th ,,	IX ,,	D.
180th Tunnelling Co.	XIII ,,	E.
182nd ,,	XIII ,,	,,
253rd ,,	IX Corps	D.
254th ,,	IX ,,	,,
256th ,,	IX ,,	,,
1st Aust. ,,	II Amer. Corps	,,
2nd ,,	II ,,	,,
CAVALRY CORPS.		
1st Field Sqn.	1st Cav. Div.	E.
3rd ,,	3rd ,,	,,
IX CORPS.		
12th Field Co.	6th Div.	E.
459th ,,	,,	,,
509th ,,	,,	,,
465th ,,	46th Div.	,,
466th ,,	,,	,,
468th ,,	,,	,,
XIII CORPS.		
105th Field Co.	25th Div.	E.
106th ,,	,,	,,
130th ,,	,,	,,
7th ,,	50th Div.	,,
446th ,,	,,	,,
447th ,,	,,	,,
430th ,,	66th Div.	,,
431st ,,	,,	,,
432nd ,,	,,	,,

SIGNALS.

CAMBRAI, 1918. 8TH TO 9TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
First Army Signal Co.		N.E.
Y Corps Signal Co.	XXII Corps	,,
56th Div. Signal Co.	,,	,,
1st Can. Signal Co.	,,	,,
Can. Corps Signal Co.	Can. Corps	,,
11th Div. Signal Co.	,,	D.
2nd Can. Signal Co.	,,	E.
Third Army Signal Co.		N.E.
2nd Signal Sqn.	2nd Cav. Div.	,,
D Corps Signal Co.	IV Corps	,,
5th Div. Signal Co.	,,	E.
37th ,,	,,	,,
42nd ,,	,,	,,
N.Z. ,,	,,	,,

SIGNALS.

CAMBRAI, 1918. 8TH TO 9TH OCTOBER, 1918.

Unit.	Formation.		Remarks.
O Corps Signal Co.	V Corps	N.E.	
17th Div. Signal Co.	,,	E.	
21st ,,	,,	,,	
33rd ,,	,,	,,	
38th ,,	,,	,,	
F Corps Signal Co.	VI Corps	N.E.	
Guards Div. Signal Co.	,,	E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
62nd ,,	,,	,,	
R Corps Signal Co.	XVII Corps	N.E.	
19th Div. Signal Co.	,,	E.	
24th ,,	,,	,,	
57th ,,	,,	,,	
63rd ,,	,,	,,	
Fourth Army Signal Co.		N.E.	
Cavalry Corps Signal Sqn.	Cav. Corps	D.	
1st Signal Sqn.	1st Cav. Div.	E.	
3rd Signal Sqn.	3rd Cav. Div.	,,	
E Corps Signal Co.	IX Corps	N.E.	
6th Div. Signal Co.	,,	E.	
46th ,,	,,	,,	
N Corps Signal Co.	XIII Corps	D.	
25th Div. Signal Co.	,,	E.	
50th ,,	,,	,,	
66th ,,	,,	,,	

YPRES, 1918. 28TH SEPTEMBER TO 2ND OCTOBER, 1918.

Unit.	Formation.		Remarks.
SECOND ARMY.			
ARMY TROOPS.			
H Special (Proj.) Co.	X Corps	N.E.	
L ,,	XV ,,	E.	
P ,,	II ,,	N.E.	
No. 4 Special (Mortar) Co.)	X ,,	,,	
411th Field Co.	X ,,	D.	No diary.
550th ,,	X ,,	,,	
20th Army Troops Co.	II ,,	E.	
134th ,,	XIX ,,	D.	
136th ,,	XV ,,	N.E.	
138th ,,	II ,,	E.	
141st ,,		N.E.	
145th ,,	XV Corps	E.	"Bellamy's Force"
167th ,,	X ,,	N.E.	
214th ,,	XV ,,	E.	
235th ,,	XV ,,	,,	"Bellamy's Force."
245th ,,	XIX ,,	N.E.	
289th ,,	II ,,	E.	
554th ,,		N.E.	
556th ,,	II Corps	E.	
557th ,,		N.E.	
573rd ,,		,,	
No. 6 Siege Co. R.M.R.E.	XIX Corps	E.	
171st Tunnelling Co.		D.	
173rd ,,	X & XIX Corps	E.	
184th ,,	XIX Corps	,,	
255th ,,	II ,,	D.	No diary.
3rd Can. ,,	XV ,,	N.E.	

YPRES, 1918. 28TH SEPTEMBER TO 2ND OCTOBER, 1918.

Unit.	Formation.	Remarks.
II CORPS.		
63rd Field Co.	9th Div.	E.
64th ,,	,,	,,
90th ,,	,,	,,
455th ,,	29th Div.	,,
497th ,,	,,	,,
510th ,,	,,	,,
121st ,,	36th Div.	,,
122nd ,,	,,	,,
150th ,,	,,	,,
X CORPS.		
200th Field Co.	30th Div.	E.
201st ,,	,,	,,
202nd ,,	,,	,,
207th ,,	34th Div.	,,
208th ,,	,,	,,
209th ,,	,,	,,
XV CORPS.		E
210th Field Co.	31st Div.	,,
211th ,,	,,	,,
223rd ,,	,,	,,
224th ,,	40th Div.	D.
229th ,,	,,	N.E.
231st ,,	,,	E.
XIX CORPS.		
61st Field Co.	14th Div.	E.
62nd ,,	,,	,,
89th ,,	,,	,,
203rd ,,	35th Div.	,,
204th ,,	,,	,,
205th ,,	,,	,,
228th ,,	41st Div.	,,
233rd ,,	,,	,,
237th ,,	,,	,,

SIGNALS.

YPRES, 1918. 28TH SEPTEMBER TO 2ND OCTOBER, 1918.

Unit.	Formation.	Remarks.
Second Army Signal Co.		N.E
B Corps Signal Co.	II Corps	E.
9th Divl. Signal Co.	,,	,,
29th ,,	,,	,,
36th ,,	,,	,,
X Corps Signal Co	X Corps	D.
30th Div. Signal Co.	,,	E.
34th ,,	,,	,,
P Corps Signal Co.	XV Corps	N.E.
31st Div. Signal Co.	,,	E.
40th ,,	,,	D.
T Corps Signal Co.	XIX Corps	,,
14th Div. Signal Co.	,,	E.
35th ,,	,,	,,
41st ,,	,,	,,

COURTRAI. 14TH TO 19TH OCTOBER, 1918.

Unit.	Formation.		Remarks.
SECOND ARMY.			
ARMY TROOPS.			
H Special (Proj.) Co.	X Corps	N.E.	
L "	XV "	"	
P "	II "	E.	
No. 4 Special (Mortar) Co.	X "	N.E.	
411th Field Co.	X "	D	No diary.
550th "		N.E.	
20th Army Troops Co.	II Corps	E.	
134th "	XIX "	D.	
136th "	XV "	N.E	
138th "	II "	E.	
141st "		N.E.	
145th "	XV Corps	"	
167th "	X "	"	
214th "	XV "	E.	
235th "	XV "	N.E.	
245th "	XIX "	"	
289th "	II "	E.	
554th "		N.E.	
556th "	II Corps	E.	
557th "	XIX "	"	
573rd "		N.E.	
No 6 Siege Co. R.M.R.E.	XIX Corps	E.	
171st Tunnelling Co.		D.	
173rd "	XIX Corps	E.	
184th "	XIX "	"	
255th "	II "	D.	No diary.
3rd Can. "	XV "	N.E.	
II CORPS.			
63rd Field Co.	9th Div.	E.	
64th "	"	"	
90th "	"	"	
455th Field Co.	29th Div.	"	
497th "	"	"	
510th "	"	"	
121st "	36th Div.	"	
122nd "	"	"	
150th "	"	"	
X CORPS.			
200th Field Co.	30th Div.	E.	
201st "	"	"	
202nd "	"	"	
207th "	34th Div.	"	
208th "	"	"	
209th "	"	"	
XV CORPS.			
61st Field Co.	14th Div.	E.	
62nd "	"	"	
89th "	"	"	
XIX CORPS.			
203rd Field Co.	35th Div.	E.	
204th "	"	"	
205th "	"	"	
228th Field Co.	41st Div.	"	
233rd "	"	"	
237th "	"	"	

SIGNALS.

COURTRAI. 14TH TO 19TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
Second Army Signal Co.		N.E.
B Corps Signal Co.	II Corps	D.
9th Div. Signal Co.	,,	E.
29th ,,	,,	,,
36th ,,	,,	,,
X Corps Signal Co.	X Corps	D.
30th Div. Signal Co.	,,	E.
34th ,,	,,	,,
P Corps Signal Co.	XV Corps	D.
14th Div. Signal Co.	,,	E.
T Corps Signal Co.	XIX Corps	,,
35th Div. Signal Co.	,,	,,
41st ,,	,,	,,

SELLE. 17TH TO 25TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
FIRST ARMY.		
ARMY TROOPS.		
B Special (Proj.) Co.	XXII Corps	N.E.
G ,,	,,	,,
25th Army Troops Co.	First Army	,,
217th ,,	XXII Corps	,,
230th ,,	First Army	,,
280th ,,	,,	,,
568th ,,	XXII Corps	,,
172nd Tunnelling Co.	,,	E.
179th ,,	,,	D.
XXII CORPS.		
9th Field Co.	4th Div.	E.
406th ,,	,,	,,
526th ,,	,,	,,
67th ,,	11th Div.	D. } Came into the area on 25th
68th ,,	,,	,, } October, 1918.
86th ,,	,,	N.E.
57th ,,	49th Div.	E.
456th ,,	,,	,,
458th ,,	,,	N.E.
400th ,,	51st Div.	E.
401st ,,	,,	,,
404th ,,	,,	,,
THIRD ARMY.		
ARMY TROOPS.		
Q Special (Proj.) Co.	IV Corps.	D.
No. 3 Special (Mortar) Co.	XVII ,,	,,
546th Field Co.	VI ,,	N.E.
547th Field Co. (73rd Div.)	XVII ,,	N.E.
549th ,,	XVII ,,	,,
132nd Army Troops Co.	VI ,,	E.
142nd ,,	IV ,,	,,
147th ,,	V ,,	,,
149th ,,	IV ,,	,,
232nd ,,	XVII ,,	D. No diary.
280th ,,	V ,,	E.
559th ,,	V ,,	,,
565th ,,	VI ,,	D. No diary.
577th ,,	IV ,,	N.E.
No. 7 R. Mon. ,,	IV ,,	,,
No. 2 Siege Co. R.A.R.E.	XVII ,,	D. No diary.

SELLE. 17TH TO 25TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
No. 4. Siege Co. R.M.R.E.	V Corps E.	
174th Tunnelling Co.	VI " "	
175th "	V " "	No diary.
177th "	XVII " "	
178th "	XVII " "	
181st "	VI " "	
183rd "	V " "	
252nd "	IV " "	
258th "	IV " N.E.	
N.Z. "	IV " "	
IV CORPS.		
59th Field Co.	5th Div. E.	
491st "	" "	
527th "	" "	
152nd "	37th Div. "	
153rd "	" "	
154th "	" "	
427th "	42nd Div. "	
428th "	" "	
429th "	" "	
1st N.Z. "	N.Z. Div. "	
2nd "	" "	
3rd "	" "	
V CORPS.		
77th Field Co.	17th Div. E.	
78th "	" "	
93rd "	" "	
97th "	21st Div. "	
98th "	" "	
126th "	" "	
11th "	33rd Div. "	
212th "	" "	
222nd "	" "	
123rd "	38th Div. "	
124th "	" "	
151st "	" "	
VI CORPS.		
55th Field Co.	Guards Div. E.	
75th "	" "	
76th "	" "	
5th "	2nd Div. "	
226th "	" "	
483rd "	" "	
56th "	3rd Div. "	
438th "	" "	
529th "	" "	
457th "	62nd Div. "	
460th "	" "	
461st "	" "	
XVII CORPS.		
81st Field Co.	19th Div. E.	
82nd "	" "	
94th "	" "	
103rd "	24th Div. D.	
104th "	" N.E.	
129th "	" "	
476th "	61st Div. E.	
478th "	" "	
479th "	" "	

SELLE. 17TH TO 25TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
FOURTH ARMY.		
ARMY TROOPS.		
648th Field Co.	IX Corps	N.E.
144th Army Troops Co.	XIII Corps	E.
146th ,,	II Amer. & IX Corps	,,
213th ,,	Fourth Army	N.E.
216th ,,	II Amer. & IX Corps	,,
221st ,,	IX Corps	,,
238th ,,	II Amer. & IX Corps	,,
283rd ,,	XIII Corps	E.
288th ,,	XIII ,,	,,
567th ,,	IX ,,	N.E.
574th ,,	Fourth Army	,, No diary.
No. 1 Siege Co. R.A.R.E.	XIII Corps	,,
No. 4 ,,	IX ,,	D.
180th Tunnelling Co.	XIII ,,	E.
182nd ,,	XIII ,,	,,
253rd ,,	IX ,,	N.E.
254th ,,	IX ,,	,,
256th ,,	IX ,,	E.
1st Aust. ,,	II Amer. & IX Corps	,,
IX CORPS.		
23rd Field Co.	1st Div.	E.
26th ,,	,,	,,
409th ,,	,,	,,
12th ,,	6th Div.	E.
459th ,,	,,	,,
509th ,,	,,	,,
465th ,,	46th	N.E. Took part in the attack on Andigny-les-Fermes just south of area.
466th ,,	,,	,,
468th ,,	,,	,,
XIII CORPS		
79th Field Co.	18th Div.	E.
80th ,,	,,	,,
92nd ,,	,,	,,
105th ,,	25th Div.	,,
106th ,,	,,	,,
130th ,,	,,	,,
7th ,,	50th Div	,,
446th ,,	,,	,,
447th ,,	,,	,,
430th ,,	66th Div.	,,
431st ,,	,,	,,
432nd ,,	,,	,,

SIGNALS.

SELLE. 17TH TO 25TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
First Army Signal Co.		N.E.
Y Corps Signal Co.	XXII Corps	D.
4th Div. Signal Co.	,,	E.
49th ,,	,,	D.
51st ,,	,,	E.
Third Army Signal Co.		N.E.

SIGNALS.

SELLE. 17TH TO 25TH OCTOBER, 1918.

Unit.	Formation.	Remarks.
D Corps Signal Co.	IV Corps	D.
5th Div. Signal Co.	,,	E.
37th ,,	,,	,,
42nd ,,	,,	,,
N.Z. ,,	,,	,,
O Corps Signal Co.	V Corps	D.
17th Div. Signal Co.	,,	E.
21st ,,	,,	,,
33rd ,,	,,	,,
38th ,,	,,	,,
F Corps Signal Co.	VI Corps	D.
Guards Div. Signal Co.	,,	E.
2nd ,,	,,	,,
3rd ,,	,,	,,
62nd ,,	,,	,,
R Corps Signal Co.	XVII Corps	D.
19th Div. Signal Co.	,,	E.
24th ,,	,,	D.
61st ,,	,,	E.
Fourth Army Signal Co.		N.E.
E Corps Signal Co.	IX Corps	E.
1st Div. Signal Co.	,,	E.
6th ,,	,,	,,
46th ,,	,,	N.E.
N Corps Signal Co.	XIII Corps	D.
18th Div. Signal Co.	,,	E.
25th ,,	,,	,,
50th ,,	,,	,,
66th ,,	,,	,,

IMPERIAL DEFENCE.

The Second Prize Essay in the Bertrand Stewart Competition arranged by the "Army Quarterly."

By COL. COMMANDANT H. L. PRITCHARD, C.B., C.M.G., D.S.O., *A.D.C.*

NOTE.—This Essay was written in January, 1927.

Subject.

Having in mind the imperative necessity for the greatest reduction possible, consistent with safety, in the annual cost of the three fighting services, how can the essential military requirements of Imperial defence best be met? No account should be taken of any international agreement for disarmament beyond that already entered into at Washington.

WAR LIABILITIES OF THE BRITISH EMPIRE.

In working out the above problem we must first be quite clear as to what are "the essential military requirements of Imperial defence."

What are the war liabilities of the British Empire?

First and foremost, Locarno has committed us, under certain circumstances, to play our part, and stake our existence once more, in war upon the continent of Europe on the largest scale.

Secondly, by the Treaty of Mudania with Turkey, we are interested with other nations in keeping the Bosphorus and Dardanelles open and undefended. We could not be indifferent to a change of ownership in this strategic key of that important part of the world. This liability might involve us in operations in the Balkans or Asia Minor.

Thirdly, by acceptance of a Mandate for Palestine we have taken up a forward position for the defence of the Suez Canal. We have the French in Syria as a buffer between the Turks and ourselves, but we have Arabs on the east. Our position on the Canal and in Egypt is one of the corner stones of the Imperial fabric. Operations in Palestine, in Egypt, or in the Sudan are therefore a possibility.

Fourthly, by accepting a mandate for Iraq we have given a hostage to fortune, and taken over a long land frontier marching with Turkey and not far distant from Russian territory. Our liabilities in this respect are far-reaching, since operations undertaken for the defence of Iraq against external aggression could not be localised, and would be likely to spread to other theatres in the Near and Middle East.

Fifthly, the passage of time has not eased our long-standing liability for the defence of the North West Frontier of India, and for the suppression of tribal disorders.

Sixthly, the maintenance of internal order in India has necessitated active intervention by regular troops in the past, and may do so again.

Seventhly, the great Dominions of Australia and New Zealand lie sparsely populated in the Eastern hemisphere alongside countries overflowing with teeming populations. These Dominions are a serious liability for defence.

Eighthly, with our enormous trade with China we have such a stake in that disturbed country that we may, however unwillingly, find ourselves involved in serious operations in that country.

Ninthly, completing the circle of the globe, one hesitates to describe the frontier between Canada and America as a military liability, as it is difficult to imagine the folly that would cause war on that frontier, and both sides wisely decline to treat such an issue as a possible one, or to make any preparation against it. We should continue to disregard this as a military liability.

We need not specify the numerous minor liabilities which may be defined as the military police work of our extensive Empire.

THREE WAR LIABILITIES OF OUTSTANDING IMPORTANCE.

Surveying the foregoing liabilities we may select three as of outstanding importance and probability, any one of which may involve us in our next big war.

(1) Operations with the Great Powers in Europe.
(2) The Middle East, stretching from the Balkans to Iraq inclusive, and down to Egypt.
(3) The North-West frontier of India, and the territory between that frontier and the Russian boundary.

If we could be confident that the armed forces of the Crown were suitably organised to deal with those three major liabilities, they would have no difficulty in dealing with any other contingencies.

TWO TYPES OF ORGANISATION AND EQUIPMENT REQUIRED.

For purposes of organisation and equipment of the armed force? we can reduce the problem to two types.

(1) Organisation of forces to operate on the Continent of Europe.
(2) Organisation of forces to operate between the N.W. Frontier of India and the Russian boundary.

The system of organisation and equipment of a force ready to operate between India and Russian territory would, with little variation, be suitable for a Force operating in the Middle East.

NATURE OF FUTURE OPERATIONS.

We must next endeavour to pierce the veil that hides the future, and to make up our minds as to how our forces will operate in future wars.

It is useless, to create, organise and equip forces unless we have definite ideas as to how those forces are going to operate, and what their tasks will be.

We must exercise imagination and attempt to prophesy. In tackling the subject of this Essay, however much one may wish to be guided by solid ascertained facts and past experience, these alone cannot give the solution of the problem in the fast-changing world of the present and the future.

SOME MAIN PRINCIPLES AFFECTING FUTURE OPERATIONS.

Let us then lay down the following principles for our guidance.

(1) The Navy, assisted by the Fleet Air arm, will continue to be responsible for keeping open the sea communications of the Empire, and for embarking and disembarking the Army, and the ground units of the R.A.F.

(2) The R.A.F,. assisted by the anti-aircraft defence organisation of the Army, and by the military Chemical organisation, will be responsible for

(a) reducing to a minimum in number and results the enemy's air raids upon the United Kingdom, so that it may be possible for this country to put forth its maximum war effort, unhindered by disastrous damage to its administrative, and productive, working.

This will be effected by offensive and defensive air operations assisted by ground organisation.

(b) To secure for the Army, with the same assistance on the ground, comparative security from air attacks in certain areas overseas defined by the Army, notably at sea bases, but also in other areas referred to later when describing the Army's operations. This measure of security will likewise be secured by both offensive and defensive air operations, assisted by ground organisation.

(3) Iu the event of war in Europe the R.A.F will have to contend with powerful and highly organised Air Forces, but should hostilities eventuate in the Middle East or East, their opponents will probably not be so efficient and well organised.

(4) It cannot be too strongly emphasised that, just as in the past the army was incapable of operating overseas unless the navy could guarantee security of the sea communications of the Empire, so in the future, we now have also to stipulate, as a *sine qua non*, that the air forces must be able to guarantee comparative immunity against disastrous damage in certain defined areas in the United Kingdom and overseas.

We cannot expect the R.A.F. to secure complete mastery of the air, equivalent to the safety on the seas that the navy secured in the Great War for a brief interval, between the disappearance of the

last roving German cruiser, and the opening of the serious submarine campaign. We must be prepared for conditions in the air to be somewhat similar to conditions on the sea, when the enemy submarines were active, but, if we are to continue the war, the Air Force must be able to guarantee us against continuous, and repeated, demolitions, and gas concentrations on a large scale, in certain defined vital areas at home and overseas. It should be noted that the anti-aircraft ground organisation will have a much greater effect in the next war than they had in the last one. In recent years this organisation has made enormous progress, so that the relative disparity in effectiveness in the competition between aircraft and anti-aircraft has been greatly reduced, and may continue to be still further reduced, until it approaches that existing between the rocketing pheasant and the average sportsman with a shot gun.

(5) The effect of Gas distributed by aircraft, by guns, or by other means, not only on troops, but, perhaps more important, on the civilian population in government and industrial centres, is a very serious matter. At present those engaged upon research for defensive measures against gas are lagging very far behind those engaged upon offensive gas inventions. It is not too much to say that, if a war broke out between nations equipped for offensive gas warfare by air and by land, the movements of armies, and probably of fleets, would soon become an impossibility, and the civilian population would be clamouring to their Government to make peace. It would be a matter of chance which side would first be reduced to impotence. The odds would be against a small, densely populated, highly industrialised, civilised country such as ours.

But we have seen the same competition before between a weapon and its antidote; the competition between guns and armour, between submarine and anti-submarine, between aircraft and anti-aircraft, between tank and anti-tank, between fortifications and measures for penetrating them. The story is always the same: a revolutionary invention starts with a tremendous lead, and dominates the battlefield for a time, but resourceful human nature searches diligently for the counter to this new force, and gradually evolves measures to bring it under comparative control. We may expect the same results in dealing with gas, but only if we set to work, not only diligently, but feverishly, to discover and evolve the counter measures. I shall therefore assume, that before the next war breaks out, our research chemists will have provided us with such counter-measures that, with good organisation, and constant watchfulness and courage, we shall be able, both in the armed forces and in the civilian population, to reduce the effects of gas to controllable, though still serious, proportions. By this I mean that armed forces and civilians will be able to go about their business, though not without serious casualties.

Certain Conditions at Sea, in the Air and Against Gas necessary to permit Military Operations.

Having thus defined the limiting conditions by sea, by air, and by gas, within which it is possible for an army to operate, we can now proceed to study the nature of an army's operations in future warfare. We must be quite clear about the nature of these operations before we attempt to pursue the main theme of this essay, viz: "the essential military requirements of Imperial Defence."

Nature of Future Military Operations in Europe.

We will first consider military operations in Europe, and then operations on the N.W. frontier of India, and the Middle East.

The first phase of operations, in Europe, is mobilisation at home. It has been stated that the R.A.F. and A.A. Organisation will be required to guarantee comparative security in certain areas. Within those areas mobilisation must be carried out, avoiding large concentrations by wide distribution within the areas.

A limited number of embarkation ports must be employed, as it cannot be expected that the R.A.F. will be able to give adequate protection to more than a few such ports.

Overseas, at least three disembarkation ports and bases must be used, in our Allies' countries, and protected by R.A.F. and A.A., but the ports themselves must be considered as defiles to be cleared as soon as possible. The concentrated base area we knew in the last war would be much too vulnerable. Munitions and supplies, having passed through the disembarkation ports, must be very widely distributed in a large base area further inland, well served by a network of railways and cross-country motor transport, and well protected by R.A.F. and A.A. Wide distribution over a large space increases the area to be protected by R.A.F. and A.A. to an extent that does not increase their difficulties appreciably, but it makes a much more difficult target on which the enemy can effect any serious demolition or produce gas effects.

The communications between the overseas bases and the area of operations can be better considered after we have settled the organisation of the fighting army, and the nature of its operations.

Commencing at the front, and dealing with the troops who gain touch with the enemy during the opening phase of the campaign, we note that in the past this was the function of the Cavalry. They were expected to screen our advance, to break through the enemy screen, to secure information, and to raid his communications.

I would ask whether it can be asserted that cavalry are the best fitted of all modern troops to execute the above task, even though they might have the auxiliary equipment which I shall presently propose for infantry.

Compare their efficiency for this purpose with a force organised as follows :—

Firstly : Light cross-country reconnaissance machines with a crew of one man, or two men, armed with Lewis guns.

Secondly : Armoured cars carrying machine guns, by which I mean not the existing four-wheeled cars that are tied to roads, and are quite obsolete, but cross-country cars, either on tracks, or on six-wheeled chassis, or of some other cross-country type.

Thirdly : Fast tanks.

Fourthly : Tractor-drawn field and medium artillery.

Fifthly : Infantry in cross-country lorries of the six-wheel type.

Sixthly : R.E. in cross-country lorries with bridging equipment, to ensure that this mobile force is not held up by obstacles.

Such a force is armoured, it moves fast, it can reconnoitre. It is not tied to roads.

Imagine such a force meeting the normal cavalry force. Is there any doubt about the result ? Is there anything which cavalry have done in the past which this force could not do ?

We shall see presently that there are other uses for cavalry, but they must now resign the role of screening and raiding ahead of the army.

What then can be accomplished by the mobile mechanical force referred to above ?

We should be able to rely upon them to search the country ahead of the advancing army, to fight similar enemy forces, and prevent them surprising our troops behind, to check enemy attempts to raid our communications, and to make every endeavour to raid those of the enemy.

We must be careful not to exaggerate the raiding capacity of such a force. It is not tied to roads, but it is tied to petrol. It will of course have petrol tank vehicles with it to increase its radius, but these are its vulnerable members. If, in contact with the enemy, these oil tanks are disabled, retreat is imperative. Convoys of oil tanks cannot safely follow up this mobile force on a raiding mission. There is therefore a limit to their cruising radius, which, however, is nevertheless considerable.

Behind this mobile mechanical screen, which has replaced the cavalry screen of former wars, the main army advances accompanied by an anti-aircraft organisation, while the respective air forces contend for mastery in the air, and endeavour to raid each other's aerodromes.

How is this main army organised and equipped ? There are those who would have it composed of nothing but tanks of various sizes and armament, but when a nation has put into the field all the tanks and armoured cross-country vehicles that its peace time budgets have enabled it to produce, and when, during the first few

months of war, it has multiplied the productive capacity of its factories to produce such vehicles, can it be said that this is the whole offensive effort of which the nation is capable on land? and will such a force be entirely suitable to conduct and complete the war?

The oustanding merit of such vehicles is their mobility, but are there no duties for slower moving forces in war, in the execution of which it would be wasteful to employ these machines? If they become locked up in these duties, which do not require their mobility, then the mobile fighting force will be reduced in numbers, and be worsted in encountering superior enemy forces of the same type.

A victory over the enemy must be followed up, his industrial centres and aerodromes occupied and held. A mechanical force is every bit as dependent upon supplies, upon repair workshops, upon depots of petrol, upon reinforcements, upon ammunition supply, as were the forces which we have known in the past. It must therefore have well organised communications, bases, and advance depots.

In a hostile country communications and depots require to be guarded, the country requires to be held down. We do not want to waste expensive mobile mechanical forces on such duties. If other arms are equipped, and organised, so as to be able to deny large tracts of country to the enemy's armoured vehicles, they will thus facilitate the manœuvres of our own mobile armoured force and restrict the manœuvres of the enemy.

The mechanical forces are armoured. Their duty is to break through, and break up, the enemy's mechanical and other forces, to open up ways through which armed, but unarmoured, and slower moving forces can steadily advance, taking over the enemy's country until the vital parts are reached, and he is no longer able to maintain his forces. We have seen that the radius of action of a mechanical force is limited. We must therefore push forward its advance bases until it is within striking distance of the vital parts of the enemy country.

In this main, steadily advancing, army a portion will be composed of armed and armoured cross-country vehicles of heavier type than those which form the mechanical screen and raiding force in front. The main army will also have tractor-drawn artillery of all calibres. The armed, armoured, and mobile portion of the main army must deal the blows which break down, and break through, the enemy's resistance, so that the infantry can advance, but, as will presently be shown, they must be infantry capable of resisting the enemy's mechanical forces.

The screening and raiding mechanical force is analogous to the destroyer flotillas, the light cruisers, and the battle cruisers, of a fleet at sea, while in our main army we have the vehicles which are analogous to the battleships of a fleet.

These battle vehicles will be more heavily armed and armoured, and possibly a little less mobile, than those in the screening force, but, in embarking once more upon the old competition between guns and armour, and applying it to the warfare of mechanical vehicles, we must be careful not to produce immobile vehicles requiring a vast amount of bridge transport to move them over the country.

We have to hit off the mean between armoured security and mobility over most types of country without the assistance of numerous bulky accessories.

By increasing the armour we force the enemy to increase the calibre, and weight, and expense, and therefore to reduce the number, and mobility, of his anti-tank guns, but we also reduce our own mobility, and mobility is itself a measure of protection against anti-tank guns. The happy mean must be hit off for these battle vehicles of the main army.

Turning to the other arms, how are cavalry and infantry to be organised, and what is their role?

In European warfare I cannot find any role for the cavalry, even if they were equipped, as it is proposed the infantry should be, with anti-tank guns. Is there anything which cavalry could do which cannot be better done by the mechanical forces described, and by infantry carried in cross-country lorries? In warfare against the big Continental nations, and in their countries, I can think of nothing, but on the N.W. frontier of India and in the Middle East we shall require them.

It seems then that we must come to the regrettable conclusion that cavalry, with their conspicuous and vulnerable men, horses, and horse lines, with their bulky forage requirements, must be banished from warfare in the greater part of the European Continent.

As regards the infantry, the most urgent necessity is to design, and hand over to the command of each infantry company without delay, the requisite proportion of anti-tank guns.

This gun should be the lightest possible gun that will pierce the armour of the enemy armoured vehicles, with a margin to spare for future development in armour, and it must be carried on the lightest possible cross-country vehicle, so as to be readily transportable over any river or obstacle.

Until these weapons are at the disposal of every infantry company commander, the infantry are useless in modern warfare, and it is simply murder to send them into it.

But, with these weapons, the infantry can steadily advance, occupying enemy country, and can hope to deny it to the enemy's armoured vehicles. At any rate they can engage them with a fair prospect of success.

The infantry battalion commander requires at his disposal cross-

country vehicles to carry his machine guns, and light cross-country reconnaissance vehicles.

Every corps would also be supplied with a pool of cross-country lorries, in which to move a proportion of their infantry from point to point.

All transport must be by cross-country vehicles. A force must be entirely independent of roads. This is not to say that roads will not be used, and will not be required. On the contrary, they will always be used in preference to the open country, particularly at night, and at bridges, but, in the presence of danger from the air, and from gas, it must be possible for a force to forsake the roads entirely for a long period, and still advance or retire.

By this means vulnerable concentrations of troops will be avoided and the effects of air, and gas, attacks minimised.

For a given length of front there will be even more dispersion of the troops per square yard of the area behind it than has been customary in previous warfare, and therefore avoidance of vulnerable and conspicuous concentrations.

The role of the infantry is, therefore, not to thrust their unarmoured bodies into unequal conflict with armoured, and armed, mechanical vehicles, and against barbed wire and machine guns, but, when our own armoured battle vehicles have obtained local superiority over similar enemy forces, and battered machine guns out of existence, the infantry advance to "mop up," and with their anti-tank guns to retain the ground won.

By their numbers and their armament they are able to take over large areas of ground, deny it to the manœuvres of the enemy's mobile forces, and secure it for the advance depots of our own battle vehicles.

As regards the artillery, the horse is obsolete. All units will be tractor drawn, except the pack batteries. Our old friend the pack artillery mule must still be preserved, because there are types of country to which the mule can take the pack gun in which no vehicle so far invented can travel. Invention may yet succeed in rendering the pack mule obsolete, but we seem to be a long way off that moment at present.

The cavalryman may ask, "If the pack mule is required for certain country, why not the cavalry horse?" The answer is that the pack mule is required to carry a gun, but the infantry will carry the rifle in such a country, which is not of the type best adapted to cavalry tactics.

The role of the artillery will be much the same as before, counter-battery work against enemy guns and armoured vehicles, support for the advancing infantry, repulse of the enemy infantry, harassing fire on enemy communications and depots, etc., etc. The main army cannot advance without artillery, and we have already noted

the screening and raiding force requires a proportion of tractor-drawn artillery.

Engineers carried in cross-country lorries with suitable bridging equipment will accompany the screening raiding force to ensure that it is not stopped by obstacles, and to carry out demolitions in the enemy's country.

With the main army, engineers, mechanically carried, will be busy with bridging and rapid road-making, to get the army forward, and with making numerous lateral and forward communications, to enable the force to abandon the usual roads and scatter over the country.

They will be running the workshops which maintain all the mechanical vehicles of the army.

They will be busy constructing, maintaining, and running railways to develop base areas and forward communications.

They will be carrying on their usual multifarious duties.

Thus we find that it is still the case that Air Forces, Navies, Mechanical Vehicles, Artillery, Engineers, exist only that they may enable Infantry to advance, to "mop up" the enemy's forces, and occupy his aerodromes and his industrial centres.

COMMUNICATIONS.

We postponed examination of the modern communications between base areas (already described) and the fighting front until we had analysed the nature of operations, and the types of forces conducting them.

We will now return to these communications. Working back from the front, the first link will be the cross-country lorry. The recently invented six-wheel lorry is probably going to effect a greater revolution in the transportation, and manœuvre, of an army than anything that has been invented since the locomotive. We have seen what it has meant in dispersing and manœuvring the fighting forces, regardless of roads, and on communications it is also going to release us from vulnerable roads.

Again I say that roads will continue to be required, and to be utilised, in preference to the open country, but, with a few minutes' notice of danger, they can be abandoned, and convoys can disperse over the country. In the presence of danger, forces will not advance in columns but in lines. Moreover, the roads themselves need only have an indifferent surface. Roads suitable for the six-wheel lorry or other types of cross-country vehicle can be rapidly constructed, and easily maintained, in which respect they differ entirely from the roads required by four-wheel lorries in the last war, which required masses of transport to bring up the stone and the wood slabs to construct them, and armies of men to quarry the stone, hew the slabs, and lay them in position. Rapid road-

making is possible for the six-wheel lorry but not for the four-wheeler. The four-wheel lorry is obsolete and should be banished from military operations. Mechanical transport which can scatter over the country requires the minimum of protection from air attacks.

There is, however, a limit to the economical length of communication by lorry. At the end of that limit, still proceeding back from the front, we must find the railheads, and the railways connecting with the base areas. Each railhead must be laid out over a considerable area, to prevent dense concentration of stores, and dense accumulation of lorries taking over from railway trucks. In fact there should be no accumulation of stores here. Organisation should permit of railing up from the base, and immediate transfer to lorries, loading at numerous dispersed loading points at railheads, protected by the A.A. organisation.

It is for the Air Force to say how they will beat off attacks from the air on the communication system.

Possibly they will concentrate their army defending forces, as distinct from their offensive raiding forces, along the front, and in base areas, to ensure the maximum protection of these two important zones. Enemy forces that evade our air forces at the front would then be engaged by air forces issuing from base areas.

Whether the Air Force would also consider it necessary to allot forces definitely for the communication zone is for them to say. Certainly the ground anti-aircraft organisation would have to be strong on the railway, and at railhead, but less in evidence in the country traversed by cross-country lorries.

Future Operations on N.W. Frontier of India and in the Near East.

Now, leaving the countries of the Great Powers in Europe, let us consider the nature of operations on the N.W. Frontier of of India, between that frontier and the Russian boundary, and in the Near East, in Palestine, Asia Minor, and the Balkans.

We require to know what organisation and equipment, are required for forces operating in those countries. As already stated, forces which can operate in such countries would, with comparatively minor modifications, be suitable to deal with the military liabilities in other countries referred to at the beginning of this essay.

In the countries named above there are ranges of hills and mountains with passes through them. These ranges divide valleys varying in width. There are also table-lands, and plains of great extent, some well watered, others more or less desert. Operations will frequently take the form of forcing a way through mountain passes leading from one valley to another, or on to a table-land or plain. The latter having been reached, there is freedom for manœuvre in much the same way as in many parts of Europe.

In working through mountainous country, and forcing the passes therein, troops must be equipped with pack transport, and be well supplied with pack artillery, but, when they debouch into the valleys, and move over plains and table lands, mechanical transport, and armament, and equipment, and tactics, become the same as already described for the Continent of Europe.

It is obvious therefore that there must be a pool of pack transport and pack artillery, to be allotted to troops who are to fight in mountainous country, which will be returned to the pool as soon as they can resume their mechanical transport. That is to say, that the infantry who, as already explained, form a very necessary part of the main army, would, on reaching mountainous country, where tanks and other mechanical vehicles cannot manœuvre, take over the task of breaking down the enemy resistance, since the enemy also would be unable to oppose us with tanks. Having secured the heights, and opened the pass, the mechanical columns would travel through, as roads always either exist, or can be made in a mountain pass in reasonable time for the cross-country type of mechanical vehicle. On the other side of the pass the army re-forms on the mechanical basis, and traverses the valley, or plain, or table land, up to the next mountain range, as already explained in European warfare.

In such countries there will be a certain amount of terrain where cavalry could be of more use than mechanical vehicles, so that on such terrain cavalry would resume their normal role, returning into reserve when the mechanical vehicles are able to take up the fighting once more.

CHARACTERISTICS OF PROBABLE ENEMIES.

In the East and Middle East the characteristics of probable enemies will differ considerably from those of western European nations.

In those parts of the world we should not expect to find ourselves opposed by the same high degree of technical efficiency and administrative capacity, nor would the mechanical and industrial resources behind our enemies be so well organised and developed.

Such deficiencies in the organisation and composition of hostile nations would have a marked effect upon the capacity of their Air Forces, and cripple their development of the use of armed and armoured mechanical vehicles and transport.

NEW ADVANTAGES OFFERED TO AN EFFICIENT INDUSTRIAL COUNTRY.

If we use our great industrial resources and technical efficiency, we can give ourselves a tremendous advantage in operations against such enemies as we are now considering.

We shall, in fact, get back, to a limited extent, to the happy state of affairs when, being in possession of guns, machine guns, and long range rifles, we used to find that the enemies we had to deal with in

our far-flung Empire were armed only with assegais, jezails, bundooks stinkpots, and the art of making faces. The comparatively small forces with which we acquired and defended our Empire were thus able to execute their tasks. Now the whole world is armed on the same scale, but, if we leap forward once more to a type of armament and equipment which only a highly industrialised, and technically efficient, nation can supply and handle on an adequate scale, we shall once more find ourselves in a position of marked superiority, securing a great economy in force.

It should give us back the capacity to move about such countries as we are now considering with comparatively small forces, defeating large armies who do not possess, or are badly served by, their Air Forces and mechanically carried troops.

The foregoing discussion enables us now to focus our attention upon "the essential *military* requirements of Imperial defence," which may be defined as below.

We must preface our definitions by the two assumptions that we possess a Navy which can give comparative security on the sea communications of the Empire, and an Air Force capable of competing on at least equal terms with hostile air forces, and of giving comparative security from air attacks in certain vital areas at home, and in the oversea theatre of war.

ESSENTIAL MILITARY REQUIREMENTS OF IMPERIAL DEFENCE.

1. The ground organisation for anti-aircraft defence, i.e. lights and guns, at home and overseas, must obviously be considerable.

2. Research work by the chemists to discover suitable measures for combating the effect of gas attacks on forces, and on the civilian population, and the organisation and equipment to apply practically the discoveries of the chemists to the protection of the nation, is of paramount importance.

3. The invention and provision of the lightest possible "anti-tank" gun that will pierce the armour of hostile armoured vehicles, with a margin for development of armour, and of the lightest possible cross-country vehicle to carry this gun, which should be supplied in suitable numbers to every infantry company as an integral part of its armament.

4. The Branches at the War Office which deal with research and invention, design and supply, of mechanical vehicles of all kinds, for fighting and for transport, should be in the closest touch with the industrial and technical resources of the country, so as to utilise for the purpose the best brains the country can produce.

5. Every unit in the Army, and all army transport, to be capable of abandoning the roads, and proceeding across country. Not a single vehicle to be utilised by the army anywhere which is tied to a road.

6. Thus infantry, besides being equipped with anti-tank guns, will have their reconnaissance cross-country machines, and their machine guns and transport also of the cross-country type.

7. Fighting armoured vehicles will be of various types and armament analogous to the ships of a fleet at sea, adapted to various purposes, as already explained in this essay. A proportion of the army must be converted on this mechanical basis forthwith. The research and experiment of the last few years has brought us to the stage where it is practicable to do this. We do not yet possess a satisfactory general service tractor, and there are many improvements required to "track" vehicles, but if we harness the best brains of the country to these problems, we shall solve them. We must not expect finality. Improvements will always continue.

8. Artillery, except for pack artillery, must be entirely tractor-drawn.

9. Pack artillery is required in a small proportion for warfare in Europe, and in considerably larger quantities in the Near East and the Indian frontier.

10. Engineers and their equipment must travel entirely in cross-country vehicles, likewise Signal units.

11. A considerable quantity of pack transport will be required for operations in the Near East, and in the country on the Indian frontier, and up to the Russian border. A force organised for European warfare can, by means of this pack transport, operate elsewhere, and alternate its transport, and tactics, according to the type of country it passes through.

12. Cavalry disappears from European warfare, but will be required in comparatively small numbers elsewhere.

13. The supplies of petrol, or of alternatives such as power alcohol, must be investigated and guaranteed.

14. Forces reorganised as described are required to be of sufficient size to:

(a) Fulfil our Locarno obligations in fighting with allies against a big Power, or Powers, in Europe.

(b) Operate with allies in the Balkans.

(c) Meet our commitments in the middle East, with or without the assistance of Allies.

(d) Ensure the integrity of India against hostile aggression.

15. Forces capable of fulfilling the conditions outlined in (14) will be adequate to meet all other emergencies with which the Empire may be faced.

SCHEME FOR PROVIDING ESSENTIAL MILITARY REQUIREMENTS.

The above being taken as "the essential *military* requirements of Imperial defence," how are we going to arrange to provide them?

The terms in which the subject of this essay is laid down contain

the important proviso, " Having in mind the imperative necessity for the greatest reduction possible, consistant with safety, in the annual cost of the three fighting services."

I would also add another proviso as binding upon anyone who seeks to give a practical solution of this problem, which I would word as " Having in mind the political impossibility of persuading this country to adopt, in time of peace, a system of compulsory military training."

We must face facts, and recognise that the politicians of this country are unable, or unwilling, to persuade the nation to:

(1) Spend a penny more on the army than the sum contained in the Estimates for 1926, viz: £42,500,000 (vide p.5. of *Army Estimates*, 1926), in fact they clamour for some reduction of this sum.

(2) Adopt any system which involves compulsory military training.

The nation has deliberately decided to revert completely to the pre-war situation of risk, when we provided the amount of force we felt inclined to pay for, and only so far as the system of voluntary service would permit, without any relation to the size of the military liabilities we might have to incur.

It is therefore again the business of the Minister of War and his military advisers, as it was before 1914, to organise and equip the army so as to obtain the maximum numbers and efficiency practicable within the bounds of the above two limiting provisos.

We will therefore keep these provisos constantly in mind in making the proposals which follow.

After the experience of the last war no one would venture to say that the military liabilities of the Empire as set out in this essay are met by four Regular divisions at Home, plus other troops in this country and on the Rhine sufficient for a fifth division, with a reserve to bring them to war strength, but not capable of providing reinforcements, plus 14 Territorial divisions, which require six months' training after the outbreak of war before taking the field, plus our garrisons in India and elsewhere abroad,

To make the best of the money, and the voluntary service system at our disposal, our main objects must be:

1. To re-organise, re-equip, and train the existing Regular and Territorial troops so as to give them their maximum war efficiency, and render them capable of operating in war in the manner already explained.

2. To organise a system which will augment the Reserve of the Regular Army sufficiently to provide replacement of casualties during, say, the first four months of war. In 1914 the " Special Reserve," which had been created by re-organising the old Militia, fulfilled this function, but it does not now exist.

3. In view of the insufficiency of the above two measures to meet our military liabilities, it is essential that a system should be fully prepared for expansion of the forces, and the mobilisation of all the resources of the nation, with the least possible delay after the outbreak of a war of the first magnitude, and thus avoid the chaos of 1914.

4. We must persuade the self-governing Dominions to continue, as at present, by interchange of officers at the Staff College, Imperial Defence College, and in units, to follow a common doctrine of organisation and equipment, and to play as big a part in preparing forces as their political situations will permit.

We will begin with some relevant facts to be kept in mind.

Army Estimates 1926, page 254, give the approximate annual cost of the following units at home. Cavalry of the Line, £108,700; R.H.A. Bde., £99,200; R.A. Field Bde.. £104,200; Battn. of Infantry, £117,600; Royal Tank Corps Battn., £232,500; so that a Battalion of 52 Tanks costs about double an Infantry Battalion.

Page 40 gives the pay of Royal Army Veterinary Corps as £42,800.

Page 24 states that there are four companies, and one depot company of horse transport, but their cost is not stated.

On page 127, it is stated that £201,000 is allotted to the Remount service.

On page 87, the cost of the Equitation School at Weedon is given as £31,700, and the Riding Establishment R.A. as £8,800.

It is not suggested that the whole of the above sums will be available when re-organising the army to contain a big mechanical proportion, but obviously the above items will be considerably reduced.

On page 203, there is an item "repayment under the military works acts, £822,000." This sum completes the repayment over a long period of years of the barrack loans. No more annual payments are due, so that this considerable sum should now be available for capital expenditure in converting existing units, and transport, to a mechanical basis."

Page 176, an item, "Transport Vehicles other than Motor Transport Vehicles, £17,300."

On page 176, the whole provision for Warlike Stores is £1,757,400. If some of these stores became obsolete by re-organisation and conversion of existing units, the money hitherto spent upon such stores will be available for new equipment.

On page 112, the allotment for movements is £1,100,000. If all changes of station by units were suspended for one year, a considerable proportion of this sum would be saved, to be available for capital expenditure on conversion of units and transport.

On page 128, the allotment for "Forage and Allowances in lieu" is £687,000. If all animal transport is converted to mechanical:

if all artillery except pack artillery becomes tractor drawn : if some cavalry regiments are converted to mechanical units, a large portion of the above allotment will be available for new armament and equipment.

No doubt there are other items which a more rigorous scrutiny of the Estimates would disclose as affected by a partial conversion of the army to a mechanical basis.

The items mentioned above total £4,668,000.

It has not been contended that the whole of this sum becomes available for expenditure on conversion to a mechanical basis, but we shall probably be within the mark if we say that, without exceeding the Estimates for 1926, we can spend annually 3 millions, plus half a million, in one year on conversion of units and transport to a mechanical basis, and on other re-organisation measures, provided that the annual cost of the mechanical units created does not exceed the annual cost of units which undergo conversion.

The Estimates of the Army in India might be analysed in the same way.

Relevant Facts concerning Existing Forces.

Next consider some relevant facts concerning number of units existing.

In England and on the Rhine we have (vide Vote A. *Army Estimates* and the *Army List*) four Regular divisions, plus, in scattered stations, the necessary units for a fifth division, less 1 pack brigade R.A. and less 2 field companies, R.E. In addition, at Home and on the Rhine, there are 3 battalions of infantry of the line and 10 battalions of Guards, two R.F.A. bdes., 10 Medium bdes. R.A., 23 heavy batteries R.A., 5 tank battalions each of 52 tanks, 2 armoured car companies. We should particularly note that we have only 6 anti-aircraft batteries at Home and apparently none in India.

Of cavalry at Home and on the Rhine we have two Household and 12 line regiments.

There are 7 batteries R.H.A. at Home.

We have 14 Territorial divisions at Home, also an Army Reserve which can bring units up to war strength, but cannot supply reinforcements, and a supplementary reserve of specialist artisans.

In Egypt and Sudan we have 3 cavalry regiments, 1 R.H.A. bde., 1 Field bde. R.A., 2 pack batteries R.A., 1 armoured car company, 7 battalions of infantry.

In the Colonies we have their garrisons which cannot be disturbed.

In India we have 5 regiments of British cavalry, 4 batteries R.H.A. 11 R.F.A. bdes., 2 medium bdes. R.A., 1 medium battery, 3 heavy batteries R.A., British personnel of 19 pack batteries, 45 battalions of British infantry, which are distributed to form brigades with Indian battalions. Eight armoured car companies.

CONVERSION OF EXISTING UNITS TO A MECHANICAL BASIS.

Bearing in mind the foregoing relevant facts concerning finance, and the number of units, we can proceed to lay out a programme of conversion of units to a mechanical basis, to be proceeded with at a rate which will involve the annual expenditure on conversion of about two-and-a-half million pounds. We shall be guided in forming this programme by the fact that it will be easier, on the outbreak of war, to improvise infantry battalions, or even cavalry regiments, than mechanical fighting units. Consequently a high proportion of our Regular and *Territorial Army* units must be mechanical.

Secondly, in India we have always kept all the artillery, except pack artillery, manned by British personnel, and we must follow the same principle with the mechanical fighting units.

We shall require, in every division, a mechanical force at the disposal of the divisional commander, to break down, and break up, the opposition he encounters, and to enable his infantry to advance.

We shall also require mechanical fighting units at the disposal of Corps and Army, as a reserve for manœuvre.

We have further to create a mechanical screening and raiding Force.

Consequently, in each of the five Regular divisions, and in each of the 14 Territorial divisions at Home, let us convert one brigade of 4 battalions of infantry into 4 mechanical fighting units. Space will not permit me, within the limits of this essay, to describe these units, and their armament, and equipment, but they will comprise several types of mechanical fighting machines. While we preserve the original name and traditions of each regiment, or unit, in its conversion, the establishment of each mechanical unit must be limited by finance, so that its annual cost of maintenance does not exceed that of the unit which it replaces.

For units at the disposal of Corps and Army we have, first, the five existing tank battalions, whose armament will in the future comprise several types of machines. Secondly, let us convert the three infantry battalions redundent to the 5 divisions, also two Guards battalions.

For the mechanical, screening, and raiding force, we will convert at Home nine cavalry regiments of the Line, leaving one brigade to remain as cavalry. Also seven batteries of R.H.A. should be converted, and two armoured car companies will be equipped with cross-country machines. All Yeomanry regiments will be converted to form part of this Force.

We have already noted that there are only 6 Regular anti-aircraft batteries to accompany the Expeditionary Force overseas. In describing the operations overseas we have seen the amount of essential work required of them. We must have at least 12 more of these batteries, with their accompanying lights, and, as finance

precludes this addition without conversion of existing units, they can only be found by converting, with great regret, a portion of the 2 field and 33 medium and heavy batteries which are outside the five Divisions, being Corps and Army units.

Anti-aircraft batteries for Home defence will continue, as at present, to be found by the Territorial Army. Their development and training is an urgent matter.

All the artillery will be converted so as to be tractor drawn, except the 12 pack batteries, which remain as they are.

All engineer and all signal units will be carried in cross-country mechanical vehicles, but, like the infantry, they will draw on the pool of pack transport always accompanying an Army when they operate in country unsuitable for mechanical vehicles.

Infantry battalions which are not converted will receive light anti-tank guns on light cross-country vehicles, also cross-country reconnaissance machines.

All horse and mechanical transport will be converted to mechanical cross-country type, and here we must look to the Ministry of Transport and the Chancellor of the Exchequer to help us. It is essential to create a demand in civil life for this type of cross-country transport, so that it will be available when we mobilise. A considerable reduction in the rate of taxation on these types, added to their well-known efficiency, should create a demand for them. Any direct loss to the Road Fund by this reduced taxation will be fully made good in the saving of cost on maintenance of roads, as six-wheel lorries and cross-country vehicles do much less damage to roads than the type of vehicle now running on them.

In Egypt and the Sudan we should convert 1 R.H.A. bde. and three infantry battalions to mechanical fighting units, and re-equip the armoured car company with cross-country machines. The engineers and signals to be also converted. All transport to be of the cross-country mechanical type, with an alternative pool of pack transport.

In India we have several regiments of Indian cavalry who would remain as such, so that all five British cavalry regiments, and 4 batteries of R.H.A. should be converted to form the mechanical screening, and raiding, force, which would also include the eight armoured car companies, re-equipped with cross-country machines.

All artillery, except pack batteries, in India would be converted to be tractor drawn.

Of the British infantry, 20 out of the 45 battalions would be converted to mechanical fighting units, of which 10 would be allotted to divisions, and 10 be kept as Corps and Army units.

Field companies, and signal units in India should be mechanical, with the alternative of drawing on the pool of pack transport when necessary.

All transport in India will be of the cross-country mechanical type, but the majority of existing pack transport, either in India or Egypt, will be kept in existence, and expanded into a pool of the necessary size on mobilisation.

EXECUTION OF PROGRAMME OF CONVERSION.

To complete the foregoing programme of conversion without exceeding the sum of £42,500,000 in annual Army Estimates, it must be spread over several years at a maximum rate of 2½ millions annually at Home, which should suffice to convert, say, ten units at Home annually, including conversion of buildings and provision of workshops. India would pay for converting, say, 5 units annually. A beginning should therefore be made at once.

The cost of the existing tank (£10,000) must not be taken as a guide. By improved design, by competitive tender, and by increased production, it should be possible to greatly reduce the cost of such vehicles.

A NEW REINFORCEMENT RESERVE.

A Reinforcement Reserve for the Regular army is the next item which calls for consideration.

For many years before the war there was a quota of the population, running into several thousands, (in 1914 it was 67,000) who were prepared to do an initial militia training of 4 months, followed by one month of training in every year, and to accept the liability for service abroad in time of war. There is a certain proportion of the population whose occupation causes them to find these terms attractive, and there is no doubt that such terms would again attract the same numbers.

Let us therefore call for them again to undergo, at the depots of Regular units of all arms, in the proper proportions, a four months' initial course, and subsequently annually a fortnight's training for, say, ten years, with the liability to reinforce the Regular army when Parliament calls out the Reserve.

The Regular army recruit undergoes a course of training at the depot for 14 weeks for artillery, 20 weeks for Infantry, and 26 weeks in the Tank Corps. A four month's course should therefore suffice to give a fairly satisfactory training. One would prefer to specify a five months' course, but finance, and the probability of securing the recruit, make it advisable to be content with four months.

Transfer to the Regular Army, if desired, would be permitted, as was customary with the Militia.

An annual sum of half a million should be allotted for this Reserve from the three millions which we have shown to be available. This should suffice to build up a "Reinforcement Reserve" of 40,000 to 50,000 in the course of ten years.

EXPANSION.

Finally, we come to the vital question of expansion for a war of the first magnitude, and the mobilisation of the whole resources of the Nation.

Expansion must be treated under two heads: (a) Personnel, (b) Munitions, using the word "munitions" in its widest sense to mean everything required by an army.

As regards Personnel, we have said that it is politically impossible to pass any compulsory legislation in time of peace, but at least we can prepare a complete paper scheme, or organisation, based on a National Register, which would allot to every man and woman their appropriate occupation in time of national emergency. If such a scheme existed it would rest with Parliament to implement it partially, or wholly, or not at all, as they think fit when the crisis arrives, but its existence would at least give the heads of the three Services some guidance. It would tell them which individuals should remain undisturbed, and what were the qualifications and suitability for employment of every individual who offered his services.

Moreover, the existence of such a Register would undoubtedly stimulate voluntary recruiting for the Territorial Army. Faced with the information that they were registered for such and such military, naval, or air force employment in time of crisis, a proportion at least of the population would begin to consider the desirability of securing an opportunity to prepare for such employment.

The National Register should not be compiled, or controlled, by any of the three Ministries of Defence, since it is not only for service under these three Ministries that the population would be registered. Moreover, it would be viewed with suspicion as "militarism" if these Defence Ministries were responsible for the Register. The Home Office, or the Board of Trade, or the Ministry of Health should shoulder the responsibility, and compile and maintain the Register with their existing staff at comparatively small expense.

We are running a great risk by cutting our forces down as we are doing. At least we should be prepared with a paper scheme of organisation, which will save us from the chaos and waste of life and resources which occurred in 1914 and 1915. Surely the politicians can muster enough courage to tell the nation frankly that this measure of cheap insurance cannot be neglected.

Next as to "Munitions."

We require one Army Councillor, and his Department at the War Office, to be charged solely with the responsibility for the supply of munitions in peace, and the rapid expansion of that supply in war. They require to be in close touch with the sources of supply, and to have all the information scheduled as to how expansion can be effected, and what are the key items which must be maintained in

peace. No doubt it would be necessary in a war of the first magnitude to recreate the Ministry of Munitions as it existed in the last war. To avoid the imperfections of that Ministry, due to hasty improvisation, a mobilisation scheme should be prepared in peace by the Committee of Imperial Defence. As before, time would be necessary before such a Ministry could become effective, and during that interval the War Office Munitions Department must bear the load. In comparatively small wars of, say, the size of the South African War of 1899-02, a Ministry of Munitions would be unnecessary, and the War Office Munitions Department would do the work.

CONCLUSION.

Having surveyed the War Liabilities of the British Empire, having assumed that the Navy, the Air Force and the Anti-Gas Chemists will play their part to make military operations possible, and having attempted to forecast the nature of future military operations in Europe, in the Near East and in India, having regard to the characteristics and capacity of probable enemies, we have arrived at, and stated, the essential military requirements of Imperial Defence.

In framing a scheme to provide these essentials, we have kept constantly in mind the limiting factors of finance, and the political aspect of military organisation.

The Scheme which has thus been deduced, and recommended, provides for the conversion to a mechanical basis of certain units of the existing forces at Home, in Egypt and in India, to provide:

A mechanical screening raiding Force..

A mechanical Force in every Division.

Mechanical fighting units at disposal of Corps and Army.

Artillery entirely tractor drawn, except Pack Artillery, which is to be retained.

Engineers and Signals carried in mechanical vehicles,

Cavalry for use in the Near East, and in India, but not in Europe.

Infantry suitably armed and equipped to contend with mechanical forces.

All transport and all units to be free to abandon the roads.

Pack Transport organisations in India and Egypt to be retained, but alternative mechanical Transport provided.

We have also provided for a new Reinforcement Reserve, which is lacking in existing forces.

Finally, we have made provision for the all important expansion of Personnel and of Munition supply on the outbreak of war, by the proposed creation and maintenance of a National Register, and the compilation and upkeep of a mobilisation scheme for Munitions.

THE TREND OF MODERN IDEAS IN BARRACK CONSTRUCTION.

A Lecture delivered at the S.M.E., Chatham, on 27th January, 1927,

By MAJOR AND BT. LIEUT.-COL. G. B. O. TAYLOR, C.B.E. R.E.

INTRODUCTION.

Lack of time prevents me from going into any of the back history of Barrack Design. I must assume that you are reasonably well acquainted with existing types of Barrack buildings, and the remarks I have to make will therefore be confined to post-war developments in their design.

The chief factors affecting post-war design of Barracks are :—

1. The financial situation.
2. The necessity for keeping abreast of modern standards of hygiene and sanitation.
3. The necessity for providing for post-war formations and for the steadily increasing mechanisation of the Army.
4. The necessity for coping with alterations in the organisation and methods of administration of units or in the Army generally.

Of these the first—i.e. the financial situation—governs the rest, which obviously all involve the expenditure of increased sums of money.

THE FINANCIAL SITUATION.

In order that you may have as complete a picture of the present situation as it is possible to give in the short time available, I propose to explain very briefly our financial position.

Immediately before the war the average annual expenditure on Military Works was some £1,356,000, whereas it is now some £2,700,000.

We should not be far out in saying that building costs now are approximately twice pre-war costs, and that our total building power is therefore just about the same as before the war. Of this total of £2,700,000, over £1,200,000 is required for maintenance of buildings and War Department property in general; and of the remainder, some £250,000—£300,000 is taken for Part II Services, leaving some £1,200,000 or so available for the larger new services.

It might be argued that as the post-war Army is considerably smaller than the pre-war one, there should be little difficulty in finding this amount sufficient to enable us to keep abreast of modern developments; but in actual fact this is not the case, and the necessity for the replacement of the accommodation lost on the evacuation of Southern Ireland, and for the provision of accommodation for new formations, etc., have been, and will for some time continue to be, a heavy charge on available funds.

In point of fact, in formulating proposals for a new military Works Loan a few months ago, little difficulty was found in compiling a list of services totalling some £14-15,000,000, which either were, or would apparently become essential, in the course of the next ten years.

I will touch on the financial aspect again a little later, and it now remains to consider how the other factors affect it.

MODERN STANDARDS.

The second factor is the necessity of keeping abreast of modern sanitary and hygienic standards.

This involves amongst other things—

1. *In the Barracks generally.* The replacement of slate urinals and trough latrines and other obsolete pattern fittings by those of modern type, and the provision of night urinals, etc. These fittings have of course been obsolete for many years and have not been included in any new barracks built in the last 15-20 years; but up till now funds have not been available to undertake their complete replacement.

2. *The provision of Dining Rooms.* These were authorised several years before the War, but were only provided in new barracks, or where they could be found by reappropriation of existing buildings. It was incidentally suggested that as men would no longer eat where they slept, they might be squeezed up more in their sleeping quarters, and thus free space for reappropriation as Dining Rooms. Fortunately the Medical authorities of the time laid down that the governing factor should be a minimum of 6 feet between centres of beds, and this remains as our present day allowance of 60 sq. feet, or 600 feet cube, per bed. Since the war, however, a systematic effort has been made to provide Dining Rooms wherever they are non-existent, and another two or three years should see this completed.

3. *The provision of electric light throughout barracks in lieu of gas or other forms of lighting.* This has enabled us to do away with our W.D. Gas Distribution Systems, some of which were over 60 years old, and consisted of a mass of worn-out piping costing a good deal to maintain, and were correspondingly inefficient in consequence. The supply of gas is now practically limited to certain fittings in Hospitals and Laboratories.

In London, gas is also supplied by the W.D. to gas cookers in Married Quarters; but elsewhere this is done by private arrangement with the Gas companies concerned; the W.D. only coming into it to the extent of making agreements for the use of existing W.D. piping, permission to lay pipes in W.D. land, etc.

A development for the future will no doubt be electric cooking, and, possibly, eventually electric heating throughout barracks; but this will have to wait until the necessary electrical appliances are sufficiently perfected and fool-proof for general use in barracks, and until current is available at a rate not exceeding one penny per unit.

Whether the electrical development schemes foreshadowed for the country will enable this to be forthcoming, remains to be seen; but at present it appears doubtful.

4. The provision of better bathing facilities, i.e., slipper baths and hot and cold showers.

5. A concentration of cook-house, dining rooms, and bath-houses into one or adjacent blocks, thus facilitating hot-water supply, and economising in boilers and attendant staff, and reducing coal consumption.

In the Cookhouse. 1. The provision of modern cooking apparatus —e.g., hot air ovens, steam-jacketted boiling units, frying tables (coal stoked from the outside), steam-heated hot closets, washing up machines, etc.,

2. The provision of adequate space for preparing meals, etc., and for washing up.

In the Barrack Block. 1. The provision of a Sanitary Annexe, containing w.c's., and ablution basins attached to each Block. It is true that this was being provided before the War, but the annexe only contained night urinals and ablution basins, and day latrines were provided in separate blocks in the barracks, whereas our modern type enables these barrack latrine blocks to be entirely done away with.

2. A strict adherence to the regulation allowances of 60 feet super and 600 feet cube per occupant.

These scales were introduced many years before the War and were of course applied to all new construction, although not always to existing Barracks, particularly of the hutted type.

Their strict application in recent years has, in many cases, resulted in a 10-15 per cent. loss of accommodation.

That this has coincided more or less with a reduction in the Peace Establishment of the Battalion has been fortunate; and incidentally this same reduction has in many cases allowed us to provide dining rooms, etc., by reappropriation of surplus sleeping accommodation, and thus save the cost of new construction.

In the Married Quarter. The provision of baths, with hot and cold water, and w.c's., to all married quarters.

Here again, w.c's. and baths were authorised before the War, but the bath was only a " sitz " one, whereas now a slipper bath is provided ; although like so many of these changes, it was practically confined to new construction owing to lack of funds. Again, it was not till 1913 that artificial lighting was authorised for the sculleries of married quarters.

It is only since the War that a systematic attempt has been made towards providing bathrooms and w.c's. in existing quarters, and a considerable sum of money is devoted each year to thus modernising our old quarters.

POST-WAR FORMATIONS.

The third factor is the necessity for providing for post-war formations, and for accommodation for the increasing mechanisation of the Army.

Post War formations are chiefly:

Royal Corps of Signals—Units and Depot.

Royal Tank Corps—Units and Depot.

Army Schools such as—Boys' Training School, School of Hygiene, Education and Senior Officers' Schools, etc.

Air Defence Units.

Chemical Warfare Organisations.

There is no need to give any particulars as regards the scale or type of provision for the majority of these formations, as they follow approved lines, and only vary in so far as the establishment of the particular formation affected necessitates it ; but the work necessitated by mechanisation must be touched on, as this is, and will continue to be, of ever increasing importance.

Mechanisation in the Army as it affects us is threefold :—

Firstly, it comprises the addition of complete new mechanised units—e.g., Tank Battalions, Armoured Car Companies—to the Army, involving in most cases complete provision of new accommodation.

Secondly, it comprises the substitution of the horse-drawn gun or vehicle by a machine—e.g., dragons for guns, etc.—involving usually the alteration of existing stabling or vehicle sheds, or in any case a limited amount of new construction only; and *Thirdly*, it comprises the provision of workshops at suitable centres to deal with the repair of these vehicles, involving in almost every case new construction, although usually as additions to existing Ordnance Workshops.

The whole question of Ordnance Workshops is under review at the present moment by a Standing Committee at the War Office, and some of their conclusions can be briefly summarised as follows:

Pre-war Ordnance Workshops took up for the repair of Armament, Wagons, and general equipment, such as Saddlery, Camp Equip-

ment, etc.; and for carrying out modifications resulting from approved lists of changes as published officially from time to time. Generally, in size and equipment they were totally unfitted to deal with the overhaul of mechanically propelled track vehicles.

A general type design of Workshop was therefore drawn up to be erected at existing Ordnance Depots at certain Military Centres geographically suited to take on this class of work.

This standard design comprises two aisles, each 45ft. in width, one aisle with an overhead 2-ton traveller running over the whole length of the aisle, the floor area beneath being assigned to dismantling and erecting bays, fitters and machine shops, gun shops, and heavy parts stores. The side aisle is appropriated to accessory shops not requiring heavy lifts.

The design is such as to permit of extension as required, the actual size in any particular case being determined by the anticipated number of vehicles to be dealt with at any one time.

The actual construction proposed is steel framing, with 4½in. brick panels or a hollow wall consisting of asbestos protected metal sheeting externally, and asbestos sheeting on the inside, leaving an air space for warmth. Internal partitions consist of breeze blocks up to 5ft. in height, with asbestos cement sheets above. Central heating is also installed.

Office Block, Latrines etc., are provided in separate structures. The all-in cost should not normally exceed 20/- per foot super for this type of building.

Alterations in Organisation and Administration.

The last factor influencing design is the necessity for providing for alterations in the organisation, or methods of administration of units, or in the Army as a whole.

Under this heading might come the following:

1. *Provision of Company Stores.* Since the introduction of the double company system before the War the company has become the accounting unit, in lieu of the battalion.

2. *Education class rooms for the Soldier.* Children's Schools have been provided for many years, and the soldier used the elder children's class-rooms as schoolrooms before the war.

3. *Recreation Grounds.* Before the War the provision of a playing area 450ft x 420ft. was allowed for each unit, i.e., just about large enough for one Football Ground. Since the War this has been increased to a total area of 8 acres per unit of 500 or over, or 6½ acres per unit under 500, with an addition of 12 acres for every Brigade formation. It allows for Football and Cricket Grounds, Tennis Courts, a Cinder Track, Pavilion, etc.

Public funds have not as yet been able to provide to any great extent for these, and so far the Army Sports Central Board has found

the bulk of the money required, but in all new construction the necessary funds for this are included in the estimate for the whole service.

Experience would tend to show that the present scales are somewhat lavish where large garrisons are found, but in the case of isolated units they are by no means excessive.

4. The development of the Regimental Institute into the form of a Soldiers' Club was legislated for in the pre-war synopsis, but it may be of interest to recall that it is only a comparatively recent development which has allowed the soldier to drink his beer in comfort in the Institute, instead of being relegated to the comparatively cheerless isolation of the former Wet Canteen. Post-war developments have therefore been in the nature of minor improvements in comfort and convenience of working.

The latest development is the placing of the soldiers' room at one end of the large Restaurant, and separated from it by a movable partition, so that it can be thrown into it at will.

The Corporals' room has also been enlarged at the expense of the bar.

5. *Married Quarters for Officers.* Before the War, married quarters for officers were usually provided for all Commanding Officers and those senior to them and for Quarter-Masters. Special provision was also made to some extent for Staff and Departmental Officers, but the unfortunate Regimental Officer got nothing. Since the War, general scales of provision averaging one-third of the establishment of Officers have been approved. Unfortunately, however, although considerable sums of money are devoted to this each year, at present only about 25 per cent. of the approved scale of Quarters have been provided, and as the rate of increase is only about 5 per cent. per annum, it will take many years to complete.

There are other additions of a minor nature which can be seen by a comparison of the pre-war and present detailed synopsis for each unit, and we are constantly being asked at the War Office to provide more and more under this heading.

Some instances can be quoted, such as regimental sports gear stores, office for 2nd in Command, barbers' shops, etc.

Most of these have to be turned down owing to the financial stringency not justifying their provision.

It may well be asked—how do we find the money to cope with all this additional provision?

Not only have we no more funds in actual building value than before the War, but such funds as we have are subject to an increasing pressure to reduce them.

The financial state of the country is well known to all, and there is a steadily increasing public pressure on the Cabinet to reduce the total amount spent on the Fighting Services. The result has been a

steady annual decrease in the total vote for the Army, and no one can say that the process has come to an end yet.

The situation is further complicated in the Army itself by the necessity for finding more money for the development of mechanisation, and the net result is that we have to meet an incessant pressure to reduce our expenditure, or, in any case, to produce more for the same amount of money.

Methods of Construction.

We have been compelled in consequence to effect a drastic overhaul of all our methods of construction, and this has taken place on the following lines:

(a) By making all possible economies in planning.
(b) By adopting the most economical forms of construction.
(c) By making the fullest use possible of cheap substitutes for various building materials, etc.
(d) By a general reduction in the standards of our buildings, other than those affecting the health of troops.

Under (a) therefore we are constantly endeavouring to reduce the plinth area of buildings by reducing waste space, while at the same time retaining the full synopsis area for each room. Heights of rooms have been reduced where possible, and external architectural features unnecessary for the stability or sound construction of the building have been eliminated.

Plans, etc., have been revised with a view to the utmost simplification of roofing, etc.

Under (b) when we consider barracks, the first question we have to ask ourselves is, What are they wanted for? and where should they be put?

One of the most impressive object lessons we can have is to look at the many large and substantial barracks built to last a century or more, and in places where they are no longer required.

Military policy changes so fast and military development is so rapid that it is unsafe to build for more than about 30 years ahead.

We have only to look at the possible future development of mechanisation to realise how our present ideas may be entirely changed in the comparatively near future.

The ideal building for military occupation should therefore be one that is cheap to put up, costs little to maintain, is warm and comfortable to live in, and which will fall down of its own accord in, say, 30 years.

Early in the 20th century we had two main types of barrack construction—the permanent type in substantial construction, as in Stanhope and Marlborough Lines, Aldershot, Tidworth, the Curragh; and the hutted type as at Bulford, Bordon, Blackdown, etc. The latter may be said to have been an attempt to obtain our ideal,

for Corps and 2 divisional units of the Royal Corps of Signals are being erected. These stables are of steel framing, with 4½in. brick walls rough cast, and in view of the probable eventual mechanisation of the Signals, they have been so designed as to permit of their ready conversion into garages for mechanical vehicles. The walls are therefore built in lime-mortar to facilitate removal and re-use of the bricks, which would be difficult were they built in cement.

Under (c) are included:

1. The use of asbestos cement or other composition slates for the natural product.
2. The replacement of natural stone in dressings, etc., by artificial stone or concrete.
3. Internal partition walls of breeze concrete slabs.
4. The use of sand lime or other cheap bricks for internal walls, such as the inner portions of cavity walls, etc.

Under (d) our modern specifications include the following:

1. Lime mortar in lieu of cement, wherever possible.
2. 1 to 5 cement mortar in lieu of 1 to 3, when cement is necessary.
3. Substitution of wood preservatives for paint.
4. Omission of all unnecessary internal decoration, such as cornices, moulded architraves, etc.
5. Solid or semi-solid floors to save excavation and floor joists.
6. Standard steel casements.
7. Ready-made joinery (of Empire production).

These last apply more particulary to Married Soldiers' Quarters, where we have to withstand a never-ending comparison of our costs with those of various Municipal Housing Schemes.

Those of you who have visited the Dagenham Estate, on which some thousands of houses are being built by the L.C.C., will realise that we cannot possibly build as cheaply as they do there, partly because mass production methods possible on a scheme of this magnitude are impracticable when applied to the W.D., who build a few quarters here and there scattered over the whole of the United Kingdom, and partly because the use of foreign materials, such as cheap Belgian and French bricks and tiles, American as opposed to Canadian joinery, etc., is debarred to us as a Government department.

We have been and are trying various substitutes for brick in an attempt to cheapen our Married Quarter costs, e.g., Cuyper Houses (wooden) on Salisbury Plain, Atholl Steel Houses at Larkhill, and concrete-block houses at Fort George in the North of Scotland. The Nissen-Petren type of house was also carefully examined, and a design suitable for Married Quarters was prepared. Actual tenders on this type shewed no economy, however, and none were therefore actually put up. It is questionable whether any of these are cheaper, or in fact as cheap, under normal circumstances, as our latest design of Married Quarters in brick, taking extra maintenance

with the grave disadvantages that they were not warm and comfortable, and that, owing to the large expanse of corrugated iron to be painted, they were not cheap to maintain.

The introduction of steelwork into barrack construction has however enabled us to build blocks almost as cheaply as the Bordon, etc., type of barrack hut, but which are far warmer to live in and cheaper to maintain.

We hope they will not fall down in 30 years' time, but we can justly claim they are the lightest form of construction consistent with reasonable comfort.

The actual form of construction is steel uprights and roof trusses, with 4½in. brick walls, rough cast on the outside and plastered internally. Floors are solid, and central back-to-back fireplaces are provided. A sergeant's bunk, and sanitary annexe containing w.c's., urinals and ablutions are included in each block.

In the case of single storied blocks, steel stanchions are not a necessity, and 9in. brick piers are built under each end of the roof truss. Roofs are asbestos cement slated.

It might be thought that these blocks would be cold to live in, but experience with those built just before the War at Bordon shows that they are quite warm and pleasant.

This form of construction is not so suitable for buildings divided up into a number of small rooms, such as Officers' Quarters and Married Quarters, when the cross-walls may be utilised for the weights of roofs and floors. And again in these cases it is perhaps open to question whether a 4½in. wall would be warm enough when a room only has a single occupant and coal allowances only admit of spasmodic heating.

A good example of this steel construction is the new Out-patients and Treatment Block at Millbank Hospital, which is five stories high, and has steel framing with 9in. brick panels. Apart from saving in brickwork, the saving in plinth area is considerable, as were the walls in brick only they would have to be not less than 27ins. thick.

For Stables, Stores, Vehicle Sheds etc., corrugated steel walls and covering are extensively used, more particularly "protected" material, such as Robertson's Asbestos Protected Metal. Although this form of construction is little if any cheaper than 4½in. walling, it has the great virtue of being easy to dismantle and re-erect elsewhere, and in the present somewhat uncertain state of development of the Army this may eventually lead to considerable economy.

As an instance, the converted war-time stables for the two artillery brigades to be stationed at Catterick have been covered with this metal. It is known that these brigades will be mechanised in due course, on which these stables will be no longer required, and will be available for use elsewhere.

A variation of this has been adopted at Smallshot, where stables

costs into account, and they can only be looked on as alternatives to relieve the shortage of certain classes of building-trade labour, such as bricklayers and plasterers.

We are also trying a system adopted in some housing schemes, of pumping hot water from an open cylinder to the bath by means of a semi-rotary hand-pump, thus saving a considerable amount of plumbing work. Reports so far are favourable, but it is not possible to say at present if it will be adopted as standard W.D. practice.

We are having much the same sort of difficulty with Married Officers' Quarters. It is of course impossible to build a married officers' quarter for a price at which the lodging allowance of an officer, viz., 4/6 a day say, would give a fair economical return, but we are being urged to produce designs for houses which will be of a standard similar to those occupied in civil life by individuals drawing the same salary.

Thus a 'Group III' Quarter occupied by a Lt.-Col., drawing, say, £1,200 to £1,400 per annum, should be designed to earn a rental of £120 to £140, assuming that the average individual is prepared to pay 10 per cent. of his salary in house rent, and a further amount varying from 5 to 10 per cent. in rates. This means that the capital cost should not exceed £2,400—taking a fair return on house property as 6 to 6½ per cent; whereas the present 'Group III' Quarter, including a garage, costs from £3,000 to £3,200, according to site and locality. It is open to question whether any such comparison is fair or reasonable, but it is certain that we shall have to reduce our standards in married officers' quarters, just as we have had to in married soldiers' quarters. In fact, this has already been given effect to as far as the 'Group V' Quarter is concerned, and the alterations in design and specification recently made in these quarters comprise the following:

Light scantlings are laid on the concrete layer under floors to form ground-floor joists instead of using ordinary joists carried on sleeper walls. This alteration saves several inches in height of brickwork all round the building, also corresponding facings, plastering, etc.

Felt layer between roof boarding and asbestos cement slates omitted.

Certain architectural features, such as tile hanging to bay windows, brick plinth courses around building, etc., are omitted, and ordinary rendering or roughcast substituted.

Plain chimney pots in lieu of ornamental.

All internal plastered cornices omitted.

Several stop-cocks to branches of the water supply omitted.

General cheapening of fittings and ironmongery.

Bituminous felt lead core dampcourse, ready made in rolls, substituted for molten bitumen poured *in situ*. Zinc flashings

substituted for lead and bituminous covering to flats (roofs) instead of lead.

General cheapening of skirtings, mouldings, linings, and other joinery.

The effect of these is to reduce the cost of the 'Group V' Quarter by some £180 per quarter, to approximately £1,350.

Similar alterations will be, or are being, introduced into our designs for 'Groups IV and III' Quarters.

A possible development in the future is the elimination from our *Synopsis* of any quarter larger than the 'Group III.'

One of the present day difficulties is that of obtaining servants, particularly in the country; and the possession of a large quarter is by no means an unmixed blessing nowadays.

It is possible therefore that quarters for officers above the rank of Lt.-Col. will in the future be considered on their merits in each case; and that a type will be evolved on the lines of a slightly enlarged 'Group III' Quarter, with somewhat bigger reception rooms to permit of larger scale entertaining, with a servants' hall where necessary, and perhaps with lounge-hall, which is becoming increasingly popular in private houses generally.

It is difficult to see how further economies are to be effected. We have of course continued to specify that materials used are to be, in general terms, of the best of their kind, and similarly with workmanship, and it would be ill-advised in the extreme to introduce modifications in this.

We are not in the position of speculative builders who sell their houses as they build them, or of municipalities who throw the cost of maintenance on the rates, and any introduction of shoddy work or materials into our specifications would merely recoil on our own heads in enhanced cost of maintenance, and hence in less money being available in the future for capital expenditure.

The same argument of course applies equally to building in semi-permanent construction, e.g., timber and corrugated iron. Not only is the initial saving far less than might be imagined, but any such saving would be quickly swallowed up in future years by the increased cost of maintenance and the shorter life of the structure.

Of course these various methods for cheapening construction must be applied with discrimination. They would certainly be applicable to new construction in any large open space, such as for a complete new barracks, etc., but much of our work also consists of adding buildings to existing barracks. In these cases we must be bound by consideration of the surrounding buildings. We cannot, for the sake of a comparatively trifling economy, put a rough cast building in the middle of brick built barracks, or roof a building with asbestos cement slates, when the genuine article covers all the surrounding buildings.

Each of the savings given in the foregoing is small in itself as applied to an individual building, and it is only in their general application to a considerable number of buildings that large economies are to be effected.

COST OF ACCOMMODATION.

It must be also realised that the actual cost of the Barrack Block, etc., forms only a small proportion of the total cost of accommodation of a unit, and in this connection the following figures taken from Smallshot, where barracks are being built for some 1,300 officers and men of the R.C. of S., are of interest.

	£
Total all over cost	300 per man.
Cost of Barrack Blocks	60 per man.
Cost of Dining Rooms, Cookhouses, .. Institutes, etc.	37 per man.

The balance is made up of preparation of site, drainage, water supply, roads, etc., officers' mess and quarters, married quarters, stables, vehicle-sheds, etc.

In this particular instance the preparation of the site cost some £25 per man, and stables, of which there are an abnormal number, cost some £40 per man; and there is little doubt that we could build a battalion barracks on a normal site and under normal conditions for round about £250 per man.

This figure can be compared with the pre-war figure given in *Coleman's Pocket Book* of £170-200 per man, which goes to show that, allowing for the difference in building costs, we have been able to effect very considerable economies by lowering our specifications and cheapening our methods of construction, in spite of having to make extra provision owing to higher standards of hygiene and other causes stated in the foregoing.

It may be of interest to give other comparisons of the cost of our present day buildings with their pre-war prototypes:

The present Barrack Block costs £55-60 per man as compared with £25 for the nearly similar type pre-war.

Married Quarters "B" Type now cost £450-500 per Qr. as against average figure of £250-280, pre-war.

Warrant Officers Qrs. £800, as against £550 pre-war.

Married Officers Qrs. 'Group V.' £1,350, as against £900.
" " 'Group IV.' £2,200, " £1,400.
" " 'Group III.' £3,000, " £2,500.

Stables £81-83 per horse, as against £38-40 pre-war. These costs being exclusive of fittings. In one or two isolated cases, stables were built cheaper than this before the war, but the figures

SINGLE STORIED BARRACK BLOCK.

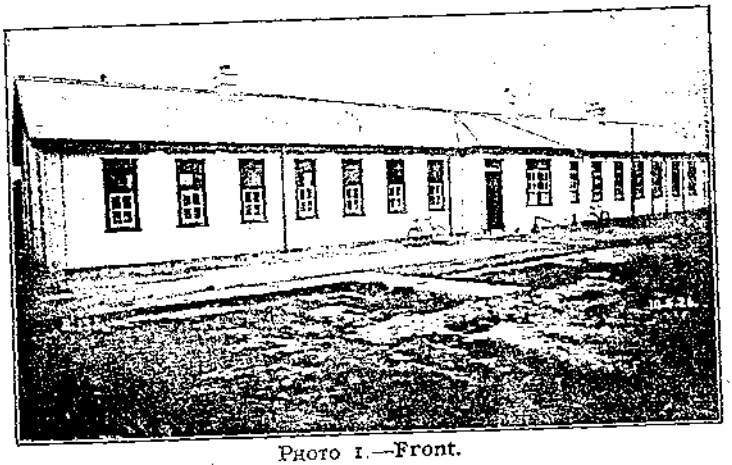


Photo 1.—Front.

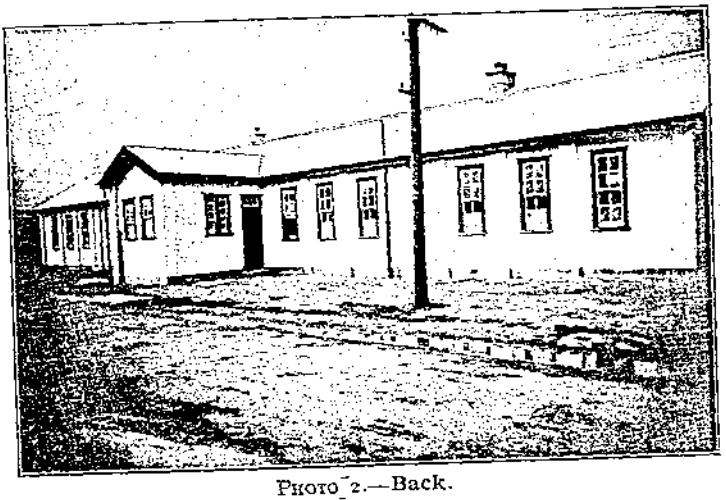


Photo 2.—Back.

DOUBLE STORIED BARRACK BLOCK.

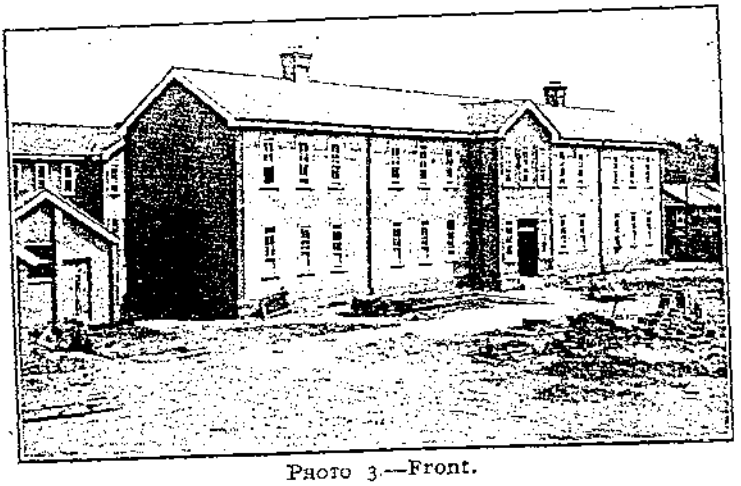


Photo 3.—Front.

PHOTO 4.—Front Entrance.

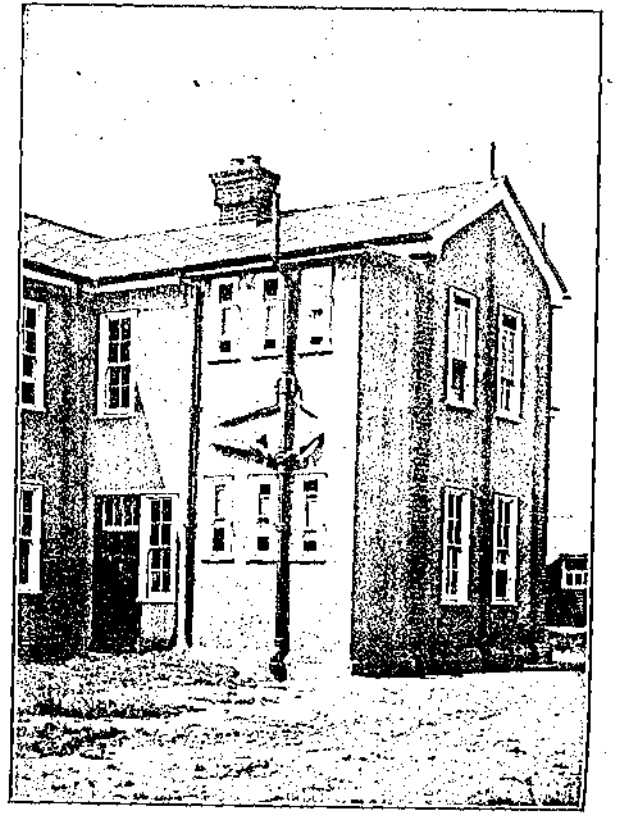


PHOTO 5.—Sanitary Annexe.

"B" TYPE.—MARRIED SOLDIERS' QUARTERS.

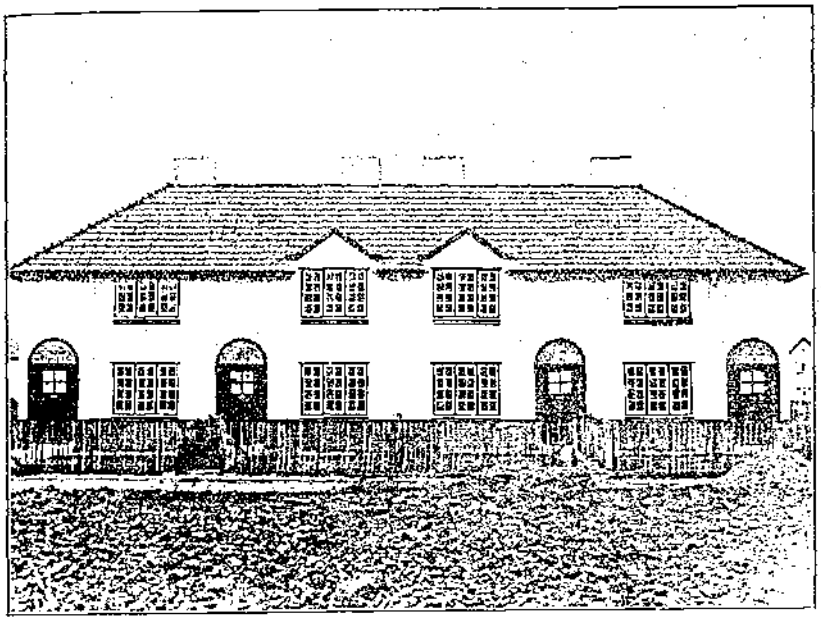


PHOTO 6.—Front.

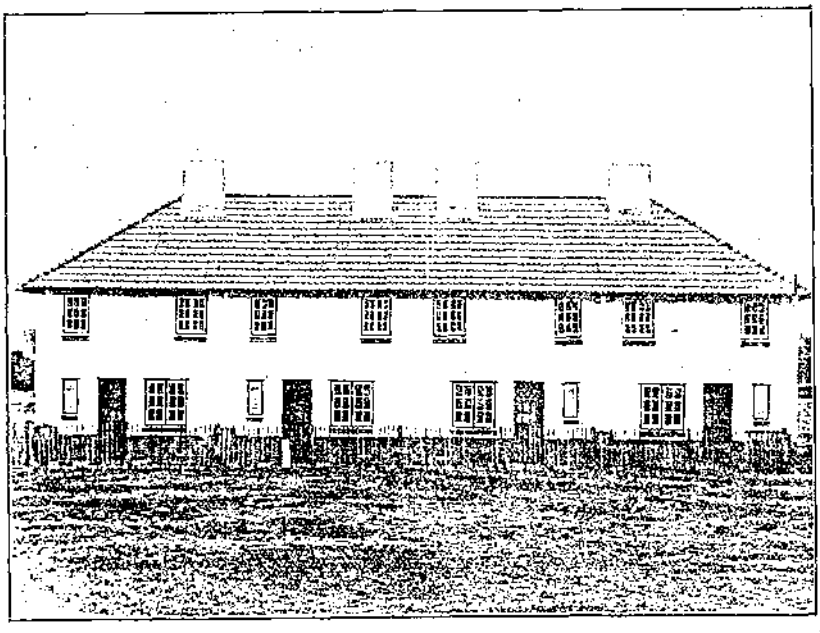


PHOTO 7.—Back.

"C" TYPE.—MARRIED SOLDIERS' QUARTERS.

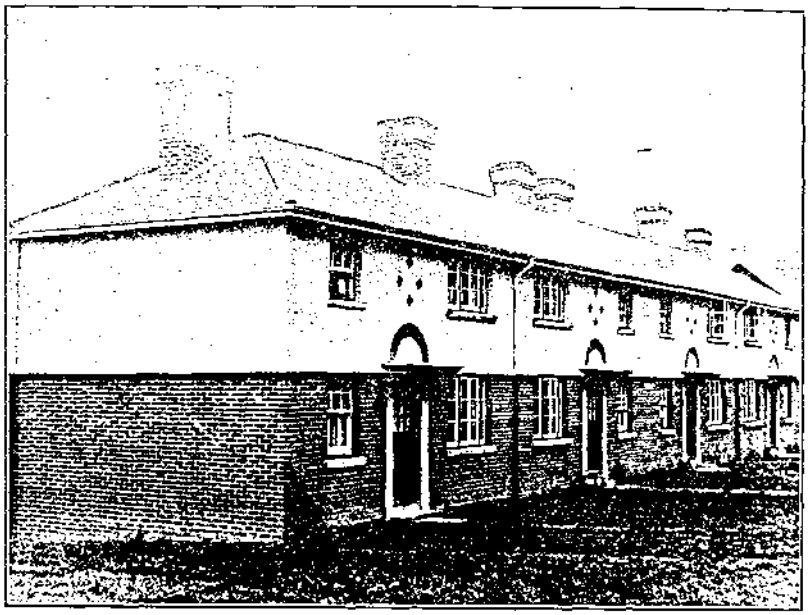


PHOTO 8.—Front.

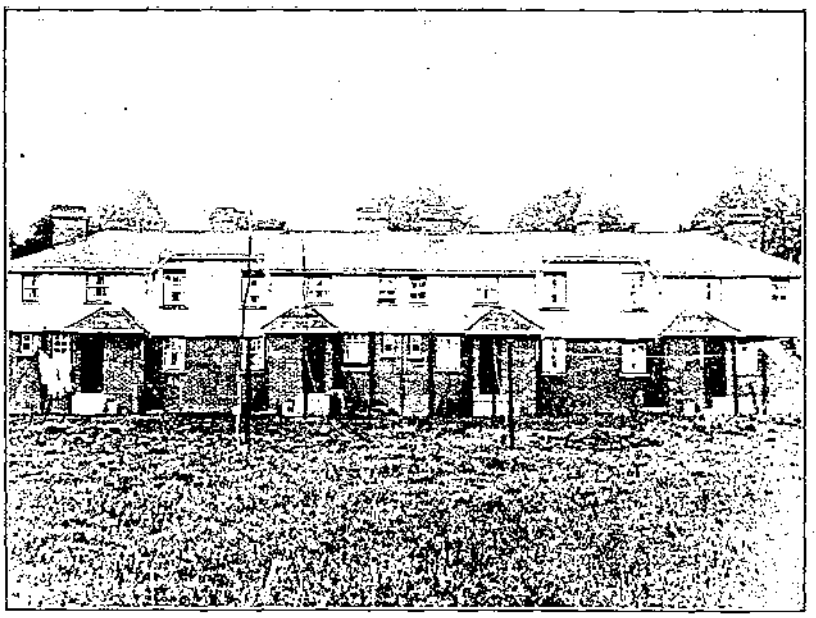


PHOTO 9.—Back.

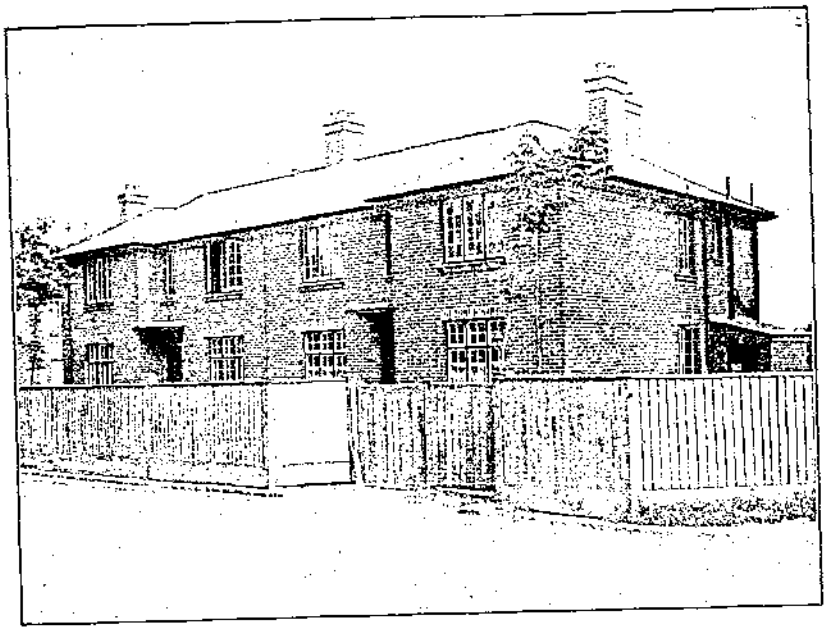


PHOTO 10.—Group V. Married Officers' Quarters, Chatham.

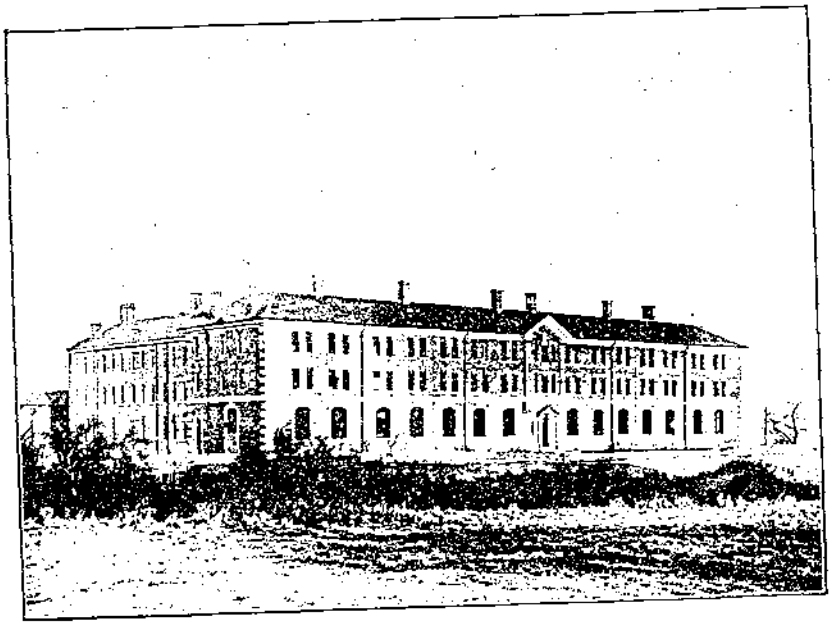


PHOTO 11.—Signal Training Centre, Officers' Mess, Catterick.

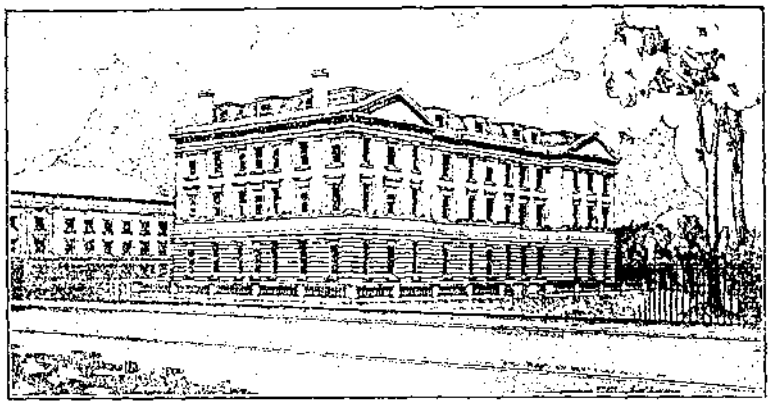


PHOTO 12.—Design for Officers' Mess, Brigade of Guards, Wellington Barracks.

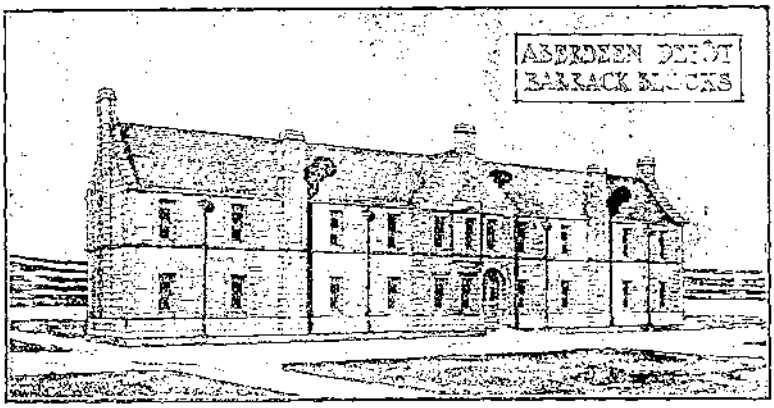


PHOTO 13.—Design for Barrack Block, Aberdeen Depot.

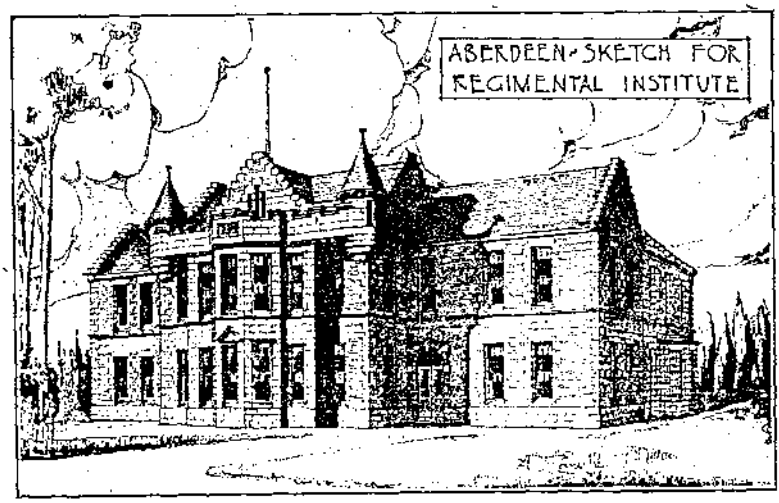


PHOTO 14.—Design for Regimental Institute.

given are a fair general average. The illustrations on the accompanying plates show to what extent architectural appearance has had to be sacrificed to the claims of economy, and it can only be hoped that in future perhaps a less imperative call for economy, together with further experiments in planning, will enable us to produce buildings which will be not only more pleasing to our aesthetic sense, but more in keeping with their position as Public Buildings.

Incidentally, I might add here that the barrack block has just been re-designed with considerable improvement to its appearance. Apart from a certain economy in the space taken up by the annexe, the main difference is in the windows, which are no longer placed between every bed.

The medical authorities no longer insist on this, and they will now be placed between every pair, with considerable gain architecturally.

Photo No. 12 shows the façade of the new Mess to Wellington Barracks, as designed by the War Office. The one actually built was designed by H.M. Office of Works, as being more suitable to its surroundings. Opinions may differ on this point, but I think that the illustration shown is a pleasing instance of what can be done when economy is not the paramount consideration.

Photos 13 and 14. "Sketch designs for Barrack Block and Regimental Institute for the new Depot for the Gordon Highlanders, near Aberdeen." Here again a Depot, with its County Regiment Associations, calls for more elaborate treatment, and the medium built in—granite—in itself helps towards the attainment of architectural distinction. *Photo* 14 is of course an application of the Scottish Baronial style of architecture to a Military Building.

A DIARY OF TWO DAYS' WORK IN THE M.E.S.

By MAJOR A. V. T. WAKELY, M.C., *p.s.c.*, R.E.

INTRODUCTION.

The object of the present article is to give those readers of the *Royal Engineers Journal* who have not been fortunate enough to serve on the North-West Frontier of India some idea of the daily life of an R.E. Officer of the Military Engineer Services.

I have therefore endeavoured to describe two days' work and play in the form of a diary. The days chosen are fairly typical of what happens during the cold weather in Peshawar.

Naturally each and every day is not as good as the two days described below, bu tthe number of really good days is considerable. You always get two days' hunting a week, and it is bad luck if you can't get a couple of afternoons' shooting as well.

There is a good deal of work to be done, and when it is remembered that besides hunting and shooting, the cold weather is the season for cricket, tennis, golf and racing, it will be realised that life is fairly strenuous.

16th December, 1926.

PESHAWAR VALE HUNT.

6.15 a.m.—*Chhota Hazri.* It is, of course, quite dark, and as one puts off getting up till the last possible moment, one has to shave with one hand and eat eggs and drink tea with the other. The evening before, very careful instructions are given to the syces as to where to go and when to be there. On this day the horses started at 5.30 a.m. and my wife and I left by car at 6.45 a.m. I am usually averse to using a car for this purpose, but in this country the practice has very distinct advantages. It saves your horse, gives you an extra hour in bed and you get home an hour earlier. The latter is a great asset when one is really busy. The best plan is to send the horses to some place about three miles short of the meet, so that the horses do not have to go out of their way to pick up the car after hunting. We arrived at Khazana Thana at 7 a.m. and got on the horses, leaving the syces in the car. We then rode on to the meet three miles further on.

7.30 a.m.—Meet of Peshawar Vale Hunt at Nahakki. This hunt was founded in 1869 by the Royal Artillery. They meet on Thursdays and Sundays and hunt the jackal, a very sporting little animal. The meet is always at the crack of dawn, because scent

generally disappears when the sun gets hot. The country hunted overlies north and east of Peshawar and is chiefly irrigated land. The fences consist of irrigation channels of various sizes and depths. Most of them are single water channels with a very small bank on either side. A horse easily clears them in his stride. There are some, however, which can only be described as multiple obstacles. The letter 'S' in the language of the country more or less, is a fair cross section of these horrors. If you have a free-jumping horse he will probably try to clear the lot and land in the second or third ditch. Fortunately, there are not many of these in the country, but there is generally a lot of grief when they are encountered. There is no wire whatsoever.

The going is almost perfect, very light plough and grass. Sometimes there are a number of irrigated fields into which the water has just been turned. These are very deep and heavy, but fortunately the area irrigated on any one farm at the same time is not very great. The Pathans keep the time of the day by means of a rough sun-dial on the wall of the village. The hours are kept by marks on the sun-dial which show when the water is turned on to each man's land.

A field of about sixty met the Master at Nahakki. The master is Lieut.-Colonel H. C. Ponsonby D.S.O., M.C. 60th Rifles. He is undoubtedly one of the best amateur huntsmen I have ever hunted with. Excellent sport is shewn, and good hunts come with a regularity which is really extraordinary. The sport is far better than is enjoyed with most provincial packs in England. On practically every day hounds are out there is a good hunt, and this under scenting conditions that would make most masters of hounds in England cry. It is all due to Ponsonby's skill and hard work. He has 25 couples of English foxhounds in kennel and they are a very level and very fit lot. He spends his spare time on reconnaissance of the country, so he knows every nook and corner. This is very necessary because there are no proper coverts. You find "jack" in the sugar cane, a crop grown by the natives. Enormous areas of it are grown, and they start cutting it in October. The cutting goes on for about four months, so up to the end of January the situation is constantly changing and the huntsman must know what part of his country is free from crops, and yet contains enough sugar cane to make certain of finding "jack." The sugar cane is about ten feet high and very thick. Going through it hounds make a noise like waves breaking on the shore.

7.35 a.m.—Having given us 5 minutes' law the master moved off to draw several large patches of sugar cane. On the way we collected two or three Pathans eager to join in the chase. They are good riders, but not well enough mounted to keep on terms when hounds run. One of them was most amusing. He saddled the

horse as we passed his village, mounted, and joined up. He wore his ordinary clothes, one article of which is a sort of blanket locally known as a "sadur" and worn round the shoulders. The horse he himself described as a "der badmash as," meaning that it possessed all the evil tricks of which the equine tribe is capable, and made the most of them. The *sadur* kept on falling off and getting entangled in the horse's legs. The last we saw of him was man, horse and blanket lying on the ground in an inextricable tangle.

All this passed the time pleasantly for about an hour, as we didn't find a jack. It is, however, dangerous to stay behind watching this sort of fun as, once found, the jack generally leaves covert on the spot, and a bad start is most difficult to make up. So, realising that we were rather far behind if anything happened, my wife and I galloped up and we were just in time to see a jack break away from a very small sugar cane patch.

8.45 a.m.—Hounds were out in no time and it was soon obvious that there was a good scent. The country we were now in abounds in large rivers, and we ran the bank of one of these very fast for a couple of miles. It was flat open country and very few obstacles, so a great view of the whole hunt could be obtained, though one had to gallop fast the whole time. We came then to a tributary of the Shah Alam river along which we had been running. There was a very slight check but it was obvious the hunt was across. Some one was shouting "hold hard," but I fear we paid little attention as we could hear nothing with the noise of the horses' hoofs in the stones and the splashing in the water as we crossed the river. We also saw that the master made no attempt to draw rein. It was as well we could not hear the "hold hard" as hounds ran faster than ever on the other side. They threw up a mile further on, and the master at once cast right-handed away from the Shah Alam thinking the jack would not face crossing such a wide stream. One hound had, however, crossed and I think the master had the corner of his eye on him all the time. This hound opened and in two seconds the master had the whole pack across the river. It was very good and very quick.

Hounds then ran fast again and now the nature of the country changed. We were south of the river and all the country to the south is irrigated from this river, so there are several large water cuts knocking about. We ran directly across these and they took their toll of the field. These cuts don't stop hounds at all. Consequently hounds run faster than in average English country, and in this hunt it was a job to keep with them. After a couple of miles of this they ran into a patch of sugar cane and there was a slight check much welcomed by the horses. It was of short duration however, as we soon viewed a very tired jack leaving it. He got a respite as it took hounds quite a time to get through the sugar cane. He was a

very game jack, as he ran on for qnother mile before they pulled him down in the open after a really first class hunt. Ponsonby's rapid cast over the Shah Alam was what really made it a first class hunt, and that cast was the work of a huntsman who is born and not made. The time was 35 minutes, the point close on 5 miles and it was about 7 miles as hounds ran.

The obsequies were then performed, brush and mask distributed and, as horses had had quite enough, we started for home well satisfied with the morning's fun and very pleased with life.

11.00 a.m.—Home, breakfast and change. Breakfast is a very good meal after hunting, but there is usually little time for it, as generally much work has to be done before dark.

Construction of a Frontier Post.

On the date of this diary I had to inspect a fortified *serai* now in course of construction some 35 miles from Peshawar. It is a typical example of the modern tendency of frontier defence where the enemy has little or no artillery.

The idea is to have a series of piquet blockhouses mutually supporting each other and acting as a support to the active defence, the troops for the latter being decently housed in peace in a parent fortified *serai*. This in its turn is covered by the piquet blockhouses and has its own local defence arrangements.

11.30 a.m.—I started in the car at 11.30 a.m. and reached the Garrison Engineer's office at 12.30. It is 30 miles from Peshawar to the G.E.'s office and it takes some doing to get there in an hour. For R.E. work in this country it is essential to have a fast car, as the distances to be covered are enormous. With a slow car you waste too much time on the road. Having settled various matters in the G.E.'s office we started for the new work. There are only two ways of getting there, riding or walking. As you cannot trot owing to the stones and steep hills, it is just as quick to go on foot. We therefore drove part of the way and then walked across country, arriving in about an hour.

The typical siting of the blockhouses and parent *serai* for the defence of a sector of the frontier includes a line of blockhouses on high ground, and, suitably sited to serve five or six of these blockhouses, there is a fortified *serai*. In the case of the new work now being built the previous accommodation was a tented camp. There is very little level ground and the tents could not be moved about. The ground in time became sodden and unhealthy and conditions were most miserable for the men. The new fortified *serai* is therefore for the accommodation of the men. Most of the blockhouses, which were built years ago as a war measure, are now in very poor condition and are being re-built.

The new work is commonly mis-named a "fort." In no sense

is passive defence contemplated. The tactical conception of the defence is that the line of blockhouses will form a support line for the striking force of the garrison which will operate over the ground up to and beyond the frontier. A small garrison would be left in the parent work, but the new *serai* is really the peace time accommodation for the striking force. The name "fortified *serāi*" gives a better idea of the tactical use of the new work. A "*serai*" is an "inn" or "place of abode," and in this case it is designed as a defensible post to act a as "keep" in the last resort. The local defence of the *serai* is arranged for by means of two towers so designed that fire along each outside face of the *serai* is possible from one Lewis Gun and three rifles. The top of the walls of the *serai* are loopholed every six feet and the roof is strong enough to bear the weight of fighting men and ammunition. One half of the *serai* is double-storeyed and the other single storey. This is necessitated by the lie of the ground. The whole portion of the roof of the single storey has a 9-foot parados wall to provide defilade.

The work now going on includes the construction of the new *serai*, the re-construction and improvement of all the piquet blockhouses, and the provision of a piped water-supply to all these places. A line design of the *serai* is shewn in *Plate I* and a section in *Plate II*. The general specification for the building is hammer-dressed stone in lime mortar. The whole building is lime-pointed externally and lime-pointed and whitewashed internally. The roof and first floor are of brick jack arches between R.S.J's with 1 inch of p.c. concrete on top. The ground floors are 3 inches of 1 : 3 : 6. p.c. concrete. The total estimated cost is Rs4,80,000/-.

The whole of the work is being done by Pathan tribal contractors. The method of giving contracts would be highly amusing if it did not give us so much trouble. The so-called contractor is nominated by the Political people, not according to his ability to do the work, but according to his capabilities for creating mischief. The big man who gets the contract immediately sublets it to others at an exorbitant rate leaving very little profit for the unfortunate sub-lessee. The result is that we get on the work a varied collection of ruffians from different tribes, most of whom are at loggerheads with each other. They all come on the work armed to the teeth. Nevertheless they are very pleasant to talk to and are full of promises of what they will do.

They require a lot of tactful handling. I remember in July last, the G.E. came to my office in Peshawar and said that two of the contractors were dissatisfied with the rates he had allowed them for some extra work. These two said they had summoned a *Jirga* for the following day at 8 a.m. and that they intended to call a strike of all contractors if their demands were not immediately met. The G.E. brought with him to my office the

running bills of all eight contractors and said he wanted the money there and then. We went along and visited the Controller of Military Accounts who pays all our bills. He promised faithfully to pass the bills for payment in two hours and he did it. He put his whole office on to the job. We collected the cheque and then raided the Bank Manager, who, although it was after hours, produced the cash. The G.E. attended the *Jirga* next morning with his pockets bulging with notes and suitably escorted. He then announced that those who struck work would not get paid. There was no strike.

On the date of this diary our Pathan friends came to me with numerous demands and requests. Their chief grouse was that they had not been paid for six weeks, the usual custom being to pay a running bill monthly. They had to sell their rifles and their wives to get money to pay their labourers. They did not in the least mind selling their wives, but to have to sell his rifle is disaster of the first magnitude to the Pathan. I sympathised deeply with them, but on further enquiry it transpired that it was only the *surplus* wives and the *old* rifles which were being sold. However we promised them that we would see to the matter at once, so that they should not be forced to sell their *favourite* wives and their *newest* country-made rifles. The G.E. and I were then most hospitably entertained to tea at the local village and we parted from our hosts on the best of terms, the Pathans being full of promises that they would try to get on more rapidly with the work.

3.30 p.m.—We then walked back to the car and started for home.

5.30 p.m.—Arrived at the office in Peshawar, I found a pile of papers three feet high awaiting attention. This is not so formidable as it sounds, because the Indian clerk puts the whole file on the subject in one's tray although one can generally deal with the paper without the file. He also usually puts up an excellent draft letter, so one's time in office is saved. It is only when a paper of exceptional difficulty comes along that there is delay. The normal rate of working through the pile of papers is twenty minutes per foot. With luck it can be done faster.

7.00 p.m.—Home. Look at the horses, drinks and bath.

8.00 p.m.—Dinner and to bed about 10 p.m. after quite an interesting day.

17th December, 1926.

When one is in the office at Peshawar it frequently happens that one of our numerous Pathan friends comes in to report large quantities of duck and snipe in the *jheels*, or *chikor* on the hills, and to invite us out to shoot. These visits have to be firmly resisted, as they are liable to waste much time. When a discussion starts, in order to arrive at the truth, it is absolutely necessary to divide the number of birds reported by ten or even by fifty. This procedure

has to be resorted to in every country in the world, and the exaggeration of the amount of game present is not the sole prerogative of the Pathan. The Irish and the Kashmiri possess the same fault.

A few days before the date of this diary a fully armed Pathan came in and refused to leave until all arrangements for the shoot had been made. Large numbers of *seesi*, sandgrouse, and *chikor* were reported near a place called Jallozai, about 25 miles from Peshawar. There was a good deal of work in progress on the road to the place, so I thought it a good opportunity to spend a few hours on this work and then go shooting, as there might be a few birds. The rendezvous for the shooting was therefore fixed for 12 o'clock.

8.30 a.m.—My wife and I started at 8.30 a.m., the car having been loaded with guns, dogs, change of clothes, sandwiches, and a plentiful supply of cartridges. We also brought our Pathan driver, a local villager trained by myself to drive the car and do all running maintenance. This man is invaluable as he saves one much trouble in the event of punctures and prevents things being stolen from the car. The Pathan is famous for his thieving proclivities, and anyone who leaves a gun and cartridges unguarded will lose them. The Pathan looks upon these articles as fair game, as of course they are, if left lying about. The necessity for bringing sandwiches requires a little explanation. The Pathans are noted for their hospitality, which is unbounded. It is quite useless to tell them that you will be very angry if they go to a lot of expense to entertain you. If they knew that we were starting at 8.30 a.m. and doing work on the way, they would produce a first class luncheon to be eaten on arrival, and, after the shooting, a most excellent tea. This would mean a good deal of expense for them, so the only thing to do is to say you are starting after tiffin. As it is a mistake in India to go without food for a long time, sandwiches, to be eaten on the road before arriving at the shooting rendezvous, are necessary.

9.00 a.m.—We arrived at the first of the new bridges on the Grand Trunk Road at 9 a.m.

THE GRAND TRUNK ROAD.

The Grand Trunk Road runs from Calcutta to Peshawar, 1,500 miles. The portion for which the C.R.E. Peshawar is responsible is from Attock to Peshawar, 50 miles. Of this, the portion between Nowshera and Peshawar is by far the most interesting. I think that when the road was built the money began to run out by the time Nowshera was reached. Consequently there are very few bridges between Nowshera and Peshawar. This road is the main artery of communication in the Peshawar Vale and carries a very heavy traffic. It lies right across the natural drainage of the country as will be apparent from *Plate III*.

In this part of India there is very little vegetation. Consequently

during heavy rains the run off is very rapid as there is nothing to hold the water up on the hills. It will also be seen from *Plate III* that the foothills lie very close to the line of the road and the railway. Both the road and the railway act as enormous dams right across the nullahs by which the water tries to make its escape to the Kabul River. There are comparatively few flood openings in the railway and fewer still in the road. On account of this the whole country between the road and the foothills becomes flooded during the rains, until the water flows over the road and gets headed up by the railway Traffic on the road is entirely held up and in some places the road is flooded to a depth of 3 or 4 feet. The problem which faces us on this section of the road is to restore the natural drainage system of the country, and to provide sufficient flood openings in the road and railway. The difficulty of the whole problem is vastly increased by the fact that there is absolutely no information about the height of the floods, and that the courses of the nullahs change in the most bewildering fashion. Also, every Pathan in the country says that all the damage done to his land by the floods is entirely due to the presence of the road, and would we immediately put in a nine-span bridge in the road opposite his land. We are not, however, competing with the Americans to build the longest viaduct in the world.

Altogether some sixteen bridges are required between Nowshera and Taru. The problem is to decide where these bridges are required, which are the most important, what sort of bridges to build, and how to get the money to build them. The first principle which the C.R.E. fixed was that the places where traffic was definitely held up should be done first and done quickly. It is almost unbelievable, but nevertheless it is a fact, that last year nobody knew exactly where these places were. The reason was that people going from Peshawar to Nowshera came to the first flooded river and being unable to get through they went back. The same thing happened from the Nowshera end, so no one really knew what was happening in between. The only way to arrive at something definite was to borrow a horse locally, ride through the floods and make a careful reconnaissance of the whole road. This I did in August, during one of the worst floods. As a result of this reconnaissance we divided the road up into areas which were capable of treatment separately, as each area afforded a more or less separate problem (*vide Plate III*). We also decided to embark at once on the construction of four bridges and two culverts. Fortunately these were all short span bridges, but their provision will remove the worst blocks on the road, i.e., places where traffic is held up for days at a time.

The next thing to decide was the type of bridge. The essential thing about this was that it must be a very simple bridge. The work is done by Pathan Contractors and any complicated reinforced

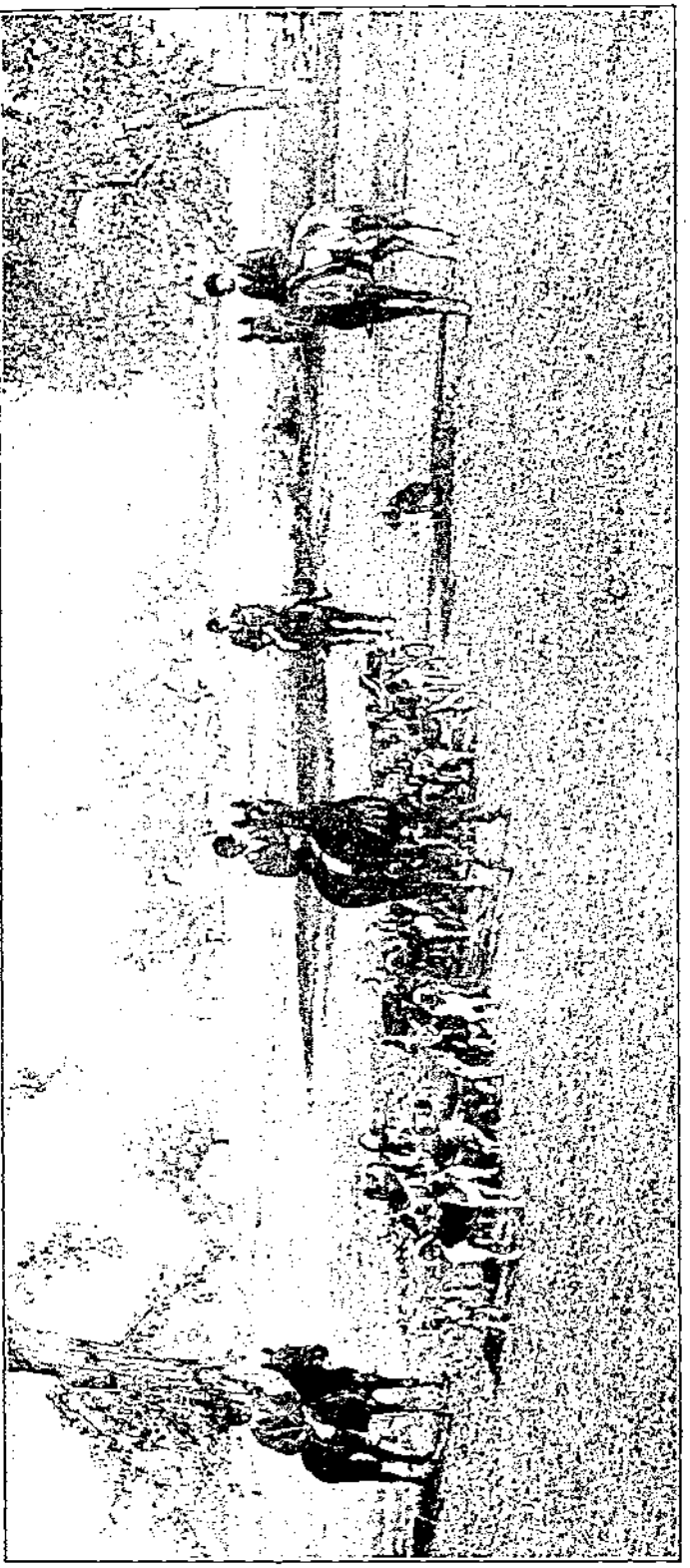
concrete work would probably end in disaster. The type shewn in *Plate IV* was chosen. The piers and abutments are straightforward masonry work and a reinforced concrete road-way is carried on seven rolled steel joists. The bridges will carry a 12-ton steam roller, the standard maximum load for a first class road in India.

No sooner had we decided on this plan of campaign when one of our existing bridges got washed away by a flood. This bridge had been built 30 years before. It was a strongly built masonry arch, but the flood left nothing but a hole 15 feet deep and 20 feet wide in the road. This job had to be tackled at once, so we had five bridges to build. We also saw that we had to start some of the bridges in the flood season, otherwise we would not get them all done within the financial year and our money would lapse. This very nearly got us into serious trouble. We had just closed the road and dug the excavations for the foundations of the first bridge, when a flood came and made our diversion road absolutely impassable and likely to remain so for an indefinite period. One's experience in France came in useful here, because every R.E. Officer in France became an absolute expert in sleeper roads. We therefore collected 800 sleepers and had a new diversion road made within 24 hours. This diversion stood well. It floated occasionally and had to be held back by wire ropes, but it carried the traffic all right.

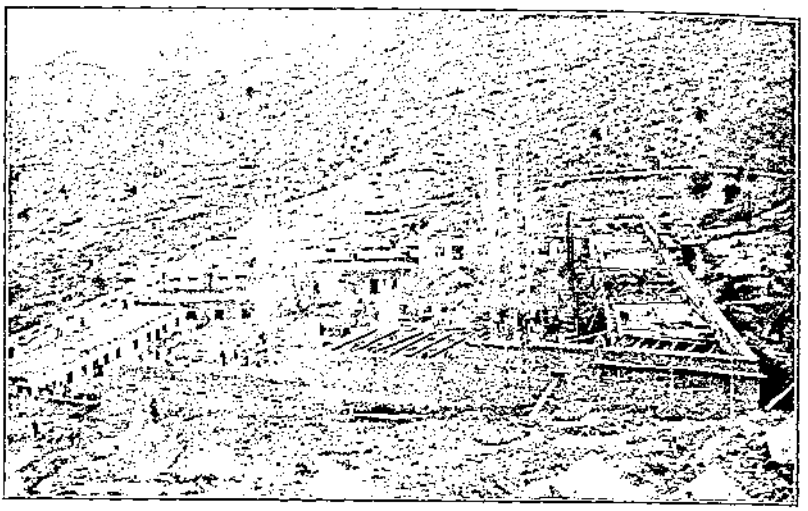
9.00 a.m.—On the date of this diary I visited three bridges in course of construction. The contractors all had numerous complaints. The first one said he was a ruined man. The floods had washed away all the earth he had collected for his filling, he had to cart more earth from a long distance and he could not do the work at the rate he had tendered. He wanted a couple of thousand rupees to make good the loss sustained. One has to deal with such applications by saying that the flood was an act of God and that we could not be responsible for it, and end up by giving him about a tenth of what he has asked for. If this is based on justice and facts investigated on the spot, the contractor is invariably happy.

10.00 a.m.—At the next bridge we wanted the contractor to use a petrol-driven concrete mixer. He was most antagonistic to the idea. The petrol and oil would be an extra expense and he would have to pay extra men to drive it. He could not dismiss any of the labour he had engaged to do the job by hand, because they came from his own village, and he would get shot that evening if he sacked the men. Also, his men understood how to mix concrete and would do it far better than the machine. This of course was not true, but it was hopeless to force it on him, so we abandoned the idea.

11.00 a.m. — At the next bridge I found them in difficulties with the foundations, which had got waterlogged. They thought they would have to dig down to Australia, or to whatever place is opposite

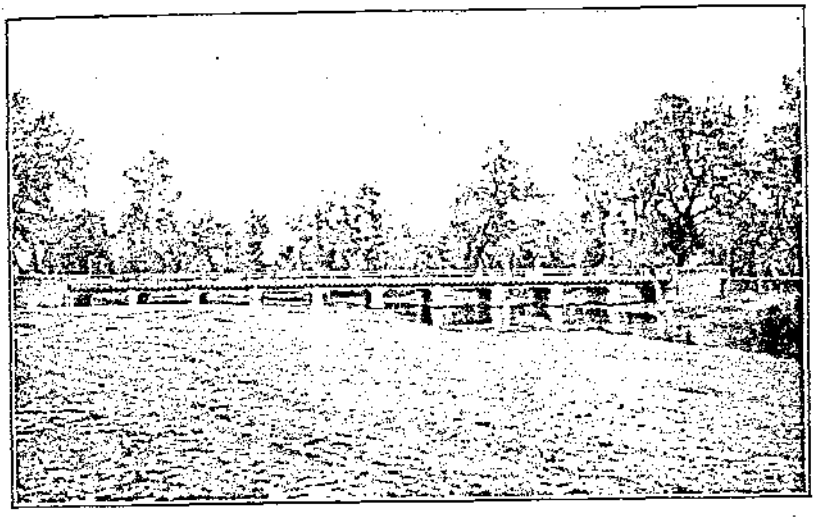


No. 1. Peshawar Vale Hunt. Master, Lieut.-Col. H. C. Ponsonby, D.S.O., M.C., 60th Rifles.

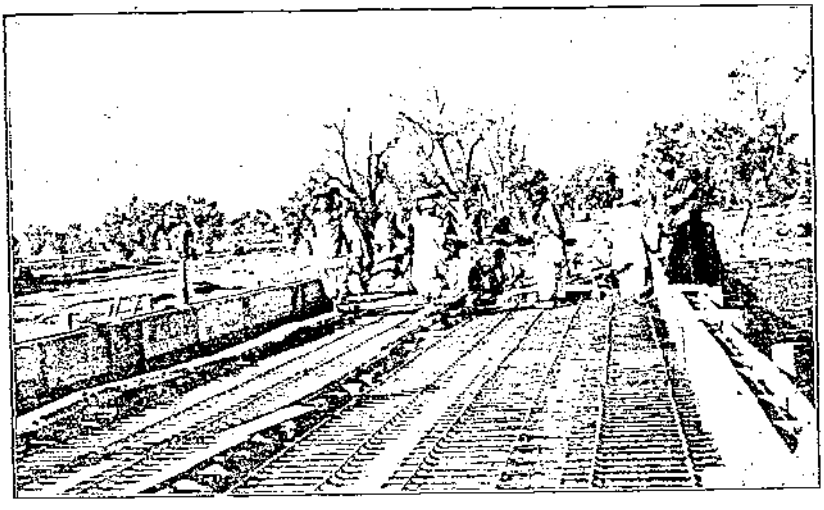


No. 2.
Fortified Serai: General View.

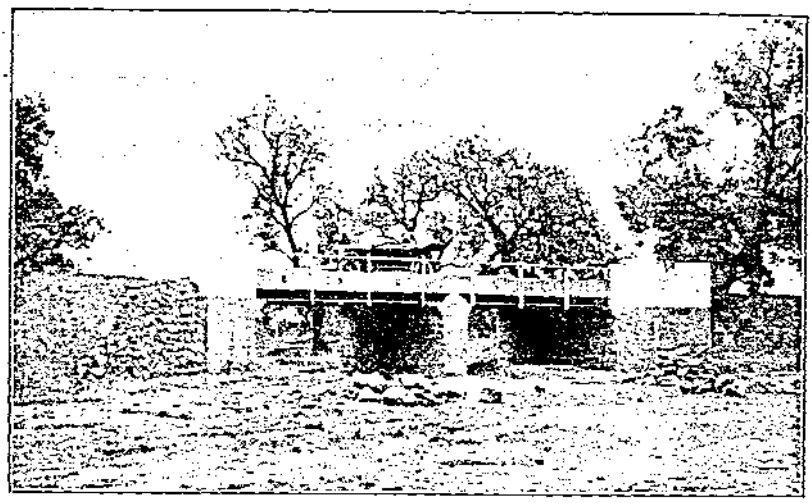
No. 3.
Fortified Serai: N.W. Corner Ground Floor.



No. 4.
G.T. Road—Nasir Kandi Bridge, 10-11′ spans with troughing.



No. 5.
G.T. Road—Bridge near Pabbi—Laying Reinforced Concrete Roadway.

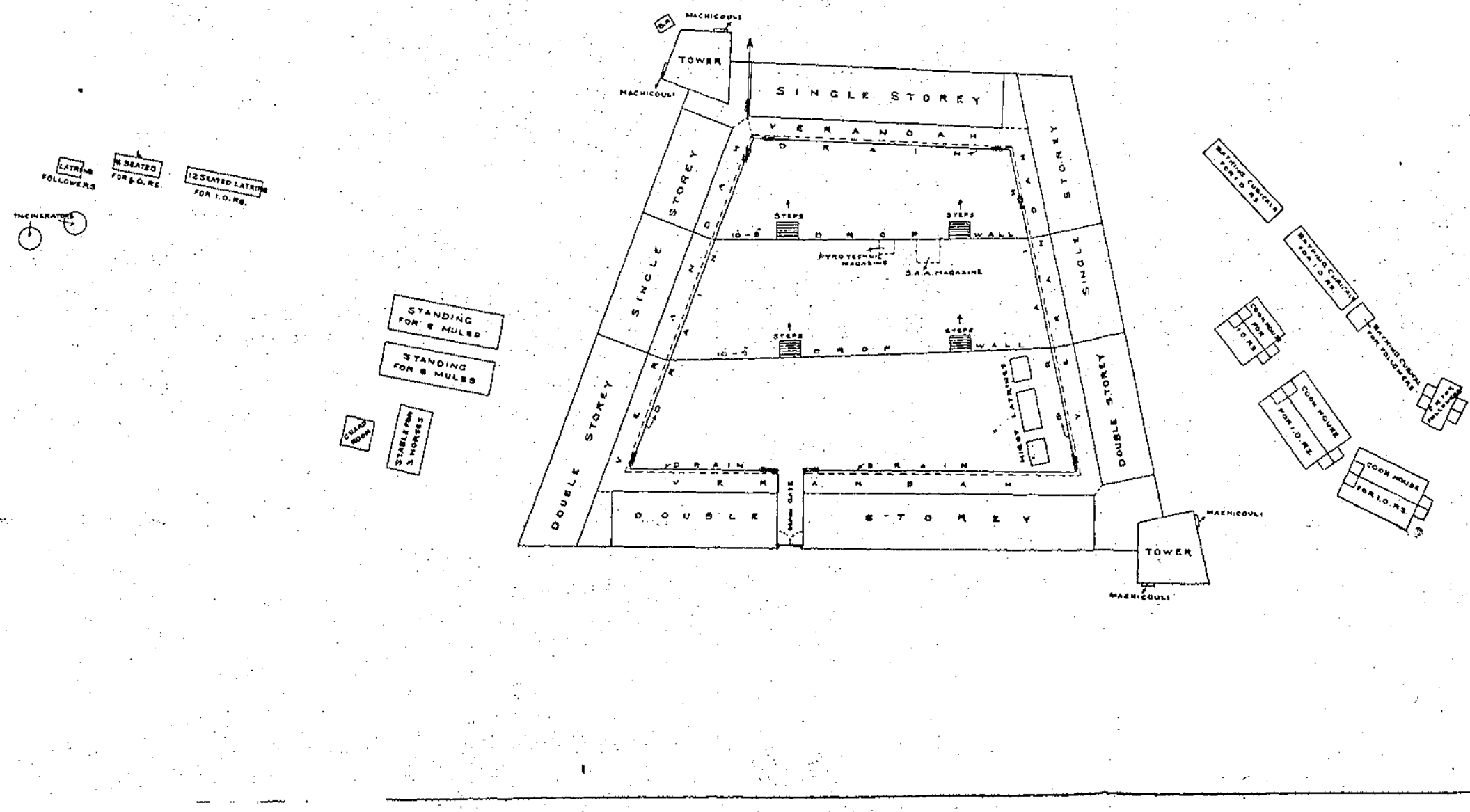


No. 6.

G.T. Road—Bridge just opened near Nasir Kandi. Original roadway level was bed of nullah.

FORTIFIED SERAI.

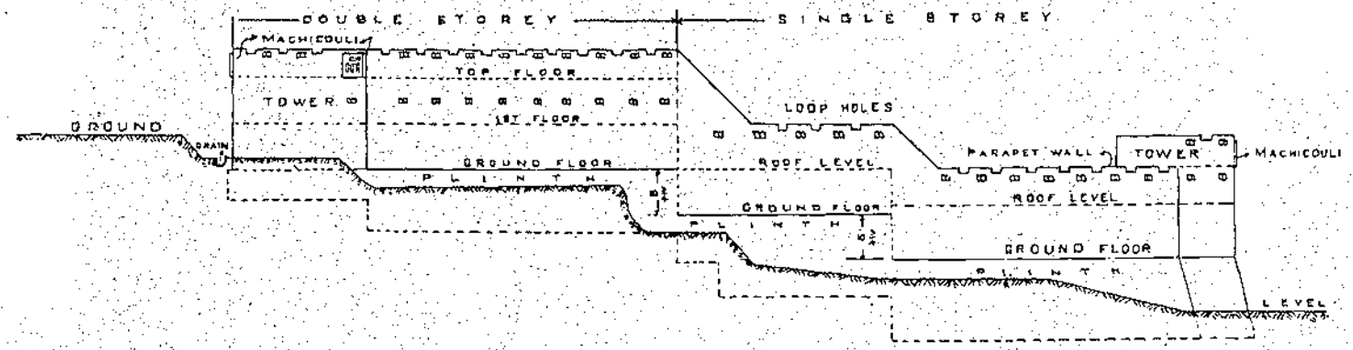
— SCALE 40 FT. = 1 INCH —



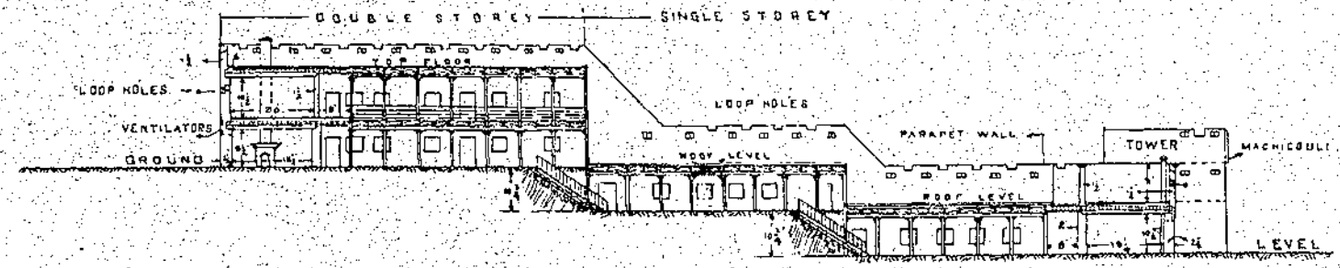
FORTIFIED SERAI

SCALE 30 FT = 1 INCH

EAST SIDE SECTIONAL ELEVATION



SECTIONAL ELEVATION



NOTE

ROOF ARCH WORK B.B. IN LIME

SKETCH SHOWING FLOODED PORTION OF G. T. ROAD BETWEEN TARU AND NOWSHERA

Scale 1 inch to 1 mile

Furlongs 8 6 4 2 0 1 2 3 Miles

Note. Existing Bridges shown thus ... -- ...

Proposed New Bridges or Bridges recently Constructed shown thus ... 3/40

N

KABUL RIVER

LOW MARSHY LAND

DAGI & AZA KHEL BALA AREA

NAZIR KANDI AREA

PABBI STATION AREA

PABBI VILLAGE AREA

NOWSHERA AREA

Shirin Khwar

Kagram Nullah

Khidder Zai

BABI

FROM PESHAWAR 13 M.

FROM TARU 1 MILE

PABBI STATION

PABBI

NAZIR KANDI

BABI NAO

NAZIR KANDI BRIDGE

Chela Khwar

Road from Cherat

Karmozai Khwar

2 Miles

RAILWAY EMBANKMENT ACTING AS DAM

N. W. R.

ROAD EMBANKMENT ACTING AS DAM

PIR PAI Ry. Stn.

1½ Miles

NOWSHERA THANA

Ry. Stn.

TO RAWAL PINDI

NOWSHERA CANTT.

TO NOWSHERA Ry. Stn.

KHAT KALAI

AMAN GARH

Yermandai Khwar

WATER HELD UP IN THIS AREA 1 Mile

DAGI

AZA KHEL BALA

PIR PAI

HILLS

LINE OF THE FOOT

RAPID RUN OFF FROM THE HILLS

CHERAT HILLS 5½ INCHES OF RAIN 14-8-26.

should be allowed to elapse, so that the degree of removal can be definitely ascertained, and if necessary further applications to be continued, until the stain in the stone is sufficiently removed.

Please note: The stone immediately under the portion to be treated should be well wetted to obviate the "green" which has been extracted penetrating to other portions of the stone.

In order to prevent a recurrence of discoloration the bronze may be coated with a celluloid varnish known as "Shelcote," supplied by the Indestructible Paint Company, King Street, E.C. The treatment results in a somewhat unpleasant gloss, which appears to be partially effective, and is estimated to last three years. Experiments which promise to be more satisfactory have recently been made with a coat of lanoline. The lanoline is laid on smooth surfaces with the hand only, and on other surfaces with a small brush. Its effect is believed to last for two years.

For Cleaning Marble Statues.—First carefully dust the statue or bust with a clean, dry brush. Then in a quart of water dissolve a teaspoonful of Hudson's soap powder and apply it to the marble with a stiff brush, with which the surface should be well rubbed. If exceptionally dirty, the wetted brush may be dipped into a little finely powdered pumice stone. Finally sponge down with cold water and rub down with a clean cloth till dry.

Note.—It is not desired to keep a uniform surface all over the statue, but only to clean off direct action dirt, and *not to remove the natural discoloration of the material.* The hollows and cavities need only have the loose dirt removed. *On no account should ordinary soap, potash or any caustic be used.*

MEMOIRS.

MAJOR-GENERAL SIR JAMES RONALD LESLIE MACDONALD, K.C.I.E., C.B., LL.D.

In the early afternoon of June 27th last, there passed peacefully home to his rest, after a long illness patiently borne, one of the most brilliant officers of the Corps. Major-General Sir Ronald Macdonald was little more than sixty-five at the time of his death; but the strenuous life he had led, and the hardships he had endured during his active career, though adding lustre to his own name and that of the Corps of which he was so talented and devoted a member, undoubtedly told severely on his once robust constitution. Consequently, he felt forced to retire from reasons of health early in 1913, when not yet 51 years of age and a Major-General of close on five years' standing. An acknowledgment of his fine record of achievements as a Royal Engineer was shown in July, 1924, however, by his selection to fill a vacancy in the Colonels Commandant of the Corps—an honour much appreciated by Macdonald in his retirement, He was also in receipt of a Good Service Pension, granted him in recognition of his valuable services to the State.

James Ronald Leslie Macdonald was the eldest son of the late Surgeon-Major James Macdonald, M.D., F.R.C.S.E., and was born on Feb. 8th, 1862. He received his early education at the Grammar School, Aberdeen, and later at Aberdeen University, whence he past first into the R.M.A., Woolwich. Here he quickly established a reputation for remarkable ability, and came out far at the head of his batch in Feb., 1882, carrying off most of the prizes as well as the Pollock Medal and Sword of Merit.

At Chatham, Macdonald took up yachting as his chief form of recreation during the summer months, and soon developed into an enthusiastic and daring skipper. Otherwise, racquets appealed to him most, and he was quite a fair exponent of the game when the present writer first met and played with him at Peshawar in the spring of 1889.

On completing his two years' course at Chatham with his customary brilliancy, Macdonald sailed for India, and was attached to the Bengal Sappers and Miners for a period, before entering the Military Works Department. Later he was employed, between

Major-General Sir James Ronald Leslie Macdonald, K.C.I.E. C.B., LL.D., Colonel Commandant R.E.

Photograph by Elliott & Fry Ltd., 63, Baker Street, W. 1.

1885-1887, on the construction of the Harnai Railway in Baluchistian, together with other since distinguished R.E. officers, under General Sir James Browne, its Chief Engineer. Semi-military conditions prevailed, owing to the lawlessness of the region traversed; but in spite of the treacherous nature of the terrain as well, Quetta was successfully linked up by rail with India proper, in March, 1887.

In 1888, Macdonald gained his first experience of active service on the Hazara Expedition, obtaining a mention in despatches and the Indian Frontier medal and clasp. Subsequently he was employed at Army Headquarters, Simla, and was responsible, among other fortification designs, for that of the defensible *serai* at Landi Kotal, at the head of the Khyber Pass. This imposing fort was constructed by Lieut. J. W. Pringle, R.E., and the work visited at intervals by Macdonald from Simla.

In this manner the young subaltern readily absorbed a considerable knowledge of the N.W. Frontier of India, and of the tribes and their language; whilst his reputation as a man of grit, resource and ability stood high at Army Headquarters. Thus, when Sir James Browne's project for a railway survey up the gorge of the Kabul River was decided upon, Macdonald was selected to carry out the enterprise and started off on his mission early in 1890. By a mournful coincidence an account of The Kabul River Railway Survey appears in this number of the *R.E. Journal*; so it is unnecessary to enlarge on it here, save to say that, despite the difficulties with which he had to contend, Macdonald brought the survey to a successful conclusion. He thereby still further enhanced his reputation, and received the special commendation of the Government of India for the work accomplished.

Macdonald, now a captain, was next employed on another frontier railway survey, which had for its object the investigation of the country lying between Quetta and Dera Ismail Khan, by way of the Zhob Valley. The distance apart of the two stations was roughly 350 miles by the route to be examined; and as every possible alternative was to be explored in the cold weather season of 1890-91 alone, Major (now Colonel Sir) Buchanan Scott, R.E., the Chief Engineer, organised five survey sections for work in the field. Of these Macdonald's Kabul River Survey party formed one, and had the good fortune to traverse most of the area surveyed, except that portion lying in the plains of India, between Dera Ismail Khan and the exit of the Gomal river thereon.

On the completion of the plans and estimates for the Zhob Valley Railway at Dalhousie, during the summer of 1891, Macdonald at length obtained his first leave home. But little leisure was granted him; for soon after his arrival in England he was offered, and accepted, the appointment of Chief Engineer for the Preliminary Survey of a projected railway between Mombasa and Lake Victoria,

commonly called the Uganda Railway. Comparatively little was then known of the regions to be traversed in order to discover a possible railway alignment between the coast and Uganda; while the question of equipment, food and transport for the venture was no small problem to solve in England by one with no previous experience of African travel. Yet Macdonald's extraordinary intuition and genius for organization proved more than equal to the task; and, aided by his friend Pringle, nothing that human foresight could provide for seemed overlooked when the expedition left Mombasa for the interior shortly before Christmas, 1891.

Macdonald has himself described, in "Soldiering and Surveying in British East Africa, 1891-1894," (Edward Arnold, 1897), his varied and stirring experiences during those early days of the British occupation of East Africa. Here it may suffice to say, therefore, that the survey under his direction definitely proved that a serviceable railway could be constructed between the coast and Uganda at no prohibitive cost. In order to establish this fact, the expedition was usually divided into two parties, examining different routes, whereby in nine months 4,280 miles were marched, and 2,724 miles of routes surveyed, to decide the location of a railway estimated in the field as 657 miles in length.

When 200 miles from the coast on the homeward journey, Macdonald received urgent instructions from England to return to Uganda, and there investigate acute differences which had arisen between the Protestant and Roman Catholic Missions; and was destined to spend close on another two years in East Africa before sailing for England again in June, 1894. Those two years, passed chiefly in Uganda, were fraught with exciting events, involving arduous expeditions against the Wavuma by lake, operations in Unyoro, quelling a Mahommedan rebellion, and thus saving Uganda, whilst acting as Commissioner of the Protectorate after the departure of Sir Gerald Portal for the coast; and much besides. For his services during this strenuous period Macdonald received the brevet of major, two medals, the Brilliant Star of Zanzibar, 2nd Class, and an acknowledgment of his valuable work from the Government of the day.

Shortly after his return to England he married Alice Margaret, youngest daughter of General George Pringle, I.S.C.; and before long was back in India, where he resumed his work in the Military Works Department, until he obtained leave to attend the Refreshing Course for Indian Service R.E's at Chatham in 1896.

Events in the Sudan were then marching rapidly, as active operations were being undertaken by Sir Herbert Kitchener for the overthrow of the Mahdi's successor, the Khalifa, at Omdurman. An unpleasant complication arose, however, owing to it being presently learnt that the French were secretly endeavouring to

forestall the British by despatching expeditions from the French Sudan, under Marchand, and another by way of Abyssinia, under Bonchamps, to join hands at Fashoda. The French obviously aimed at establishing a belt of French territory right across the African continent from their western possessions to Abyssinia, thus barring access to Britain along the Nile, from the Sudan, likely to be reconquered shortly, to Uganda.

The French were warned that their contemplated action would be regarded as an unfriendly one by the British Government; but since they paid little heed to the warning, it was decided to despatch a British expedition from Mombasa through East Africa, to reach Fashoda before Marchand, if possible. Macdonald was at once selected for the command of this important undertaking, and landed at Mombasa early in July, 1897, at the head of a force consisting of ten British officers, thirty Sikhs from India, and some 500 locally enlisted Swahili porters. On arrival at Kibwezi, 200 miles from the coast, Macdonald was again taken seriously ill with his former African gastric trouble, and it was feared he might have to be invalided home; but his powerful will gradually conquered his physical weakness, and he insisted on proceeding with the expedition, carried now in a hammock, and now in a waggon, until he slowly recovered his normal strength and energy.

It was well for the country that he did so, as it was largely due to his outstanding personality that Uganda was later extricated from one of the most grave crises of its history, owing to the outbreak of the Sudanese Mutiny, which threatened at one time to drive the British out of that Protectorate. The story is told in "With Macdonald in Uganda," published by Edward Arnold in 1903; but what hurt Macdonald more keenly perhaps than anything is that, while he was bringing his great brain, energy, local influence and resource to bear on combating the serious situation with which Uganda was faced, certain cowardly attacks were being made on him in England. Their author, without knowledge of the actual facts, ascribed responsibility for the Mutiny to Macdonald's previous handling of Sudanese malcontents, when acting as Commissioner some years earlier.

This despicable accusation has long since been demolished; but a man of Macdonald's sensitive nature felt these unwarranted attacks bitterly, particularly as they only came to his knowledge months later, when still fighting desperately for the safety of Uganda, and thus unable to clear himself immediately in the opinion of those who had entrusted him with the command of the expedition. His younger brother Norman, too, had been killed before his eyes in an engagement with the Sudanese Mutineers at Lubwa's.

For close on nine months the Macdonald Expedition was employed on active operations against the Sudanese Mutineers and Waganda

Mahommedans over a wide stretch of country, far removed from the coast; and it was not until well into May, 1898, that Macdonald felt justified in handing over the command of the operations to the senior officer of such reinforcements as eventually arrived from over-seas. By that time the mutineers had been driven out of Uganda, and as the safety of the country now seemed assured, Macdonald decided to resume his original mission, so far as possible with his sorely depleted numbers and stores. Any attempt to reach Fashoda before Marchand, however, appeared out of the question, and Macdonald had to rest content with penetrating to the Latuka country himself, and despatching another column to the north of Lake Rudolf. Both columns then returned to their base on Mt. Elgon, whence the re-united expedition reached the coast again in April, 1899.

For his invaluable services Macdonald received the thanks of the Government, a brevet lieut.-colonelcy, C.B., and a medal with two clasps. He was still a captain in the Corps, though promoted to major later in the year. Maps, reports, etc. of the expedition were prepared at the War Office in London during the summer months of 1899; and a crowded meeting of the Royal Geographical Society addressed by Macdonald regarding the geographical results of his travels.

For a brief space thereafter he remained in England, being posted to Aldershot shortly after the outbreak of the South African War, in charge of the balloon factory there. With his usual organising ability he soon evolved means for turning out three balloons in the same time as one had been produced previously; and when the Boxer trouble broke out in 1900 he was despatched to China in command of a balloon section. He was found far too valuable a man, however, to be employed in that minor capacity, and was early appointed Director of Railways for the China Expeditionary Force. This onerous task he carried out with his wonted energy and skill, in the face of numerous pin-pricks and difficulties placed in his way by our various allies in the theatre of operations, concerning which he would relate many amusing yarns to his intimate friends. By a strange coincidence, Macdonald and Marchand now met for the first time, far from the remote Sudan, in distant Cathay, when both were honoured guests one evening at an official dinner held at Peking. Macdonald's services in China were rewarded by a mention in despatches, followed by a brevet-colonelcy and the China medal.

India claimed Macdonald again shortly after the China Expeditionary Force was broken up, and some time was spent by him in the Military Works at Quetta. In 1903 the Government of India decided, however, to despatch a Political Mission to Tibet, in order to counter Russian intrigues and to put an end to recent truculent actions of the Tibetans, by means of a Treaty. Lord Kitchener,

then C.-in-C. in India, at once selected Macdonald, whose organising abilities were so well-known, to command the troops under the protection of whom the Mission was to proceed to its destination. As soon as fighting broke out with the Tibetans, political considerations had necessarily to give way to military ones, and Macdonald was vested with the chief command of the operations, which terminated in a successful entry into Lhasa after various engagements en route, the signing of the Treaty there, and the safe withdrawal of the force to India. The operations had lasted nearly a year, and some 25,000 men were employed on them. For his services during this arduous campaign, under peculiarly trying climatic conditions, Macdonald was made a K.C.I.E., and received the medal and clasp granted for the expedition. His health had been severely tested, however, by long residence in altitudes of 15,000 feet, and more, above sea level; and it was probably during this period of his life that the mischief was done which seriously affected his heart later, and resulted in his relatively early death.

This was to be Macdonald's last experience of active service; but in 1905 he was given the command of the Presidency Brigade, with his headquarters at Calcutta, whence he was transferred to command the Lucknow Infantry Brigade in 1907. Whilst holding this latter appointment he was promoted to Major-General at the, then, early age of 46; and closed his active career by commanding the troops in Mauritius from 1909 to 1912. Here his health showed signs of completely breaking down, owing to the trying climate, after all the vicissitudes through which he had passed. Under strong medical advice he resigned the appointment and returned to England, but felt compelled the following year to retire, and was placed on the Reserve of Officers.

When the Great War broke out in 1914 he sought service in the field, but was unable to satisfy the medical authorities as to his fitness for the task—a great blow, as may be imagined, to one who had served his country with such devotion in the past, and yearned to do so once more in the hour of Britain's sorest need. He therefore turned his mind to other ways of assisting his country.

Towards the close of the year 1914, the military situation was such that the authorities felt they could not ignore the possibility of a landing of enemy troops on some part of the East Coast, so preparations to meet this possibility were taken in hand. Macdonald was then residing near Aberdeen, and was selected as the Military Member of the Emergency Committee for the Aberdeen District. Space does not permit an enumeration of the multifarious duties that devolved on this Committee during the four years of the war that it was in being; but it may safely be said that Macdonald's far-seeing grasp of essentials played a prominent part in the preparation of the comprehensive plans designed to deal with every

contingency, in the event of a successful enemy landing within the area he represented.

With his customary public spirit, Macdonald declined to draw any extra pay beyond his pension during these four years of unremitting toil and labour, for which he received no reward. When the pensions of British and Indian Army officers were sensibly increased in 1920, however, he justifiably applied for the extra £200 p.a. granted to retired Major-Generals, on the strength of his services in Scotland during the war. It seems hardly credible, but is nevertheless a fact, that this request was refused on the score that Macdonald, having drawn no extra pay during the war, was debarred from receiving the increased pension! In other words, had he but taken one single day's extra pay during those four years he would have been entitled to £200 p.a. more pension; but because he deemed it his duty to give his services entirely free, at that time of stress, instead of saddling the Government with some hundreds a year besides his pension, he was subsequently denied approximately £1,500 in the matter of pension, up to the time of his death. Could Red Tape possibly stretch farther than this?

In truth, there was nothing of the 'canny' Scot about Macdonald; for it is within the writer's knowledge that in Africa, and elsewhere, he paid out of his own pocket hundreds of pounds that should rightly have been paid by those whom he served. He was generosity itself, and normally set small store on the possession of means as, despite his limited income, he often made further sacrifices in order to help others financially.

During the great coal strike of 1921, Macdonald was as assiduous as ever in assisting to evolve road transport arrangements for feeding districts in Scotland hard hit by the cessation of normal railway traffic; and when in 1925 there was danger to the State by the threat of the Triple Alliance of Coal, Railway and General Transport Workers, Macdonald signed on at Bournemouth as a labourer, or in any other required capacity, to combat the menace. The General Strike of 1926, unhappily, found him too ill to take any active share in confounding the extreme elements abroad at the time.

For some seven years before his death the cold winters in Scotland proved very trying to Macdonald's now delicate constitution; so he and his wife usually wintered in the south of England, generally Bournemouth, where they finally decided to make their home three years ago. Until the last two years of his life, Macdonald remained a keen exponent of golf, but he then felt compelled to give it up owing to his failing health; and in the spring of 1926 he was struck down by a severe heart attack, from which he never properly recovered, and had been practically confined to his bed since last autumn.

No memoir of Macdonald would be complete without some

remarks concerning the man himself. Above all things, he was a patriot, in the best sense of the term. His loyalty to King and Country knew no limit. Imbued with the highest of principles, he was honour and straightforwardness itself, and expected these virtues in others with whom his work brought him in contact. Sometimes it was his misfortune to be deceived in this respect; and he then made no secret of his contempt for those who played him false, and seldom forgave these lapses from the paths of rectitude. Still, should the need arise, his quick wit could shrewdly counter cunning; and so, like most able, masterful men, he was not entirely free from detractors and enemies during the active years of his career.

Yet, speaking generally, Macdonald was naturally of a shy and retiring disposition, though a fluent and entertaining conversationalist with those whom he regarded as his intimates. His versatility and memory were amazing; and he seemed to be one of those gifted individuals who, having once done, read or heard anything, remembered it ever after. No subject appeared too abstruse for him to acquire a thorough grasp of it; nor too trivial to be rejected from the storehouse of his brain. Thus he could discourse learnedly on many scientific subjects, or, in lighter vein, regale his listeners with many amusing yarns and experiences concerning episodes throughout his eventful career. Though a Scot is often credited with a lack of humour, Macdonald was full of it, in his quiet, effective way.

Despite his unobtrusive manner this covered a man of much determination. Macdonald rejoiced in positions of great responsibility, and then did not lightly tolerate interference with his carefully thought-out plans to attain success. He trusted his subordinates to the full, while expecting them to give him of their best. Nevertheless, he was patient and considerate of colleagues far less gifted than himself, and was ever ready to help them with his advice and rare clarity of vision. Thus, few there can be that worked directly under Macdonald in his prime who do not retain a mental picture of his untiring energy and great ability, and would not willingly have gone to the ends of the earth with him. Had his health and vigour not been unduly sapped by the ceaseless labours of his earlier days, he would undoubtedly have risen to still loftier heights, both as a soldier and administrator. Even so, he will always be remembered as a great man and loyal friend by those who knew him best.

Needless to say, his active brain continued to work at high pressure during his retirement; and one of his published brochures, "Roads and Road Transport," is an able treatise on the capacity of different classes of roads for the movement of troops. This pamphlet appeared some little time before the Great War, and was made considerable use of on the Western Front and elsewhere.

For the last fifteen years or more he had been engaged on a colossal task, which he hoped might some day become a standard for students of botany. This unique work was concerned with the classification of flowers and plants; and Macdonald's orderly mind and methods had enabled him to compress, by means of tables and other devices, within 250 pages of one volume, the researches comprised in seven bulky books dealing with different branches of botany. It is illustrative of his thoroughness that, in order to cope with the task, he took up the study of Latin again after the lapse of well-nigh fifty years. His labours had nearly reached completion, and he was contemplating the publication of the work at no distant date when struck down by his last illness; and though Lady Macdonald had assisted him throughout by typing intricate forms and tables, and in other ways, it is now feared that their toil of years may never assume final form for publication.

And here this memoir may suitably be brought to a close by an expression of sincerest sympathy to Lady Macdonald in the great bereavement that has befallen her; and if the sharing of sorrow can soften the blow, may it be some small consolation to Macdonald's devoted partner of thirty-three years to feel that many mourn with her!

H.H.A.

BRIGADIER-GENERAL SIR EDWARD RABAN, K.C.B., K.B.E.

Brigadier-General Sir Edward Raban was born on the 8th August, 1850, being the fifth son of the late Major-General H. Raban, and belonged to a family of soldiers chiefly associated with service in the East; his grandfather, Lt.-Colonel William Raban, of Beauchamp Lodge, Hatch, Somerset, served in Java, and his father, who was present at the Battle of Aliwal (India) in 1845, afterwards joined the Police Force and attained the grade of Deputy Inspector General.

One of his great uncles, Lt.-Colonel George Raban, C.B., saw much active service in India under General Lake in the early part of the 19th century, and one of his maternal uncles, Major-General George Baker Pasha, V.C., was a distinguished officer who served and obtained his V.C. during the Indian Mutiny for an action described by Lord Clyde as "the most gallant of any during the War," when, with 123 horsemen of all ranks, he charged and routed a body of more than a thousand rebels.

The subject of this memoir was educated at Sherborne School and the R.M.A., Woolwich, which he entered in January, 1868, and received his Commission in the Royal Engineers in August, 1871.

Brigadier-General Sir Edward Raban, K.C.B., K.B.E.

Photograph by J. Russell & Sons, 73, Baker Street, W.

He remained at the S.M.E. for the usual two years' course when an important event occurred in his life which, without doubt, contributed greatly to the happiness and success of his career, for he married Miss Welman, a daughter of Colonel Welman, of Rochester, a youthful marriage attended with the very best result; they celebrated their golden wedding on 4th December, 1923, after 50 years of ideal married life.

Raban proceeded to India in January, 1874: he was first attached to the Sappers and Miners at Roorkee, but did not remain there long, for after passing the Lower Standard Examination (Language) he was, in September, 1874, posted to Shillong in the Secretariat of the P.W. Department. In November, 1879, however, he was ordered to join a Field Force formed to operate in the Naga Hills against the natives who held Kohima Fort, which they had fortified strongly.

The attack was unsuccessful in the first instance, the attackers losing over 30 per cent of their numbers and having to retire, but they occupied the position on the following day, as the Nagas had retreated. It was a trying initial experience of active service, but Raban came out of it very well, being specially commended for his conduct on this occasion: he was mentioned in despatches, and received a medal with clasp.

He then returned to his Secretarial duties for a short period previous to his reverting to British Service, when Sir S. C. Bayley, Chief Commissioner, reported "Lt. Raban has always given complete satisfaction in the performance of his duties. His work in the Secretariat was of a very high order and gave evidence of marked capacity for this class of Administrative duties. I have no doubt that in whatever capacity employed, Lt. Raban will give the same evidence of ability, industry and judgment as have characterised his service in Assam."

On his return to England in 1881, Raban was posted to the S.M.E., Chatham, and became Assistant Instructor in Field Engineering, but, a year afterwards, he accepted the appointment of Instructor in Military Engineering at the Royal Military College, Kingston, Ontario, to assist Major Walker, R.E., the Professor of Military Engineering, whom he succeeded in the following year, and remained there until September, 1886, when he resigned and returned to England.

Raban now proved himself a "born instructor," and his work in Canada is perhaps best described as follows, by an Officer who was associated with him at that time.

"At the time of his joining at Kingston, the College was in its infancy, having been started but six years before with a class of eighteen cadets, a number which had risen to between seventy and eighty by the year 1882.

"Raban threw himself with characteristic ardour into his work and

was soon recognised, to quote the Official reports, as "a fluent lecturer and zealous and energetic instructor" and, at this early stage, he already shewed that gift of gaining the enthusiastic devotion of those serving under him, which was so marked a feature of his later career.

"With the small numbers and meagre equipment of the College in those days, it was no easy task to impart reality to the practical side of the Engineering Course, and by no means the least of Raban's qualifications for the post he held, was his power of firing the imagination of the Cadets and of giving life to the dry bones of the course of instruction.

"In addition to his regular work with the cadets, he undertook a very large amount of voluntary work every year in connection with courses of instruction to classes of Militia officers of all arms and of N.C.O's and men of the Canadian Engineers, for the Canadian military authorities were then endeavouring to utilise the facilities afforded by the Military College, to make up for the absence of any Staff College or School of Military Engineering in the Dominion.

"The professorship of Military Engineering at that time carried with it the Inspectorship of the Engineer Arm of the Canadian Militia. This was a very congenial duty into which Raban entered with his whole heart, and a glance of his reports to the Adjutant-General of the Militia during the three years he held the Inspectorship shows that already he had much at that grip of essentials and power of marshalling facts and arguments which, later on, was so marked a characteristic of all his official reports and correspondence."

Letters from two distinguished Generals, R.E., received recently, fully confirm the value of Raban's teaching in Canada, and express the view that much of their success in life has been due to his example and precept at that time. "A leader and a guide," says one letter, "Endeavour to think fearlessly and straightly," quotes the other.

On his return to England towards the end of 1886, Raban was first stationed at Chatham as Divisional Officer of the Chatham Defences, but shortly afterwards he was selected for duty at Shoeburyness, where important works were in contemplation, thus commencing the constructional part of his career. These works included the erection of a new gantry for lifting 110-ton Naval guns, at that time considered a most formidable weight, and other appliances for placing these guns into position on the Ranges: the construction of a specially heavy railway, the provision of new R.E. workshops, and the sinking of a very deep well through the chalk. These works were all carried out in a most satisfactory manner under Raban's supervision, by the end of the year 1889, when, the Admiralty having applied to the War Office for Raban's

services, he was appointed Superintending Engineer at Portsmouth Dockyard.

Now commenced the most important period of his official career, for after nearly five years as Superintending Engineer at Portsmouth, he was appointed Director of Works at the Admiralty, an appointment which he held for about 17 years, at a critical time when the Navy with all its auxiliary services was increasing in strength enormously, as a result of a revival movement, partly political, but mainly professional, which exposed the weak condition to which this great service had been reduced, when viewed from a modern standpoint, and with reference to the possibilities of another European War. From the point of view of the Corps, this is interesting, as Lord Sydenham, then quite a junior officer of the R.E., took an important part in the discussion as it affected coast defences and other military operations, and strongly advocated the provision and maintenance of a powerful Navy as the primary means of protection. The results of this policy as far as the Naval Works votes were concerned, soon became apparent, as larger and more numerous ships meant, of course, larger docks and more of them, and a large increase in personnel meant new barracks, schools of instruction, stores and many other requirements on shore. Provision was made by Parliament for these services in the form of Naval Loans, and also by a large increase in the annual services estimates. To quote a few figures, from a normal annual expenditure on Admiralty Works (building) of about £350,000 to £400,000 in the years preceding this change of policy, the average annual expenditure on these works some 15 years later was approximately 3½ to 4 millions, and the strength of the staff employed by Raban to assist him at Headquarters as Director of Works, increased from about 30 in 1895 to over 200 individuals when he retired in 1912. The total estimate of expenditure for the Naval Building Works, which commenced about the year 1890, reached the very high figure of £40,000,000 by 1912, nearly all of which had been expended. It is useful to bear these figures in mind when framing some idea of the great value of the services rendered to the state by those officials who are responsible in every detail for the planning and the execution of such vast works. Like Wren, their monument lies in the works themselves, but their names are apt to be soon forgotten.

When Raban commenced his duties as Director of Works he succeeded another very capable R.E. Officer, Sir Henry Pilkington, who relinquished this appointment, but retained the control of the work which he had been carrying out under the Naval Loan Act, and this arrangement continued until 1904, when Sir H. Pilkington retired, and Raban, at the request of the Admiralty, assumed control of both Loan services, and those executed under the Annual Naval Votes.

It is not possible in this memoir to describe in detail the whole of the great engineering works for which Raban was responsible during his tenure of office as Director of Works, but I would specially mention the new Dockyard and Naval Base at Rosyth, which was perhaps the most important. Raban was responsible for the presentation to the Board of Admiralty of the complete design for the construction of a Naval Base on the Firth of Forth to fulfil the conditions laid down by the Admiralty. In this he was most ably assisted by the late Colonel S. H. Exham, C.B., C.B.E. (late R.E.), who was the Superintending Engineer on the site from the start until his retirement in 1911.

Rosyth was undoubtedly the special child of Sir Edward Raban, and of no work carried out under his direction was he so proud. Legitimately so, I think, in that the British Nation and the Admiralty were fortunate to have in their service one whose singleness of purpose, professional experience and foresight, together with the great gift of clear expression, were invaluable in overcoming the difficulties arising from changes in political and Naval opinion and the inherent technical problems of this great project. Rosyth affords the only case in the history of the British Navy in which a complete design for a Naval Base of the first importance was prepared and put into execution.

Other large works which were completed under Raban's direction were important extensions of the dockyards at Portsmouth, Bermuda, the Cape, Malta, and elsewhere, including new Docks, Workshops, Magazines, Hospitals, Barracks, and a new Breakwater, involving a total expenditure of many millions sterling. The electrification of Dockyards and Naval Stations was also carried out, including the erection of large Power Stations. As previously stated, it was a period of great progress in Naval construction, and armament and provision for works had to be made accordingly. Battleships and cruisers had been lengthened considerably, Torpedo craft had been much enlarged and Submarines introduced, hence the necessity for a large increase in the size of Docks and Basins. The Naval Armaments had also increased enormously, requiring much larger magazine accommodation on shore. Workshops had to be modernised and new ones built. Due to the large additions to the Naval personnel, and to the necessity for more up-to-date accommodation, modern barracks had to be provided and also new Hospitals. Technical Schools, Gunnery and Torpedo, were built at some stations and numerous smaller services.

A much enlarged and improved service for Dredging was also introduced, and placed under the control of the Director of Works. Last, but not least, was the organisation and administration of a staff competent to deal with the huge mass of work and with the financial problems involved.

In addition to his work at the Admiralty, Raban was also consulted by Dominion Governments in consequence of his great reputation as a Docks Engineer, thus I find in 1910, that the Government of Australia sent him a letter of thanks for his co-operation in connection with the provision of a new Graving Dock at Melbourne, and in 1905 he was appointed as a member of a small committee to consider the question of the additional protection required for the Coaling Jetties and Coaling ground at Colombo. Occasionally, also, Consulting Engineers engaged on large projects sought advice, which, from his wide experience and sound judgment, he was ever ready and so competent to give.

Although still full of work in 1912, after 17 years' service as Director of Works, age limitation intervened, and he retired from the Admiralty service, receiving very many expressions of regret and approval of the great services he had carried out whilst Director of Works, and in this connection it may be noted that he received the honour of the C.B. in 1903 and K.C.B. in 1907.

But perhaps as much to his liking as any honour he received was the general expression of regret, esteem and affection which was conveyed to him by the members of his own Staff on retirement, including also much mention of the great improvements which had been effected through his long continued efforts in the conditions of and the general efficiency of their department. After his retirement from the Admiralty service, he was frequently called in to advise Consulting Engineers and Authorities with regard to important schemes at home and abroad in respect to river, dock and harbour works and water supply proposals. He had a wide experience of Parliamentary Committees, and his evidence, when retained as an expert witness, carried great weight. He also gave much assistance to the Junior Institute of Civil Engineers, of which he was at one time president.

Not long after his retirement, the Greek Government, having in contemplation the construction of a new Naval Arsenal and the improvement of existing naval facilities, asked for the services of a British official to advise them, the result being that, on the recommendation of the Admiralty, Raban was offered the appointment of Consulting Engineer, on the understanding that he would proceed to Greece at an early date, prepare plans and contracts, establish a staff there and visit Greece two or three times a year to inspect the works during progress.

He went to Greece in September, 1913, and remained there until December, consulting the various officials concerned from the Prime Minister downwards.

After visiting various places, he made a number of reports on the necessity for the construction of an entirely new Dockyard, complete with Magazines, Barracks, Hospitals, Docks, Workshops and all

subsidiary works in Eleusis Bay, near Athens, and the advisability of constructing subsidiary bases in other parts of Greece.

On the arrival of his engineering staff in Greece, the survey of the site suggested by him in Eleusis Bay was at once started, and later, complete plans for docks, workshops, hospitals, barracks, water and sewage services and gun testing grounds were prepared and estimates of the cost made, but before any decision could be come to, the conditions in Greece, owing to the outbreak of the Great War, became such that the British Naval Mission were ordered to leave Greece, and the work for a time was suspended.

In 1919, however, on the conclusion of the War and after another visit to Greece by Raban, the Greek Government decided to proceed with the works in connection with the new Arsenal in accordance with the plans prepared previously by the staff employed under his supervision.

For this purpose, Raban was instructed by the Minister of Marine to nominate a civil engineering staff to proceed to Greece, and the officers appointed arrived in Athens at the end of June, 1920. But in 1920-21 a general election took place and a new government came into power, who deferred any action as regards work on the new Arsenal: instructions were issued to cut down work in progress to a minimum, and the local staff which was approved was never appointed.

During the year 1922, financial and other difficulties having become greater, it was decided towards the end of the year to stop all work, except the water supply, and the British civil engineering staff was withdrawn from Greece.

Whilst Raban was in Greece in 1913, he was also requested to report on the desirability of improving the Commercial Port of the Pyraeus, which he did at considerable length, advocating that new jetties and stores houses should be constructed, and general improvements and repairs undertaken as regards railways, wharves and breakwaters, preliminary to a more comprehensive scheme being drawn up. On the termination of his agreement in 1923, he received the thanks of the Greek Authorities for his very valuable assistance.

We now come to the period of the Great War. Raban at once offered his services in any capacity in which they might be of use to the nation, only to be informed that there were so many applications from senior retired officers of the R.E. that no opportunity presented itself of utilising his services at the time: he was also given leave to go to Greece to carry out the work he was engaged on with that Government. Fortunately, however, for the service, in November, 1914, I was able, as Chief Engineer Central Force, to get him appointed to assist me in carrying out the works for the defence of London, which had recently been approved: his appointment

being that of C.R.E. Southern London Defences. As I anticipated, it proved to be an ideal appointment, requiring a good knowledge of Field Engineering, much experience in the organisation and distribution of large bodies of men and stores, and, above all, the power of imparting his knowledge to all those employed under him. In addition to these qualifications, he seemed to have revived the energy of his youth and to be able to inspire all others with his own zeal and enthusiasm.

The Defences of London during the Great War were, in some ways, rather a remarkable undertaking, decided on hurriedly in October, 1914; a large staff had to be extemporised at the moment from retired officers, R.E., and Civil Engineers with no previous military experience, and contracts made at two or three days' notice with some 50 of the largest London Contractors for the employment of 10,000 navvies, who commenced work within a few days on a line of defence some 20 to 30 miles outside London, which eventually reached about 60 miles in length. Not long after work was commenced, the construction of the trenches was also assisted by successive battalions of newly formed Infantry, the National Guard and other Volunteer Associations; in fact, the defences became a very useful school of instruction for infantry before proceeding to France, for in addition to trench work on a large scale, schools of instruction for bombing and pioneer work were also formed.

The defence works under Raban's general supervision, extended from a position near Reigate to Halling, overlooking the Medway, altogether some 30 miles in extent: it was divided into Sections under the direction of either retired officers R.E. or Civil Engineers, and other officers were appointed to deal with the large amount of tools and stores required. Raban had to consult with his section officers on the general lay-out of the defences and the detailed arrangements to be made for executing the works, including the distribution of the various working parties, visiting them as frequently as he could. But in addition to this, as so many of the officers and men were quite untrained in such work, he would spend much of his time in instructing them in their duties, not only in connection with the London Defences, but those which they would probably be required to perform when they were in the presence of the enemy; much detailed information to this effect having been received either from France or from the War Office.

Raban and his staff also worked out an elaborate scheme for assembling troops on the Southern Defences in case of emergency, and for the employment of many thousands of civilian workmen to complete the defences in a few days. All the necessary tools were collected in stores placed at short intervals and always ready for issue.

After he had been engaged on the London Defences for rather

more than a year, he was specially selected by the D.F.W. to supervise the construction of Anti-Aircraft Defences which had now assumed large dimensions, these duties being carried out under the orders of the F.M.C. in C. Home Forces, on whose staff he was named R.E. Adviser.

His duties in this capacity dated from March, 1916, and embraced the whole of Great Britain, where air defences were required. In April, 1917, he was promoted to the rank of temporary Brigadier-General, and two months later he was removed to the War Office as Deputy Director of Fortifications and Works with special charge of Aerodrome Construction, where he continued until the 31st January, 1918, when these works were transferred to the Air Ministry and Raban's appointment came to an end.

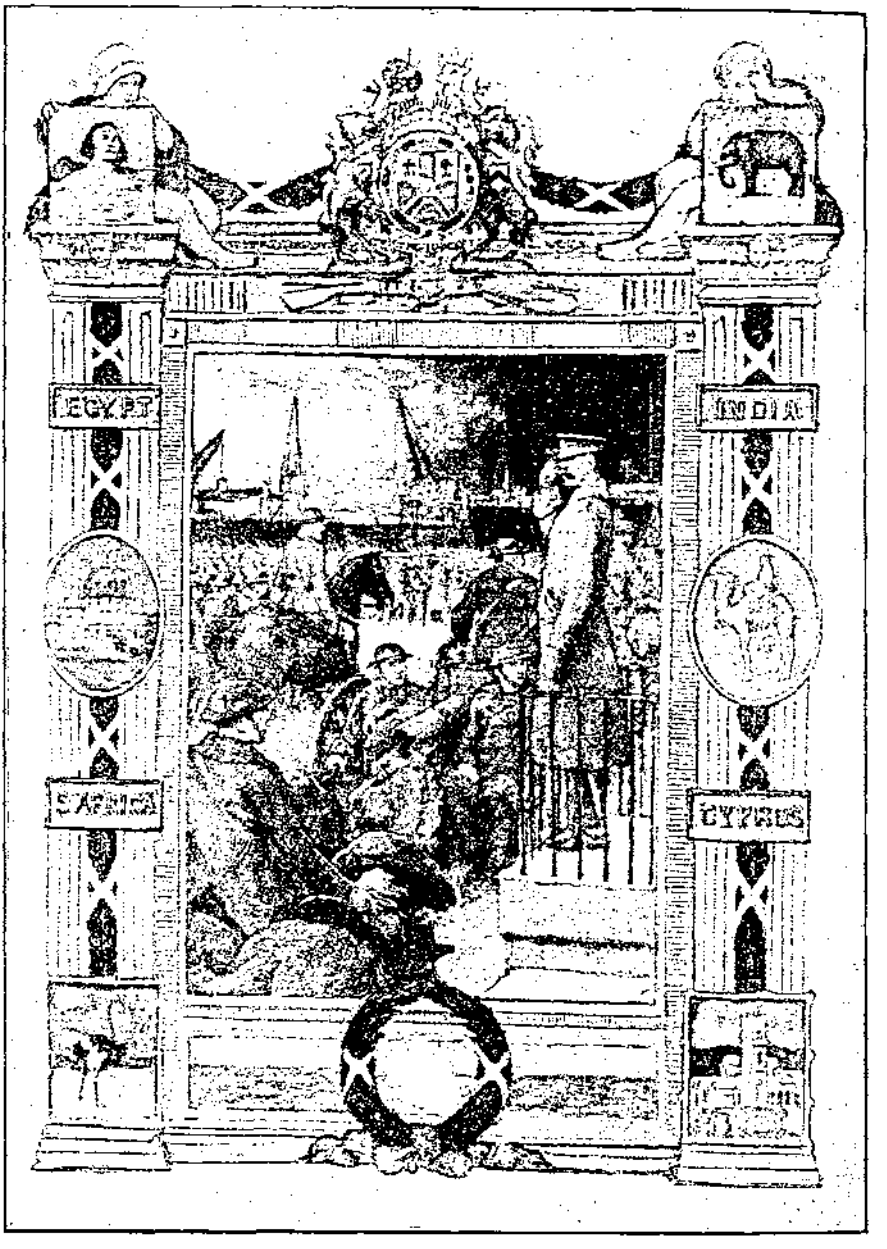
For his services during the Great War, Raban received a special letter of thanks from the Army Council, he was granted the honorary rank of Brigadier-General on retirement, and was afterwards made a Knight of the British Empire.

It is safe to say that no event in his career gave him greater satisfaction than his return to the Army during the Great War, and the renewal of his association with his old Corps of which he was always so proud.

He afterwards devoted much of his time to public and charitable work; he was always ready and anxious to undertake any work or duty of a public nature, and served for a time on the Chelsea Board of Guardians. In 1918, he became a member of the Council and Executive Committee of the Officers' Families Fund, and was for some time Chairman of the Education Committee. After the War, until the time of his death, he was a member of the main Committee of the Charity Organisation Society, and at once became one of its most important members. His great knowledge of public service, keen criticism and desire for ever improving standards of work, constituted him an adviser of a high order at the headquarters of such a society. In the 58th Annual Report of the Council of this Society, his death is referred to in the following words :—

"The Society suffered a loss of the first magnitude by the death "of Sir Edward Raban, K.C.B., on February 8th, 1927, at the "age of 77. From his long life, passed in very important Govern-"ment service in India, Canada, Athens and other parts of the "world, besides this country, both for the Navy and the Army, "he brought into every question which came before our Adminis-"trative Committee unrivalled wisdom, and combined with it "courage, independent judgment and decision of character only "equalled by his personal charm, and the inspiration to work "hard and honestly and fear nothing, which his friendship "inspired."

With unimpaired energy and mental grasp, he continued these



Frontispiece to the Roll of Honour of the Royal Engineers.
Painted by Mr. Solomon J. Solomon, R.A.

activities until early in this year, when he caught a sudden chill which developed into pneumonia and resulted in his death on the 8th February.

When reading the many letters of regret which were received by Lady Raban, one could not help being greatly struck by the unanimous note of admiration for Sir Edward's personal qualities, always cheerful, always helpful, and always inspired by the highest sense of duty and absence of self-interest.

I found amongst them one from a distinguished Head of one of our great Public Departments, apart from the Admiralty, but in close association with his work there; the concluding sentence in this letter appears to me to furnish as fine an epitaph as any public official could wish to have, and it rings true:—

"Of all distinguished men whom I knew in the Public Service, he "perhaps most nearly approached the ideal as a Public Servant. "A man of shining honesty, great personal charm and kindness, "he was a perfect colleague, and a most warm-hearted friend; "he was, moreover, the ablest administrator I ever knew."

R.M.R.

MR. SOLOMON J. SOLOMON, R.A.

WE regret to report the death, on July 27th, of the eminent artist, Mr. Solomon J. Solomon, R.A., P.R.B.A. During the Great War, in the winter of 1915, when the full importance of camouflage was beginning to be recognised in the armies of the *Entente*, Mr. Solomon was given the temporary rank of Lieutenant-Colonel, Royal Engineers, and was invited to visit the army in France and investigate the question of organizing a camouflage service in the British Army. The result was the formation of the Special Works Park under Captain Wyatt, and Lieut.-Col. Solomon, who shortly afterwards returned to England, was nominated as Technical Adviser. In the meanwhile, Lieut.-Col. Solomon had designed and, on 11th March, 1916, erected near Burnt Farm, on the canal north of Ypres, the first Observation Tree, constructed of metal, on the outside of which was bark from a willow in the King's Park at Windsor. Later, in 1916, he was for a time in control of the War Office Camouflage Exhibition ground, in Kensington Gardens.

At the end of the war Mr. Solomon published his book on *Strategic Camouflage* (John Murray), in which he maintained that an artist alone could fully appreciate the true value of the various shades which were found in air photographs, and that the whole camouflage service should have been under the control of an artist and not under that of professional soldiers. But whatever soreness he may have felt that his services were not more highly utilised in the war,

he showed a fine magnanimity in painting for the Corps the beautiful frontispiece for the Royal Engineers' Roll of Honour, in which he depicts Earl Kitchener witnessing the embarkation of his New Armies for foreign service. It is pleasing to reflect that in the spring of the present year, when the *Miscellaneous* volume of our War History was published, which includes the account of the Camouflage operations, it was unanimously decided by the Council of the Institution of Royal Engineers that a copy should be presented to Mr. Solomon. Mr. Solomon wrote a very grateful letter in reply, adding, "It amuses me to see that the square yard of trimmed fishing net which I threw down in triumph in Col. Liddell's office, developed into seven million square yards . . ." His many friends and admirers in the Corps will deplore his loss and offer their respectful sympathy to his bereaved family.

F.E.G.S.

BOOKS.

THE GREAT DELUSION.

A Study of Aircraft in Peace and War, by NEON; with a preface by A. H. Pollen. (Ernest Benn, Ltd., 1927.) Price 12s. 6d.

Mr. Pollen must have enjoyed writing the preface to Neon's illuminating volume. It is an able review of the book, and leaves little to be said on the subject. The reviewer cannot do better than to quote him:—

"The truth about flying has at last been told. And it is not a comforting truth. . . . Neon has stripped flying of its hocus pocus. . . . The physical laws that govern flight have been set out. A long array of facts have been collected which tend to show that our expectations never have and never will be realised. They are neither new, nor hitherto hidden, nor inaccessible facts. . . . Neon, has, in fact, done little more than quote the laws and collect the facts that show these laws in operation. But so well have the relevant laws been marshalled, with a sufficiency of the facts, that the case does not rest on any argumentative ingenuity. . . . The laws and facts speak for themselves. . . .

"The disinterested reader will be left somewhat painfully disillusioned. Flying, whether by dirigible or 'plane is not really all that we have been made to believe."

After discussing the immense expenditure during and since the Great War on aircraft, Mr. Pollen sums up as follows:—

"What have we got from it all? Where does flying stand to-day? . . .

"The aeroplane and the airship share with the submarine the curious distinction of being vehicles that work in a single medium. All others work in two. It is this fundamental distinction which introduces insoluble navigational disabilities for long distance airship flights for reasons which this book makes abundantly clear. . . . No airship yet has ever

attempted a commercial task . . . ; there seems to be but one airship in the world to-day with which it is contemplated to continue even experimental flying."

The story of the aeroplane is different. There are "actual services that have been operating for years and are still operating. . . . But when due allowance is made for the skill and courage of the pilot, the resources of the mechanic, and the immense knowledge and perfect practice that has gone to produce the engine and the 'plane, what is the practical utility of it all?

"It is only over short distances—that is, on point-to-point flights—that the speed of the aeroplane is greatly superior to that of a ship or superior to that of a railway train. One recognizes, of course, that speed may at certain conjunctures be of special importance. This possibility may justify a national subsidy to keep civil aviation in being. But if the nation chooses to keep it going, it should be for reasons that can be clearly stated. We should not be fooled into thinking that in time it will pay.

"That aeroplanes must have, or will have, a value in war, is just as certain as that they have a value in peace. But in both, their value can only be proportional to their efficiency as vehicles. As in civil aviation, so in military action. Steam and petrol and horses have left gaps, and in military life, as in civil, those gaps are narrow, and aircraft can fill them but seldom; and to be *always* ready for *every* chance of filling them is a luxury for the prodigal alone. . . .

"And so one finds oneself faced with the master puzzle, how are we to explain the fact that an improverished nation, crippled by debt, industrial disputes, and unemployment, can afford to spend over £20,000,000 a year on an activity the proved value of which is so very small?"

Mr. Pollen goes on to discuss our Air policy, and, after examining the various statements of the Prime Minister, Sir Samuel Hoare, Lord Thomson, Marshal Trenchard, Sir Sefton Brancker, and Sir Alan Cobham, comes to the conclusion that there is no policy. He asks: "Is it because there can be none?"

"There is no doctrine," he writes, "behind our Air policy, or rather, as each untoward thing happens a new theory has to be produced. Are our spokesmen subconsciously aware that the present limitations of the airship and the aeroplane as vehicles are fatal to their playing a great part in peace or war—and so must find either new arguments to meet new cases, or get rid of the limitations?"

In a postscript to the Preface, the distinguished writer on naval affairs uses the book as a peg on which to hang an indictment of the British declaration on disarmament at Geneva, and asks who was responsible for its authorship. It is interesting enough to reproduce in connection with our Air policy:—

"Speaking of sea power," he writes, "the delegates declare the Navy of an island power to be maintained for two primary reasons. First, there is the safeguarding of its trade routes, commerce, and food; and, secondly, the defence of its coasts and those of the outlying parts of the Empire. Now, had the delegates got their doctrine from the Admiralty, it would have been stated very differently. They would have said that

the Navy exists for *one* purpose only. That is, in war to attack and destroy, or by threat of attack to immobilise the enemy's fleet. With this disposed of, by victory or neutralisation, our sea services are secured, which means that our armies can be landed and kept supplied, and that the civil population is assured of food and of the raw materials which it can convert into the munitions needed by the armies. The Admiralty, that is to say, would never have led the delegates into the quaint mistake —long ago detected by Admiral Custance—of mixing up the consequences with the cause.

"Now let us pass to the Air Force. First, we are told that the air is a medium free from the limitations which necessarily limit the action of land and sea forces. . . .

"It is wonderful to hear that the air is free from the limitations that circumscribe the action of armies and navies! If this is true, why waste money and effort on forces so unfortunately restricted? And, for that matter, has not the air a few rather embarrassing limitations of its own?

"But hear the delegates again. 'It follows,' they continue, 'that a maritime country . . . must possess an air force which is sufficiently strong to resist invasion.' Now they cannot, of course, mean invasion by sea, which they have only just told us is the primary purpose of the Navy. Are we, then, to be militarily invaded by way of 'the medium free from the limitations which necessarily limit the enemy's armies and fleets'? Or, is it to be invasion in the sense only of bomb attacks from the air? I confess my imagination cannot rise to the first alternative. The delegates must then have had the second in mind. . . . It cannot be Adastral House (the Air Ministry) that has made this priceless contribution to military wisdom, for one remembers that Marshal Trenchard has taught us that the R.A.F. is not a defensive but merely an attacking force!"

Mr. Pollen has perhaps underestimated the moral effect of aircraft in war. He is certainly straining a point when he says that "the actual contribution of air fighting to victory is pretty hard to find. Until the trench war began, little was heard of the air. The moment the war of movement was resumed, the air arm faded into insignificance. . . . The airmen neither warned us of the great attack of March, 1918, nor could help the army when the attack began. They could only watch it dazed by their own impotence."

It is true that weather conditions when the attack began did prevent our airmen from fulfilling their roles, but to say that they were practically a negligible quantity in the war of movement shows that Mr. Pollen is ignorant of the facts—to say nothing of the assistance given us by the air photographs taken before the attack.

So much for the Preface. Neon's object in writing the book was obviously to try and induce the public to take stock and think twice before assenting to the continuance of the enormous expenditure on aircraft, especially airships. The case is presented in moderate language, and the book is in no sense an attack on the R.A.F. or the Air Ministry. It would ill befit an airman to do so, for no doubt the book is inspired by a man who knows all about aviation, though it is said to be written by a woman—his wife. It is Mr. Pollen who dots the "i's" and lays the

blame for the blinding of the public on the shoulders of the "young enthusiasts and experts who frequent Adastral House." If the Government, or the heads of the Air Ministry and the Air Force, are to be criticised, let it be, he says, for "their strange hesitation in perceiving that the experts do not all, or any one of them, always tell the same story."

Neon's case against airships is convincing, and would appear to be the last word on the subject. They can neither be made to pay their way in peace, nor can they be depended on in war. Further expenditure on them is therefore waste of money, which can be better spent on other forms of insurance.

Aeroplanes cannot, at present, pay their way in peace without subsidies. They have proved their value in war, and therefore we are justified in subsidizing them in peace. It is difficult to see what further development is possible. The locomotive engine has not greatly increased in efficiency during the last fifty years. Thanks to the unlimited expenditure on aeroplanes during the war the aeroplane engine has been developed at an abnormally rapid rate, but it has probably reached the zenith of its efficiency, and the comparatively small increase in speed obtained since the war has only increased the danger of landing.

Such are the conclusions which the reader of Neon's interesting book will find forced upon him, and, as Mr. Pollen says in his Preface, the numbers of those who have been so bold as to doubt that in future wars air fighting will be more important than ever before will be increased by a high precentage of Neon's readers. In one of the first reviews that appeared after its publication it was said that the book would do the cause of flying more good than harm. With that verdict the reader will probably agree. For the lesson from a military point of view is that the Air Force can only be an adjunct of the Army and the Navy, and can never be regarded as a separate entity.

The book should certainly be read by soldiers and sailors; the chapters on "The Law of Currents" and on "The Principles of Transport and Navigation" are very instructive.

H. B-W.

"THE INDECISIVENESS OF MODERN WAR AND OTHER ESSAYS."

By HOLLAND ROSE. (Bell). Price 10/6.

The volume consists of a series of essays strategical and historical.

Professor Holland Rose's object in the first two essays is to contrast the prolonged deadlock in the North Sea and on the Western Front in 1914-18 with what was achieved by the weak, slow fleets and small professional armies of earlier times. He suggests that history would abdicate one of her functions if she did not examine the causes of the mass wastage into which mass warfare has degenerated.

The attraction of the essays on the indecisiveness of sea and land warfare lies in the challenge to the professional sailor and soldier in the assertions and deductions made from the events of the last war. They are of considerable value as a stimulus to thought.

No candid German, however, or still less so an Austrian, is likely to agree that the war of 1914-18 was not decisive: the result to his country is too obvious. The loss involved in man-power and material on all sides was prodigious; but the results throughout the world have been on an unprecedented scale.

As regards the essay on Naval warfare, the author's generalisations and deductions are unfortunately based on a somewhat imperfect appreciation of strategical principles and a superficial knowledge of technical facts. This is especially evident when he deals with the question of surprise. Wireless and aircraft, in their present state of development, are far from rendering surprise impossible. Wireless may betray the intentions and position of a fleet; and the action of aircraft away from land aerodromes is limited by many technical difficulties, as well as by weather, which must always play such an important rôle in all naval action. The difficulties of the recent Geneva Conference on the limitation of armaments have shown the variance in the opinions of technical experts, and the struggle of all nations to find a solution to the question of the practical and economic size of ships and guns. The battle between the weapon as against armour, design and speed, is at its height. The power of evasion of the weaker fleet, and the difficulty of forcing an unwilling enemy to fight, have always been and always will be peculiarly difficult problems of naval strategy and tactics. The blockade is no new thing: its application during the Napoleonic and American Civil Wars is particularly interesting.

In the essay on "Modern Land War," Professor Holland Rose gives a very interesting historical summary and analysis of the successive phases of the war on the Western front: the difficulties of mass-warfare; the influence of numbers; reliance on artillery and machine-guns; the preservation of mobility in the face of the defensive power of modern weapons, difficulties of transport and of communications; trench warfare and the reasons which forced both sides to adopt it; successive changes in tactics, the introduction of gas and finally of the tank, in the effort to gain surprise and effect a break through; the repeated failure to exploit and to maintain the momentum of an initial success; the effect of propaganda among troops and the exhaustion of reserves. These are all questions receiving the closest attention of General Staffs.

Although the fundamental principles of war remain constant, no war can resemble its predecessor: the factors of the situation and its execution must differ. Military thought is at present very much in the crucible. The best brains are endeavouring to find the way to obtaining quick results: how to achieve surprise, how to retain mobility, how to avoid being forced into "static" warfare—which Professor Holland Rose suggests may be an inevitable phase of future war. How far mechanisation, the greater development of air action on the battlefield (*not* against civil populations, as suggested), the better organisation and training of small highly technical armies, will achieve our object, are questions to be solved.

As far as the British Empire is concerned, the reviewer contends that intimate co-operation between our Naval, Military and Air resources will provide us with a mobile weapon, in the widest sense of the term, such

as no other nation possesses, which will do more than anything else to enable us to attain our object in the minimum time.

The essay on "Plans of Invasion of the British Isles," provides a historical review, but the soldier should consider in each case the influence of early information, the defensive power of weapons, and the mobility of defending forces. Weather and moral conditions are, however, the constantly recurring factor in plans for invasion.

Of the eight historical essays which follow, those on the "Struggle for the Mediterranean in the Eighteenth Century," "The Influence of Sea-Power on Indian History (1746-1802)," and the "British Title to Malta," provide an interesting historical background to present-day problems.

That on "Admiral Duckworth's Failure at Constantinople in 1807," provides an example of the necessity for Naval operations in restricted or enclosed waters being adequately supported by land forces: a lesson which was lost sight of in the initial operations at the Dardanelles in 1915.

K. J. M.

CANADA IN THE GREAT WORLD WAR. VOL. VI.

(Toronto. United Publishers of Canada).

This is one of a series of volumes which claim to be "an authentic account of the Military History of Canada," and includes a chapter on the Canadian Engineers, by J. L. Melville.

The greater part of the chapter is given up to a summary of the activities of the Engineers of the Canadian Corps in popular form and requires little special note. That part, however, dealing with the organization of the Engineers is of more interest, showing how the Canadian Corps reorganized their engineer services to meet the needs of the Great War.

The arguments against the organization of three Field Companies and a Pioneer Battalion are somewhat surprising. It is stated that the field companies "were only small units of highly-skilled personnel, *wholly intended for supervision.*" We hardly think that this statement will be subscribed to by officers of the Canadian Engineers who were serving before the reorganization in May, 1918.

The new organization, by pooling the 3 field companies, the pioneer battalion, and a tunnelling company, produced in each division an Engineer Brigade, commanded by a Brigadier General, assisted by a staff, of three battalions and a pontoon bridging transport section.

Each battalion was to have a strength of 39 officers and 975 other ranks, though this strength was never reached. The establishment of the divisional engineers amounted therefore to 124 officers and nearly 3,000 other ranks, which exceeds by more than 50% the strength recommended by Lord Rawlinson's Committee on the reorganization of the Royal Engineers. At the end of the volume is a table of Commanding Officers of all the units of the Canadian Corps.

R. P. P-W.

THE REMAKING OF MODERN ARMIES.

By CAPTAIN B. H. LIDDELL HART. (John Murray, 10s. 6d.).

This book will be welcomed and should be read by all who are studying the future development of the army. The author in his preface says that "the keynote of this book is mobility of movement, action, organisation, and, not least, of thought." He follows out this idea in three phases. In the first he argues that the present army is that of a nightmare, and that the cure is to be found in mobility by mechanisation; and he points to the logical outcome in an army that is to be "reborn" in a form very different from that it now holds. In the second part he considers the material available, and some of the ways in which the transformation, or rejuvenation, of the army might be begun. In the third part he discusses the effect of the Great War on the policies of Germany and France, and shows how differently they have interpreted the lessons they learnt.

From this short summary it can be seen how full the book must be of matter not only interesting but stimulating. The invention of the six-wheel vehicle has, in the author's opinion, given so much more strength to the defence that we cannot hope to overcome it with our present organisation. We must no longer wait for the gradual reorganisation consequent on the peaceful development of ideas. In his opinion, drastic action must be taken, and that soon.

While it may be claimed that Capt. Liddell Hart exaggerates some of the factors in the present situation, notably the alleged retrogressive attitude of infantry officers, yet there is no doubt that he is right when he says that ideas from outside the army have the merit of freshness, unbiassed by tradition and precedent. If one agrees with him in his diagnosis, one may be permitted to doubt whether the patient would be able to stand the shock of his remedy without a long and painful convalescence.

N.W.N-C.

POPULAR HANDBOOK ON TIDES.

For Navigators and Others. J. F. RUTHVEN. (pp. xv+76 with diagrams, London. J. D. Potter.) Price 5s net.

This small book is entirely concerned with the explanation of the tides on physical and mechanical principles. Part I consists of about forty pages devoted to what mathematicians call the "uncorrected equilibrium-form of the tides," followed by about twenty pages on the effects of the atmosphere, land and shallowing sea-floors. Part II consists of sixteen pages devoted to waves in water, the properties of the cycloid, and the adjustment of the sea to changes in atmospheric pressure.

The "equilibrium-form of the tides" is the name given to the fictitious distribution of tides, calculated on the hypothesis that the water has lost its inertia without losing its gravitational properties. On this hypothesis the tides are independent of the depth of water where there is water at all, and the only terrestrial factors are the shape of the coastlines and the value of gravity. For the "uncorrected equilibrium-form" the further hypothesis is made that water covers the whole Earth. Whether "un-

corrected" or not, the equilibrium-form takes full account of the tide-generating forces of the sun and moon, and responds immediately to all changes in these forces. It is a very convenient way of representing the tide-generating forces and is largely used for this purpose by writers on the analysis of tidal observations, the construction of tide-tables and the dynamical theory.

The author's account of this form is, on the whole, clearly and forcibly written, and certain parts, such as that dealing with the centrifugal effects of the motion of the Earth round the centre of gravity of the Earth and Moon, are exceptionally good. But he is under the impression that his explanation utilizes a principle of "differential pressure" only discovered by the late Rev. J. H. S. Mosly. Where a mathematician would say that the equilibrium-form occurs when the pressure differences due to the weight of raised water balance the disturbing forces, the author says (p. xii) that it occurs when "the weight of water raised balances the pressure" of the disturbing forces, and nothing essentially new is introduced.

The author is also under the impression that if water covered the whole Earth to a uniform depth, and the atmosphere were perfectly quiescent, the actual tides would be identical with the equilibrium-form. This is entirely wrong, because the inertia of the water is by no means negligible. On p. 24 it is stated that the instantaneous and continuous response of the water to the disturbing forces would follow from the mere absence of viscosity. What the tides would be under the ideal circumstances supposed was worked out by Laplace, and the fact that his results bear no resemblance to the actual tides only means that the distribution of land and of varying ocean-depth are factors of the first importance in determining the actual tides. From the time of Airy steady progress has been made in allowing for these factors, but up to the present the chief results relate to small seas, and the mathematical problem presented by the great ocean-basins remains unsolved.

J. PROUDMAN.

TIDAL LANDS,

A Study of Shore Problems, by Carey & Oliver. (Blackie & Sons). Price 15s.

In this book, a copy of which has just been added to the Corps library, the authors have collected and co-ordinated a great deal of miscellaneous information about a subject on which there are practically no recognised modern text-books.

To the average engineer it makes interesting reading, touching, as it does, the outskirts of botany, geology, water supply and sanitation, investigating the reasons for, and cure of, "wandering" sand dunes, and in less detail the phenomenon of the fresh-water supply, which so often overlays the salt water in shingle beaches.

To those engineers whose problems include battling with the flow of water, this book should be very useful for reference and a foundation upon which to build their plans; it may also save them trouble in

elementary experiments, and possibly a good deal of unnecessary expenditure.

Each of the three materials of which an unstable shore may be composed, viz., sand, shingle and mud, are taken in turn, the reasons for their movement analysed, and the natural agents for their fixation described. In the first two cases this analysis is followed by practical notes for the planting of the shore with suitable vegetation so that the expenditure on artificial protection works may be lessened.

That these details are not given in the case of mud "saltings" may be due to the investigations not being yet sufficiently advanced, but it is a serious gap in an otherwise admirable book.

The recommendations and theories are all illustrated by diagrams in the text, and in many cases by excellent photographs of beaches in which reclamation or fixation has been successfully effected.

Artificial protection works, such as groynes, sea-walls and embankments are described, together with methods of repair, and there is a brief account of the "Air-reef" method of protecting work in heavy seas.

The book is completed by chapters on tide data and legal aspects, and by appendices giving many types of lichens, seaweeds, plants, and trees, which grow in, and are useful for, the fixation of the three types of shore.

The book is not limited in its application to the British Isles; it is sprinkled with references to, and examples from, foreign countries, both European and Trans-Atlantic, and the Dominions. India, however, is hardly mentioned and the tropical side of the subject in general requires expansion before it is properly covered.

A.M.

SURVEY COMPUTATIONS.

HIS MAJESTY'S STATIONERY OFFICE, 1926. Price 8s.

THIS book will appeal mainly to those who are fully conversant with that masterpiece of conciseness and clearness, the "Text Book of Topographical and Geographical Surveying."

It is, in fact, a corollary to that book, and references are frequently made to chapters in the text book. As the first book of its kind "Survey Computations" fills a very long felt want, and there is hardly an item of Survey science which is now not dealt with either in one book or the other. Once and for all, the forms of computation which are to be used in military surveys of any kind are laid down, and though criticism may be levelled at some of the "official solutions," chiefly on account of their possible obscureness to those who are not already fully practised in the art of computation, there can be no question that it is most desirable thus to have standard forms from which no departure can be allowed.

One grave defect in the book is to be found in the paucity of tables of geodetic functions at the end. The only tables given are based on Clarke's 1858 figure, yet only a minority of the specimen computations employ that figure. Some of the specimens (*e.g.*, G.S.G.S. forms 27, 28, 48) have stated upon them the figure of the earth that has been employed

(Airy's, Clarke's 1880, Carte de France Spheroid, in the cases cited) but the large majority have no such useful note (vide G.S.G.S. forms 37, 38, 40, 41, 42, 43, 44, etc.).

The luckless computer approaching these forms for the first time naturally wishes to run through a specimen computation to ensure that all is clear to him, but he at once comes up against geodetic functions which do not agree with those given in Table III (Table IV is not used to the same extent). He cannot guess what figure has been employed unless it is stated, and even in the cases where this is done, there are no tables available in the book itself except for Clarke's 1858 figure. Surely it should be possible to include further tables, based on Airy's figure and Clarke's 1880, even if for no others, and thus make the book self-contained. No objection is taken to the use of different figures of the earth for different specimen computations, as this brings home in a most arresting manner the great divergencies between such accepted figures. These possible divergencies are given in para. 1 of Section 1 of the book, and will come as a surprise to some.

Section 1 itself makes most interesting reading, and much of the subject matter is new. Particularly useful will be found the tables of projection errors (para. 12), and those who have had dealings with the preparation of special maps for wireless direction-finding for aircraft will be interested to see how that old shibboleth "D.F. work demands a gnomonic projection" has once more been refuted. The tables further strengthen the position of Transverse Mercator with standard sub-meridians as one of the best for military purposes.

In a book so full of good matter it is hard to pick out individual features of merit, but the nomogram on page 35 should save many an hour to those who have been forced to observe at satellite stations. Section VIII will be found more than useful to those in high places who compile and produce maps. The gridding of charts, a matter that has lately been very much to the fore, is well explained in para. 3; and the examples of how to find the cutting lines of a grid and, what is almost as important, of how to record them for the drawing office, will be welcomed by all those to whose lot it falls to perform such seemingly simple but actually complicated duties.

There remain two minor criticisms, both of which concern the rules laid down in the Introduction to the book. To write down logarithms "in the style of a cash column" seems asking for trouble, for the addition or subtraction will be made as if degrees, minutes and seconds were being dealt with, and it is not clear why the old rule of three and four should be departed from. The use of "X" for northing and "Y" for easting will undoubtedly confuse. The battle is between "current mathematical use"—one would almost have said "universal mathematical practice"—and Colonel Clarke and the Ordnance Survey. Revered though the latter two may be, it seems that the weaker side has won the fight. The "Umpire" has officially decided, however, that the battle shall be thus lost and won, and so:—

"Ours not to reason why,
We must change from "X" to "Y."

P.K.B.

FOUR-PLACE TABLES WITH FORCED DECIMALS.

By F. S. CAREY, M.A., Professor Emeritus in the University of Liverpool, and S. F. GRACE, M.Sc., Lecturer in the University of Liverpool. (Longmans, Green & Co., Ltd.) Price 1/-

The distinctive figures claimed for these tables are :

(1) Forced decimals.
(2) Improved devices for interpolation.
(3) Special tables.

No formal definition of the term "forced decimal" is given, and the reader has consequently to infer the meaning from the somewhat scanty explanations. A forced decimal appears to be one in which the 4-figure approximation is either over or under the true value, the distinction being indicated by the type, italics or clarendon.

This departure from practice is quite sound. A great deal of useful information is given, such as constants, Naperian logs, and the values of the hyperbolic functions sin, h, x, etc., also tables of squares and reciprocals.

J.M.W.

THE ACTIVATED SLUDGE PROCESS.

By ARTHUR J. MARTIN, Chartered Civil Engineer, M.INST.C.E., M.INST. WATER ENGRS., M.CONS.E., F.G.S., F.R.SAN.I., Past President of Institution of Sanitary Engineers, and of the Association of Managers of Sewage Disposal Works. (Macdonald and Evans.) Price 30/-.

This book brings together in concise form all the available information on the Activated Sludge Process, and extensive reference has been made to publications on the subject in every country in the world.

The development of the process is traced from its earliest days, the various methods of working it are compared, and descriptions are given of a considerable number of installations at home and elsewhere.

The subject is fully dealt with, both on its theoretical and its practical side, and the opinions of every expert are quoted *in extenso* and reviewed by the author. In view of the considerable time that the process has been in practical operation, it is disquieting to find what a large variation of opinion still exists, even on what might be called the fundamentals of the process; and to what extent the process has been allowed to develop on experimental lines without a proper determination of the underlying theory, and of the conditions essential to its success.

That so many installations have proved to be a success in spite of this is undoubtedly a tribute to the value of the process, but there is no doubt that the time has come for further analysis from the purely theoretical aspect.

Even on such fundamental points as aeration *versus* mechanical agitation, the desirability of pre-sedimentation, the proportion of activated sludge to raw incoming sewage, the duration of aeration, etc., expert opinion varies to a marked degree.

In one important phase, namely, that of disposal of the sludge, the progress made is small and is still in the experimental stage. Military

engineers are naturally more concerned with the possible application of the process to military needs, and there are certain factors which appear to be sufficiently well established to be considered as reliable data for this examination. Generally it can be accepted that it is not suited to small stations. A d-w-flow of 500,000 gallons per day may be taken to be the minimum.

The process is very sensitive to changes in the character of the sewage, and the greatest difficulties occur in the treatment of various trade wastes, grease, etc.

With domestic sewage, even strong sewage, as would normally be the case with military sewage, there is no reason whatever why it should not be perfectly successful.

Skilled supervision is necessary—some authorities, in fact, go so far as to say that a chemist is required to keep it constantly under observation. It might be agreed, however, that where no trade wastes occur, and the sewage is fairly constant in character, as in a military station, a chemist is hardly necessary.

The saving in original cost of installation over the normal system of tanks and sprinkling filters is large—probably not less than 25—33⅓ per cent. Against this must be set the greatly increased cost of operation, due to the large amount of mechanical plant required. This increase is put by various authorities at from 10 per cent. to 100 per cent. It is probably fair to say that the process taking all in all shows little, if any, saving on other means of sewage purification. It requires far less space and is comparatively innocuous, which are important and sometimes ruling factors near towns; but against that can be set the difficulty of dealing with the sludge.

The sludge produced differs in many respects from that yielded by any other mode of treatment. It is flocculent and very voluminous, containing, as it does, from 97.5 to 99.74 per cent. of water, which it retains very tenaciously. Owing to the high water-content, the bulk of activated sludge is often more than 1 per cent., and sometimes as much as 6 per cent., of that of the sewage from which it is derived.

Owing to the state of flocculation, it is difficult to de-water and reduce to a marketable condition.

Drying and compressing operations are expensive, and so far not very successful.

Land treatment is the cheapest method at present, but this requires a considerable area, and far more than is saved in tank space. If successfully de-watered and dried, however, the sludge is richer in nitrogen and phosphates, and should have, therefore, a higher fertilising value.

On the data given in this book it is difficult to form a definite opinion as to the value of the process for military requirements. The preliminary data are determined from an analysis of the sewage to be treated. From this point everything is a matter of opinion, e.g., duration of treatment, amount of air required, etc.; and there are no means of check until the results confirm it or otherwise.

On the whole it would appear that the process requires too much skilled supervision, and offers too little prospect of any real economy to justify its adoption for military purposes at the present time, except at

stations where the W.D. can insist on sound chemical knowledge on the part of its Sewage Farm Managers.

Mr. Martin has performed a valuable task in bringing together within the scope of one volume, and in a form to permit of its analysis, the flood of information scattered throughout many reports and publications during the last few years on this subject.

That much of this is conflicting, and that the Author has not altogether succeeded in giving, or indeed, attempted to give, an authoritative opinion on every point, is not to be wondered at, in view of the complexity of the process, and of the fact that works installed to date have been largely laid down on the basis of experimental data collected for those particular works only.

He indicates, however, possible lines of advance, as also methods of cheapening the process, and it appears hardly open to doubt that the large amount of highly skilled research now in progress will enable such improvements to be introduced as will definitely establish the superiority of the activated sludge process over others.

It may be of interest to indicate the lines of future advance suggested by the Author.

The fundamental essential requirements are, of course, well known—these are, some oxygen, a supply of sludge inoculated with the appropriate organisms, and sufficient agitation to prevent local stagnation and to keep the contents of the tank thoroughly intermixed.

The relative importance of these essentials and the minimum amount of each which must be supplied are still unknown; and opinions vary widely on the point. It is sometimes assumed that owing to the success of the Activated Sludge process, the day of the sedimentation tank and filter is over, but this is by no means certain.

The present tendencies are rather towards sedimentation as the first step, aeration as the next, and filtration as the final one. It has been shown repeatedly that it takes 4 to 5 hours with a big expenditure of air (or power) to do work which a filter will do easily and cheaply in one hour.

This means, of course, a departure from the fetish of a "single operation," which has undoubtedly hampered the development of the process.

The purification of sewage involves several distinct operations, and it is generally wise to carry on each stage of the work under the conditions most favourable to the requirements of that particular stage.

Again, the reduction by sedimentation of the amount of suspended solids in the sewage, and of the amount of sludge in the aeration tank to the minimum required for purifying the sewage, greatly reduce the amount of oxygen required in the process, and hence the amount of power required. The shortening of the agitation period has, of course, the same result.

Experiments would tend to show that the sufficient flocculation of tank liquor for one hour removes 60 per cent. of its impurity and all objectionable smell, and that the liquor so produced may be oxidised at more than double the present rate on a percolating filter.

The system or method of admixture of sludge with the sewage is also not wholly satisfactory. The declared object of the process is the

conversion of non-settleable impurities into a rapidly settleable form, this conversion being effected by the "floc" which sweeps the colloidal substances out of the sewage.

This is not so easy. We cannot merely push or pull our filter along, it must be moved with the sewage, and even then this is useless if sewage and sludge merely move on together. The sludge must have a motion relative to the sewage, and in the process as ordinarily carried on this relative motion is only obtained as a by-product of the movement of the whole body of sewage.

This is not an effective way of going to work, and requires an enormous amount of power, most of which would be saved if the filter could be kept stationary, and the sewage passed through it.

There are several methods by which this could be done, one on the lines of the "Nidus Rack," by collecting the sludge on the meshes of a series of nets and passing the sewage through them at not too high a velocity.

A better plan, possibly, would be to use a fairly heavy artificial sludge such as river silt or clay.

Experiments on a small scale encourage one to hope that, provided such sludge is kept in condition, a great part of the power now expended on agitation might be saved, but as the Author points out, the subject is very complex and requires far more investigation.

G.B.O.T.

HISTORICAL ILLUSTRATIONS TO *FIELD SERVICE REGULATIONS, VOL. II.*

By Major H. G. Eady, M.C., *p.s.c.*, R.E. (Sifton Praed & Co.) Price 10/6.

Major Eady has brought out a second edition of this book, in which he has now included a Campaign Index, which should add considerably to its value in the study of individual campaigns.

VADE MECUM FOR FIELD-GENERAL COURTS MARTIAL.

By Major O. M. T. Frost. (Gale and Polden, Ltd.) Price 1/6.

A useful and handy guide to procedure.

THE WHITWORTH BOOK.

Prepared by The Whitworth Society. Hon. Editor, David A. Low, Whitworth Scholar, M.I.Mech.E. (Longmans, Green & Co., Ltd.) Price 10/6.

Contains all information about the Whitworth Scholars and Society.

ERRATUM.

National Frontiers in relation to International Law.—The description of this book, which is reviewed on page 161 of our March issue, should read, after the word 'Translator,' "Oxford University Press 1927, 9¼ x 6½, pp viii + 127 + xii. Frontispiece and Sketch maps 10/6 net."

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

January, 1927.—Lieutenant-Colonel Doumenc completes his article "*Les trois glorieuses*," as the three days of revolution in Paris, July 27th to 29th, 1830, are called. This instalment completes the picture of the failure of Marshal Marmont, Duc de Raguse, and draws therefrom various lessons for the repression of civil disturbance. It is rather pathetic to read of the failure and disgrace, in an affair of this kind, of one of Napoleon's most famous marshals.

The fourth instalment of Lieutenant-Colonel Baills' "*Evolution des idées sur l'emploi tactique de l'organisation du terrain, de Napoléon à nos jours*", deals with the preparation of a defensive position when the opposing forces are in contact. Several interesting quotations from Napoleon are given, which show how clearly he realised the importance of basing his operations on sound defensive dispositions, while the principles laid down are as applicable to present conditions as to those of a hundred years ago. The instalment is practically an expansion of the French regulations on this subject, special stress being laid on the selection of positions, allowing the full fire power of the defence to be developed, rather than providing obstacles for passive resistance. The necessity for defence in depth and the value of concealment are clearly brought out.

Les étapes de guerre d'une division d'infanterie, by Lieutenant-Colonel Laure, which deals with the various stages passed through by the 13th Division, is continued in this number. The instalment covers the period September 7th to October 13th, 1914, during which the division took part in the battle of the Marne, and was then employed in the race to the sea, finding itself eventually about Notre Dame de Lorette. It is interesting to note the lack of vigour in the advance from the Marne, which was apparent on several parts of the front. It seems, however, that the division did not realise that anything was wrong until orders appeared signed by a new Corps Commander!

The first instalment of Capitaine Girves' article *La guerre civile en Chine* is an excellent sketch of the internal dissensions in China from the fall of the Manchus to November, 1926. The early events of the revolution and the dictatorship of Yuan-chi-Kai are briefly described, the greater part being devoted to the civil wars of 1924 onwards. For those to whom the situation in China is nothing but a confused mass of unpronounceable names, this article should be of real interest, as the various situations are clearly set out without any distracting details. A useful sketch map, showing the spheres of influence of the various "War Lords," is given.

L'emploi des feux dans la guerre du Rif, by Lieutenant-Colonel Gemeau, is a very short article designed to illustrate the necessity for obtaining superiority of fire, before an assault can be made, in mountain warfare just as under more normal conditions. Two examples, of attack and defence in the Rif operations, are given as illustrations of the principle.

February, 1927.—The third instalment of Lieutenant-Colonel Laure's

Les étapes de guerre d'une division d'infanterie covers the period October 14th, 1914, to December 25th, 1915. The most important operations, in which the 13th Division took part during this period, are generally known as the Battle of Artois. The author's comments are more interesting than his description of events. Apparently the infantry still continued to attack in great numbers without sufficient artillery preparation, and when the German line was pierced on a front of one or two kilometres, most commanders thought that a break-through was imminent. It is instructive to read that General Pétain was not of this opinion, as when one division in his XXXIII Corps did effect a rupture in the German line, it was withdrawn before it could be cut off by pressure on the flanks.

Lieutenant-Colonel Baills completes his article *Evolution des idées sur l'emploi tactique de l'organisation du terrain, de Napoléon à nos jours* in this number. The instalment is mainly devoted to a discussion of the type of defensive organisation required behind a stabilised front, for use in case of retreat. The author's view is that successive defensive lines, connected by switches, are useless, as there will never be sufficient troops to hold them. He recommends a number of localities organised in depth for all-round defence over a very considerable area. Small garrisons with automatic weapons can then hold these localities, and they can be connected up, as more troops become available, according to the direction of the attack. The instalment is based far less on Napoleon's doctrine than any of the preceding ones, but it is perhaps the most interesting, as the author has evidently made a thorough study of this special form of defence and puts forward his views both forcibly and clearly.

Captaine Girves completes his short study *La guerre civile en Chine* with a review of the characteristics and capabilities of the various Chinese arms. He finishes with a few tentative remarks about the future, evidently written before the recent troubles began. He thinks that the state of disorder is not unfavourable to European nations, as a strong central government would probably turn all the foreigners out. The recent policy of the Cantonese government seems to bear out his theory.

Lieutenant-Colonel Paquet begins an interesting article, entitled *Avant l'offensive allemande sur Verdun*, in this number. His object is to indicate to Intelligence officers how to forecast the enemy's intentions; in this number he deals with the study of air photographs, illustrated by the actual information available from this source before the battle. At that time there were no regimental Intelligence officers, and co-operation was apparently lacking between the Commander of the Verdun sector and his staff. The author shows clearly how, with a more efficient Intelligence service, better provisions might have been made against an attack which everyone knew to be imminent.

In *Le 10e salon d'aviation*, M. Grimault, Chief Engineer of the Air service, describes the various features of the last aircraft exhibitions in Paris. Apparently this was not well attended by the public, and foreign countries (notably Great Britain) were badly represented, but the writer considers that the exhibition promises well for the future.

March, 1927.—The fourth instalment of Lieutenant-Colonel Laure's *Les étapes de guerre d'une division d'infanterie* covers the period December

27th, 1915, to December 23rd, 1916, during which the 13th Division took part in the battles of Verdun and of the Somme. As before, the interest of the article lies in the author's comments. Lack of depth and too many troops in the front line still caused excessive casualties during the Verdun fighting; and during the summer of 1916 an innovation was introduced which caused much opposition among units, but which was most beneficial in its results. This was the formation of a divisional school and depot by the withdrawal of one company per battalion, and at which all drafts received further training before being put into the line. The writer holds the view that, after the wastage of Verdun, it was impossible for the French to press home the great success of General Fayolle's army in July, 1916, but that the British reserves should have been used for this purpose, if only there had been unity of command at the time.

L'art de la guerre, Epoque contemporaine, by General F. Canonge, begins in this number. It consists of a summary of the decisive operations on the various fronts, preceded by a short account of the various distinguished French officers who graduated or instructed at the "Ecole supérieure de guerre." The greater part of this instalment is devoted to Marshal Foch's strategy, after he was placed in command of the Allied forces, in the late summer and autumn of 1918.

The second instalment of Lieutenant-Colonel Paquet's *Avant l'offensive allemande sur Verdun* deals with intelligence obtained by the infantry. The author was fortunate enough to find an eye-witness able to give details of the intelligence available from the front line in the sector between the Bois de Ville and Bois de l'Herbebois, opposite the German III Corps, on which to base his account. In this instalment the actual defences and observation posts on the front are described.

L'emploi du canon de 75 comme canon d'accompagnement, by Colonel Pagezy, is a short study of the "seventy-five" as the weapon designed for immediate support of the infantry. After discussing the characteristics and principles governing the employment of the weapon, some interesting examples are given, taken from the course at the "Ecole supérieure de guerre." The examples illustrate well the right and wrong method of employment; but it is seen that success depends almost invariably on communications. The author recommends an efficient wireless set; but with the enormous number of batteries, each requiring communication with an observation post as well as the infantry whom they are supporting, one may well wonder whether the introduction of these sets on a large scale would not make for confusion rather than efficiency.

The first instalment of *Le Flambeau*, by Capitaine de Gaule, consists of a dialogue between a regular sergeant and a volunteer private in 1793 on the subject of the fluctuations of fortune of the French Army since the outbreak of the Revolution.

H. A. J. PARSONS,
Major, R. Signals.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1927. *Tome* I. *Nos.* 1 *to* 3 *inclusive.*)—*Les opérations de l'Armée belge* (1914-1918). The movements of the Belgian Field Army on October 13th, 14th, 15th and 16th, in the retreat to the Coast, are dealt with in the three numbers of the *Bulletin* under notice; a number of sketch maps are included in the text and a map (scale 1/320,000) is provided, showing the general situation in Flanders on the night of October 15th/16th, 1914. Intelligence reports of October 13th and 14th indicated that two German columns were advancing westwards, namely, one from Eeclo and Ghent on Bruges, and the other from Deynze towards Thielt; the latter appeared to be the larger force and seemed to be marching on Roulers and Cortemarck. The text of the orders issued by the Belgian High Command to meet this situation are given in No. 2; therein the Belgian Army was directed to assume the offensive against the column marching on Thielt and to take defensive measures against the more northerly of the enemy's columns. Apparently, the arrangements for the co-ordination of the staff work at the French and British G.H.Q. were at this time still defective, and the Belgian General Staff was, in consequence, placed in a perplexity in the framing of its plans. It is stated that at noon on October 14th a communication was received at the Belgian G.H.Q. from Rawlinson, in which he stated that his orders were to hold himself in readiness to carry out a strong offensive movement—probably on the following day—and therein he expressed the hope that the Belgians would have troops in the neighbourhood of Roulers to support the attack by his force; on the other hand, at 10 a.m. on the same day, Foch telegraphed to the French representative at Belgian G.H.Q. urging that, in view of the Allied offensive then in progress, it was important that no check should occur at any point on the Western Front, and, in consequence, he suggested that the Belgian divisions should only fall back when absolutely forced to do so by the enemy's pressure, and that the Belgians should maintain touch with Ypres, where a strong "centre de résistance" had been created. Foch's intention was that the Belgians when forced back should retire to the line of the canal from Ypres to Dixmude and strongly entrench themselves there.

The Belgian troops, in pursuance of the orders issued to it (based to some extent on Rawlinson's communication), were, on the evening of October 14th, in occupation of positions on the line Eerneghem-Gortemarck; in the meantime, however, the British 7th Division had fallen back into Ypres and the British 3rd Cavalry Division had moved to Wijschaete. On the same day, the French 87th Territorial Division was on the line Ypres-Poperinghe. In consequence of the withdrawal (mentioned above) of the British troops, the Belgians found themselves in a position approximately 12 miles in advance of their Allies, and were there confronted by a strong German force on a line extending from Bruges to Courtrai, only some 7 to 8 miles away.

Intelligence reports received at the Belgian G.H.Q. during the 14th further indicated that large bodies of troops belonging to the German XII and XIX Corps were on the line Armentières-Menin, and it was also reported that a German column (2,000 strong) was on the Menin-Roulers road. In view of this situation the Belgian High Command

decided to withdraw the troops under its command, on the following day, to the line of the Yser—the text of the orders issued for this move is set out in the original article. By the evening of October 15th, the Belgian Army, now consisting of only some 50,000 rifles, succeeded in reaching the line of the Yser and took up positions on a line extending from the coast near Nieuport to Boesinghe—a front of about 25 miles in extent.

La bataille de Mons. Part IV and the concluding part of the account of the Battle of Mons, by Major Van Egroo, are contained in Nos. 1 and 2; in these parts the strategical and tactical aspects of the battle are analysed and the lessons to be learnt severally from the operations of the British and German troops are briefly summarised.

La vérité sur la défense de Namur en 1914. Part IV of the article by Colonel Merzbach and Captain-Commandant Herbiet on this subject is published in No. 1; the article by M. Jean Fleurier (*Revue Militaire Suisse*, May, 1924) is further analysed and criticised. The authors of the article now under notice explain that the Governor of Namur put into execution the scheme of defence which had been prepared in peace time and was not at liberty to, nor did he, call upon the French to detach troops to his support; however, Joffre recognised that the retention of this fortress by the Western Allies possessed certain advantages, and he therefore authorised General Lanzerac, the Commander of the French 5th Army, to utilise a part of his force in support of the Belgians, and Lanzerac, in consequence, sent three battalions into Namur, where they arrived about 6 a.m. on August 22nd. In conclusion, the authors set out in some detail the numbers of the German troops held up during August 21st, 22nd and 23rd before Namur, owing to the resistance put up by the Belgians: the Belgian force employed there was 37,000 strong, and this relatively small force, reinforced on August 22nd by three French battalions, detained, at a critical time, a German force which amounted at one time to 153,000 men. The defenders of the fortress, it is claimed, amply fulfilled the difficult duty which fell to them in the opening phase of the Great War.

La fortification permanente dans la défense du pays. Part II and the concluding part of the article on permanent fortifications by Major Deguent are published in Nos. 1 and 2; three maps are provided. In these parts Major Deguent deals with the defensive system on the western frontier of Russia and the part played by the Russian fortresses during the Great War; the part played by the fortresses of Austria-Hungary during the Great War; the permanent fortifications of Germany in 1914 and the *rôles* of the German fortresses during the Great War; the employment of, and the necessity for, permanent fortifications; the changing views held in France regarding the *rôle* and provision of permanent fortifications; standardised systems of permanent fortifications and the basis on which a scheme of permanent works should be designed; the Belgian defensive system; the defensive organisation which Germany is creating at the present time (January, 1927) on her eastern frontier. These articles cannot fail to prove of considerable interest to the young Sapper officer.

W. A. J. O'M.

REVUE MILITAIRE SUISSE.

(1926. Nos. 7—12 *inclusive.*)

L'organisation du haut commandement dans l'armée suisse. Colonel H. Lecomte sets out in No. 7 of the *Revue* certain features in the organisation of the High Command of the Swiss Army which, in his opinion, constitute a point of weakness in relation to Home Defence; he considers that under the present arrangement serious difficulties might arise on the sudden outbreak of hostilities in changing over, with due promptitude, from peace methods of command and administration to war methods, particularly as this involves the vesting of the command of the Army, with all that implies, in the officer who has to be designated, when the occasion should arise, as generalissimo. Colonel Lecomte gives his views as to the way in which the alleged defects in question could be cured, and suggests that only by new statutory provisions will it be possible to place matters in connection with the organisation of the High Command on a satisfactory basis.

La vérité sur la défense de Namur en 1914. M. Jean Fleurier contributed a series of articles to the *Revue* a few months ago (October, 1923, to July, 1925) entitled *Une legende. La faillite de la fortification permanente pendant la grande guerre;* notices relating to them duly appeared in the *R.E. Journal.* The views expressed by M. Fleurier in his articles are not acceptable to a large number of officers of the Belgian Army, and, in consequence, Colonel Merzbach of the Belgian General Staff, has sent a contribution to the *Revue* challenging some of M. Fleurier's statements and deductions. The Editors of the *Revue* find Colonel Merzbach's contribution too long for publication *in extenso*; however, the final chapter, which deals particularly with M. Fleurier's deductions in relation to the defence of Namur, is reproduced in Nos. 7 to 9 inclusive now under notice. The subject is necessarily controversial, but the treatment of it by Colonel Merzbach is distinctly temperate, and will, no doubt, prove of considerable interest to the rising generation of Sappers.

Un probléme actuel. L'aviation de chasse. In the original article, which appears in No. 8 of the *Revue*, Lieut. E. Naef discusses aviation requirements in relation to the defence of Switzerland.

L'emploi des troupes de génie dans l'armée suisse. The original article is contributed by Colonel H. Lecomte and appears in No. 9 of the *Revue*; stress is laid therein on the fact that the rôle and activities of engineer field companies are matters which to some extent must depend on the organisation, as a whole, of the Army of which they form part. Colonel Lecomte compares the organisation of the French with that of the Swiss Army and calls attention to the following features of the former: a "section de pionniers" permanently forms part of every infantry regiment; a French division, in addition to a "bataillon de sapeurs-mineurs"—consisting of two strong companies—has also allotted to it a "bataillon de pionniers" (of four companies); and further a French Army Corps and Army, in addition to a large number of companies of "sapeurs-mineurs," have each of them various specialist units. On the other hand, the Swiss infantry regiments have no pioneers, and the

Swiss division, consisting of nine infantry regiments, has allotted to it only four *small* "compagnies de sapeurs" (of three sections each) and a *small* "compagnie de pontonniers"—about 130 men and 50 drivers. Colonel Lecomte is clearly of opinion that the provision made for the engineer arm in the Swiss Army is wholly inadequate, and puts forward suggestions as to engineer units which should form part of the Swiss Army.

Procédés de stratégie défensive. The original article, which appears in No. 10 of the *Revue*, is a translation of a contribution by Colonel Paul Knapp, entitled *Gedanken zu den Artikeln des Herrn Obersten von Diesbach*, published in the number of the *Allgemeine Schweizerische Militarzeitung* for September 1926; comments are made therein on certain views put forward by Colonel de Diesbach in relation to the defence of the Swiss frontier. Colonel Knapp's contribution has led to some correspondence, which is published under the title, *Au sujet des procédés de stratégie défensive*, in No. 12 of the *Revue*.

Notes fragmentaires sur la nouvelle organisation militaire Italienne. In the original article, published in No. 12 of the *Revue*, Major Moccetti describes very briefly the new organisation recently adopted in the Italian Army. The organisation is based on two fundamental conditions, viz., (a) 18 months "Colour Service," and (b) a Budget provision for 225,000 men. The main features of the new organisation consist in the creation of a so-called "ternary" division and of a new type of infantry battalion —details relating to this formation and this unit are not yet available. Broadly, the new type of infantry battalion will consist of three companies with light machine-guns and one company with heavy machine-guns. The reorganised Italian Army will contain 28 "dernary" divisions, which will be grouped in 10 Army Corps, consisting of from two to four divisions. The old territorial infantry brigades are to be abolished, and in future the three infantry regiments of the division will form a brigade; these brigades will bear consecutive numbers throughout the Army. The regiments of "bersaglieri" are to be retained, but will, it is believed, be converted into cyclist units; together with certain cavalry regiments and mechanised batteries of artillery to be grouped with them, they will be converted into very mobile detachments, which are to be known as "corpi celeri."

W.A.J.O'M.

MILITARWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*January and February*, 1927).—*A Fight for a Crater*, by Capt. Weisz, Czechoslovakian Army, formerly commanding the 1/9th Coy. of Sappers, Austrian Army.

On the 8th June, 1917, during a thunderstorm, an Italian mine was fired on Monte Zebio, N. of Asiago, and removed nearly forty yards of the Austrian front line, making a crater twenty-five feet deep. As no infantry assault followed, the explosion was taken to be accidental—an assumption confirmed later by the statements of prisoners. The 1/9th Sapper Company started that evening to incorporate the outer edge of

the crater in the front line, thus creating a slight salient where there had previously been a slight re-entrant.

The work, which was interrupted throughout the night by the Italian artillery, but at such regular intervals as to afford a minimum of disturbance to working parties having dug-outs handy, was completed by 5 a.m., and the front wired. A quarter of an hour later the Italians started a bombardment of the crater, which lasted eleven hours. At dawn next day they assaulted and captured it, subsequently consolidating the outer edge and running wire across the middle. Since the crater had formed a part of the Austrian front line, from which the latter could be rolled up right and left, re-capture was essential. One of the Austrian mining galleries leading under the crater was cleared of débris, and it was decided to utilise it for placing and firing a mine. Before this could be done, however, an infantry relief took place, and the new commander decided to recapture the crater without using the mine. This was done on the night of June 16th, after which, in spite of an Italian attack, preceded by twenty-six hours of drum-fire, the crater remained in Austrian possession.

The Artillery Revolt in Spain, by Gen. v. Mierka. The revolt of the artillery officers was due to the introduction of promotion by selection instead of by seniority. Those of the officers who were serving in Spain saw themselves as likely to be passed over by those who had had opportunities of distinction through service in Morocco. The Spanish Government immediately dissolved the corps of artillery officers—to the number of 1,817—stopped their pay, forbade them to wear uniform, and ordered the troops to carry on without them. The N.C.O's and men came out of this difficult position with great credit. The officers then gave in, and six weeks later were reinstated by Royal Decree, always excepting 150 of them who had been court-martialled and cashiered, and any who had not made formal application for reinstatement.

International Review of 1926. Lieut.-Col. Paschek reviews the chief events affecting international relations in all the more important countries. Among the latter he devotes the greatest space to Great Britain, mentioning the General Strike and the Coal Strike, the improvement in Indian internal affairs owing to the disappearance of Gandhi and the Caliphate, the improved relations in Egypt, and the successful termination of the quarrel with Turkey over the oil territory of Mosul, the agreement with Italy about Abyssinia and the understanding with Ibn Saud. He adds that the haste with which Great Britain is completing and securing the Cape to Cairo route should make it clear to Germans that there is no intention of parting with " the pearl of Germany's colonial possessions," East Africa.

He sums up in general :—1926 has not materially advanced towards a solution of any of the European or of the world questions of international politics. In spite of the settlement of Locarno, the so-called peace treaties continue to oppress. Europe, which is without peace, has found its latest peace-disturber in Mussolini. In the matter of disarmament on land and in the air every country that is free does no more than it wishes to do. It is to be hoped that the League of Nations, now that Germany has acceded to it, will achieve statutory purposeful work; but, without the United States and Russia it will hardly arrive at putting Europe

in order, let alone approaching the problems of Bolshevism and of the Yellow Race. Finally, nearly every important question, either in the League of Nations or outside it, soon expands to an affair of the world-politics of the Great Powers of special economic importance, *e.g.*, the necessity for emigration, the provision of raw materials, the supply of oil. Above all these stands the question of Germany's need. 1926 has furnished further proof that the world, too, has a need, *viz.*, that of a united, strong Germany.

General Falkenhayn's Campaign in Palestine, 1917-18. The Turkish History now discloses why the Germans, and especially Falkenhayn himself, have kept silence about the failure of this campaign. When in August General Allenby's reinforcements made a British offensive probable, the 8th Turkish Army, under Gen. Kress, was holding a position fifty km. long, from the sea coast near Gaza to the desert of Beer-Sheba. Gen. Kress's idea of holding the position was to oppose the British advance by the tactics, familiar to the Turks, of manœuvring in open country and covering his relatively weak front S. of Gaza by means of mobile flank groups. Falkenhayn on taking over changed all this. Instead of the mobile defence preferred by the Turks, he decided, from a lack of confidence in the Turks, and in order to have them more firmly under control, upon a pure defence of fixed localities. This decision was fatal, since the position was too extended for such treatment, and the necessary communications and supply arrangements were lacking for a counter-stroke. Thus, when on October 31st the British outflanking movement at Beer-sheba overwhelmed the Turkish Division there, another division which was due to reinforce it had not yet arrived, and it had no communication with A.H.Q., fifty km. away at Hebron.

The figures given for the forces engaged are :—Turks, 29,000 foot, 1,000 horse, 206 guns ; British, 56,000 foot, 20,000 horse, 550 guns.

F.A.I.

HEERESTECHNIK.

(*September*, 1926).—*The Effect of Tyring on the Wear of Roads.* Extracts from the Russian periodical *Army and Technics.* Professor Becker, from practical trials, places the wear on roads by motor vehicles according to their types as follows :—

Pneumatic : Air-cushion : Hard :: 1 : 4 : 10-3.

As regards the wear due to different speeds, Professor de Guerrain has taken seismograph records of loaded lorries with pneumatic and with hard tyres, from which it appears that the same amount of shaking of the ground occurs with hard tyres at 22 km. per hour as with pneumatic tyres at 40 km. per hour, and that the amount of shaking of equal loads at the same speed (30 km. per hour) is :—

With pneumatic tyres : with hard tyres :: 1 : 3-5.

If in the interests of the roads speeds, are limited and speed with hard-tyred vehicles is reduced to 20 km. per hour, then for air-cushion tyres 30 km. per hour should be permitted, while for pneumatic tyres the maximum speed does less damage than hard tyres at 10 km. per hour.

The Instructions for Rapid Bridges, by Lieut.-Col. Klingbeil. Rapid bridges are defined as "light foot-bridges which can be carried by hand and quickly pushed across the water." Such bridges have hitherto been included amongst temporary bridges, but the new Bridging Manual of the German Army gives them for the first time a Part of their own. It divides them into (*a*) bank to bank bridges, (*b*) rapid bridges with solid supports, (*c*) floating rapid bridges, and (*d*) rapid bridges made out of the prepared rapid bridging equipment of the Pioneers.

Bridges under (*a*) are made of planks, beams, ladders, logs, etc., with a roadway of boards, shutters, garden fences, doors, etc. The fish-belly girder can also be used, consisting of two planks with their ends firmly bound together with hoop iron and their centres strutted apart, or a bowstring can be used by replacing one of the planks by stout wire. As regards (*b*) the supports are put in afterwards, where the bottom permits. Carts can also be used for this. (*To be concluded.*)

(*October*, 1926).—*On the retirement of Gen. von Seeckt.* "The President has approved of the resignation of the Commander-in-Chief, while most warmly appreciating and heartily thanking him for his great services in war and peace. This is not the place to speak of Gen. von Seeckt's valuable services in the Great War. Almost greater still than these was his particular task of creating, in most troubled times and under the most difficult circumstances, the present German Army. That this has become to-day, in spite of its small numbers, the most powerful factor in the life of the State, and an object of reluctant recognition on the part of Germany's former enemies, is before all and quite specially due to him.

"The Army is grateful to Gen. von Seeckt that through his foresight at least that technical equipment which was left to Germany has remained in continual development and up-to-date."

The Instructions for Rapid Bridges.—The commonest type of rapid bridge is the floating bridge, since it is independent of the depth of water and nature of bottom, provided always that the water is deep enough for the bridge to float when loaded. The gangway need not be broader than two feet. Steadiness, which is otherwise given by strutting laterally, must be provided by making the supporting rafts not less than 10 feet long. Floating rapid bridges are usually built up in bays, and it is always desirable to bring the bridge forward complete, since bringing it forward in pieces and putting it together in the water makes surprise more difficult and delays the crossing. Since bridges have to be pliable for carrying, they must be stiffened up afterwards by tightening the lashings and putting on couplings. Lashings should be provided for places where the movement of the bridge causes nails to work loose. Special measures are often necessary for bringing up a rapid bridge, with wide-spreading rafts, when woods, undergrowth or sunken roads have to be traversed. In this respect there have to be considered: a thorough preliminary reconnaissance of bank and approaches, and the design of the bridge accordingly, necessary preparation of the route, making the rafts capable of turning through 90° into the line of the bridge for carrying purposes, or the bringing up of bridge and rafts separately with arrangements for quick assembly.

When the bridge is to be pushed over the water, a pair of light poles must be put out on the further bank to give alignment. With long bridges it may be necessary to do this on both banks. The easiest way to get the bridge across is to have it pulled by men who have swum over with ropes for the purpose.

Floating rapid bridges can be made either from the equipment of the Bridging Train or from extemporised materials. From the superstructure carried by the Bridging Train comparatively solid bridges can be built: a lighter bridge, by using chesses for rafts and outriggers, and a heavier type, by using road-bearers and baulks as well as chesses. Both types should be improved by the subsequent ramming of piles into the bed of the stream and by firm anchoring to the banks. A 24-inch gangway floating bridge can be made for a river up to fifty yards broad by means of four hawsers to which chesses are tied close together. The bridge is lowered into the water alongside the bank and then swung into position.

The floating supports of rapid bridges of extemporized material may be rubber bags air-filled, water-tight tin cans, boxes wrapped in tent canvas, watertight wagon covers, small barrels up to 44 gallons, etc., etc. In the rapid bridging equipment of the Pioneers, and carried in their 1st line transport, there are rubber bags which are filled with straw (80 lbs. each) and then put together with prepared planking to form bays. Four men can put together such a bay in ten minutes.

F.A.I.

COAST ARTILLERY JOURNAL.

In the December (1926) number appears a description of the great final attack, which was being prepared by Marshal Foch to complete the discomfiture of the German Armies in November, 1918, when the Armistice intervened.

By October 3rd, the Allies had acquired an ever-increasing superiority over the Germans, and even Marshal von Hindenburg was suggesting to the Imperial Chancellor that the time had come to make an offer of immediate peace. But the War Party was stiff-necked, and tried to gain time. Meanwhile the Allied High Command realised the rapid deterioration of the German fighting forces and hastened the plans for the knock-out.

From the beginning of hostilities the German Army had utilised to their full extent the highly developed railway system in the north-east of France, not only to transport men and munitions from their own country, but especially to effect very quick re-grouping of forces in accordance with strategical or tactical requirements. These five lines, called by the French *rocade* lines, because they ran more or less parallel with the front, permitted the easy debouchment of reserves on any point selected, and gave them an enormous superiority by the facility for rapid movement.

Though the German line had been considerably shortened by the retirement, they had lost the use of three out of these five railway lines.

On October 14th they had 164 divisions north of Montmédy, and only 23 between that place and the Swiss frontier.

And it was particularly behind this southern sector that their lateral communications were most restricted.

By 19th October the entire coast of Flanders was liberated from the yoke of the invader, so that the energies of the Allied Generalissimo could be turned fully to his "crowning mercy." Strict orders were given that the whole organisation of the assault was to be carried out with the utmost secrecy. Its aim was to assure entry to the open country north of Chateau-Salins and the Forest of Bride and Koeking, which lies 45 kms. east of Pont-à-Mousson.

The attack was to be pressed by twenty French infantry divisions, supported by the Second American Army, which was to move forward towards Metz and secure the French left flank.

But by October 20th there were only thirty-two German divisions east of the Meuse, and in order to take advantage of this grouping, which reduced the expected opposition to a minimum, the advance was ordered for a date as near the 15th November as possible. The operations were to envisage a break-through by the VIIIth and Xth French Armies between Nomeny and Parroy, 30 km. east of Nancy, and the immediate exploitation of success by both these forces to the N.E., so as to cut communications behind the main groups of the German Armies, by aiming at far distant objectives, including Sarreguemines. The attacking corps were instructed to "push straight to their objective. Surprise, manœuvre and vigour will constitute by themselves their best security and will assure success."

The greatest stress was laid upon secrecy of preparation, and it was forbidden to use telephones till zero day. As the Anglo-French attacks had now placed Valenciennes, Guise and Landrècies in the hands of the Allies, Marshal Foch directed that the great surprise blow should be hurried forward.

But by that time German representatives had been instructed to meet the Marshal, so that it fell out that on November 9th, when the Germans were informed of the terms of peace, final orders had already been given for the French attack to be delivered on the 14th. Though German G.H.Q. had more than an inkling of the contemplated blow, it was yet ignorant of the sector in which it was to fall, and was engaged in moving back from the Lorraine front, which was held by only six divisions, three of which were Landwehr, while the last reserves had fallen to only 17 divisions for the whole front, so that the result would never have been in doubt. Besides which, by Nov. 9th, they had lost three of their *rocade* lines and only retained the one via Sarreguemines, Namur, Brussels, and the other via Sarreguemines, Strasburg, Mulhouse. The immense importance of Sarreguemines is thus demonstrated.

The exploitation would have threatened the lines of retreat of the bulk of the German force, already beaten several times during the last few months; they would have been completely demoralised; they would have lost all hope of ultimate success and would have been in no condition to observe that strict march discipline so essential to prevent a rout. To regain the interior of their country, the six German Armies of the Imperial Crown Prince and the Crown Prince of Bavaria would have available, between Fumay and Visé, only three railways, of which the capacity was sadly depleted, since they all met at Aix-la-Chapelle. In addition to this

restriction, to avoid the salient formed by Dutch Limbourg, the two Northern Armies of the Crown Prince of Bavaria were forced to retreat in a south-easterly direction and must have jostled the lines of retreat of the remainder.

The consequent crowding would have offered targets and objectives to airmen, artillery, cavalry, and infantry commanders such as they had only dreamed of in the wildest flights of fancy and enthusiasm. It would probably have meant the capitulation in the field of the entire German Army by about the end of November, whereas, soon after that date, the skilfully-elaborated legend of the invincibility of her armies was generally accepted in Germany, and enabled them to march home under triumphal arches with all the honours of war. Only history can decide whether this wilfully misunderstood generosity was a fatal mistake on the part of the Allied and Associated Nations, or a gesture which shall lead to real peace, understanding and mutual trust.

The attack described above for the final prosecution of the war by direct means is quite distinct from the preparation of the great British Independent Air Force in the Vosges for the continuous bombing of Berlin and other principal cities of Germany, which was also to be launched at the same time, and thus provide the German Nation with a convincing, though indirect, argument for the cause of disarmament.

D.M.F.H.

CORRESPONDENCE.

WATER DIVINING.

DEAR SIR,

My friend, Mr. Huddleston, of the War Office Library, having drawn my attention to Sir Hugh Bruce-Williams's kind notice of *The Divining-Rod*, by the late Sir William Barrett and myself, and to Lieut.-Colonel Hugh Rose's article on the subject, in the March and June issues respectively of the *R.E. Journal*, may I take this opportunity, in thanking your reviewer for his impartiality and freedom from prejudice, of putting a query that some of your readers may be able to answer from first-hand knowledge of the facts.

The circumstances are these: in 1916 various stories began to circulate in the English and Dominion press of the striking dowsing achievements of a Sapper Kelly at Gallipoli. When putting together our book, after Sir William Barrett's death, I was anxious to get definite and detailed confirmation of the case, in order to put it with the other cases of dowsing successes in military connections quoted in *The Divining-Rod*. I did eventually succeed in getting a statement from one of the persons actually present at the time, namely, from Captain Fitzpatrick, who, writing from Australia in December, 1925, summed up as follows the best of his recollection of the matter:

"In reference to Sapper Kelly, the circumstances were these. November 27th, 1915, on Gallipoli, was marked by a heavy rainstorm, followed that night by a short blizzard of snow and by two days and

nights of freezing wind, 7° of frost at night. The water steamer supplying Anzac was driven upon the beach at Imbros and no water could be brought to Anzac for three days. The water ration was reduced to normally two pints per day. Actually for many it was two cups per day. The water in the distributing pipes ashore had frozen, many bursts had occurred, and the reserve ashore was fast diminishing. At the original landing, wells had been dug in different valleys, but many had gone dry or become blocked.

"After the rains, it was hoped that by sinking again water might be struck in quantity. It was for these reasons that Sapper Kelly suggested seeking suitable spots by water 'divining.' The Quartermaster, the Q.M. Sergt., Kelly, and I, during poor visibility, therefore, went down Clarke Valley at the rear of our trenches. Kelly used a freshly-stripped green twig, broken off so as to form a V shape. The sketch best shows

how he held the V. When the angle of the twig was moved it was taken as an indication of water beneath at an easily accessible depth. The area he located proved successful. At his suggestion I tried the experiment with another twig, and while blindfolded got results coinciding with his." [Capt. Fitzpatrick then proceeds to describe some dowsing experiments in New South Wales.]

I did not consider this information up to the high standard of evidence set in our book, and consequently did not include it. Nevertheless, if it could be fully authenticated, this would be a very valuable and interesting case, and it is for this reason that I write to inquire whether any reader of the *R.E. Journal* may remember the circumstances with more geological and generally evidential details than does Capt. Fitzpatrick.

Yours faithfully,

THEODORE BESTERMAN.

The EDITOR, *Royal Engineers Journal*,
CHATHAM.

To the EDITOR, *The R.E. Journal*.

DEAR SIR,—The interesting article by Lt.-Colonel Hugh Rose of Kilravock in the June number of the *Journal* has reminded me of an occasion on which the divining rod was used for the benefit of the War Office some years ago.

It was about the year 1900 that it was decided to provide barracks at Bordon for a brigade of infantry, and huts which during the South African War had been erected at Longmoor were transported bodily from thence to Bordon. A water supply had, of course, to be provided. The river Wey in its upper course formed the boundary of the W.D. land on one side. It came to my knowledge that a retired judge, who lived a mile or two lower down the stream, was getting an ample supply of water from an artesian well which he had sunk. He was accordingly approached to see whether he could and would provide the new barracks, and if so on what terms. He was quite willing, and the supply appeared to be sufficient, but the terms were thought to be unreasonable. He was told, therefore, that we would try boring for ourselves. The judge expressed a very strong opinion that this would be useless, and would not modify his demands. The geological conditions in the neighbourhood of the Camp appeared to be similar to those lower down the stream, and it was therefore decided to try boring there.

The Division Officer, R.E. at Bordon was the late Lieut.-Colonel W. S. Gordon, who, it may be remembered, was a nephew of Major-General Charles Gordon, and was transferred to the Corps from, I think, the Royal Marine Artillery, after the death of the latter at Khartum. I went to Bordon to select a suitable site for boring in consultation with Lt.-Colonel Gordon. There was a small flat meadow on the W.D. side of the stream. When I arrived there Gordon said he was a "dowser," and produced his rod. Holding this in his hand he walked up and down the meadow. At one particular spot the rod gave a strong indication of water, so we decided that the boring should go down there. I tried the rod myself, but it was a case of "nothing doing." Then I got Gordon to walk with the rod in his hands over the stream on a plank bridge there was there. Oddly enough there was no sign, though the surface of the water was only some five feet below the point of the rod. I may say that I should have had the boring put down in that field whatever had been the result of the dowsing.

Gordon got the necessary plant and started on his well. After driving through some 60 feet of impermeable clay, in which were many troublesome boulders, a water-bearing stratum was struck and the well became a gusher. It was a rather curious spectacle to see the water coming in a regular fountain out of the top of the boring pipe which was only a few yards from the bank of the small river. Arrangements were made to raise the water to the higher level of the camp by means of an air-lift.

I was transferred from the Aldershot Command before the barracks were occupied, and consequently never saw the scheme in operation. In reply to an enquiry which I have just made I am informed that "the original well still serves the whole Camp area and gives an ample and unfailing yield at all seasons."

Where all this water comes from, under 60 feet of impermeable clay, is a puzzle, and whence the pressure is derived is another. Obviously it cannot be from the Wey.

By an odd coincidence there is an article on "Dowsing" in the July issue of *The Estate Magazine*, published by the Country Gentlemen's Association, giving instructions in the use of the divining rod to those

who have the faculty. The writer lays considerable stress on the necessity of a knowledge of geology, so it is evident that he does not regard the rod as an infallible guide. In this opinion I quite agree. Many years ago, whilst on furlough from India, I lived in a small village in Devonshire, built on a hill of marble. There was no water supply. I hear" that some time after I had left the local authority engaged a " dowser d to find a place for a well or wells. Several were sunk, at considerable expense, through the rock without any result, and subsequently the members of the authority were surcharged with the cost.

What follows has nothing to do with water divining, but may be of interest to anybody who has ever been quartered at Bordon Camp. I daresay the R.E., or the Railway Company, or both, have been reviled for putting the station so far from the barracks. Well, the reason was this. When it was first decided to build barracks at Bordon it was intended to quarter two brigades there, some little distance apart, and the terminus of the branch railway was located half-way between the two sites. Eventually the second brigade was dropped, but by that time the railway had been made, and there it is.

Yours faithfully,

W. PITT,

Colonel R.E. (ret.).

IMPERIAL WIRELESS.

SIR,

Isn't there a small slip on p. 274 of the June *R.E. Journal*? The author of the interesting article on Imperial Wireless says there that the vertical electric component of a wireless wave "is best intercepted by a lineal conductor placed horizontally"; and again (when he compares an ordinary overhead aerial with a frame aerial) that "They are alternative means, since each of them absorbs energy from one particular component of the wave, allowing the other to pass."

Surely those statements are incorrect. It would probably take too much of your space to enter into a detailed discussion of this question of the effects which wireless waves have on different types of aerials, but anyone who wishes to pursue the subject further will find it fairly fully discussed in textbooks such as Keen's "Direction and Position Finding by Wireless."

Yours faithfully,

F. C. CURTIS. *Lieut. R.G. of S.*

The Editor, R.E. JOURNAL.

DEAR SIR,

As regards the two statements on p. 274 of the June *R.E. Journal* to which Lieut. Curtis' letter takes exception:—

(1) It is true that a wave with its electric field strictly vertical and its magnetic field horizontal would have no effect on a horizontal conductor; but, owing to the earth's imperfect conductivity, and to other causes, the fields get slightly tilted in practice, and do therefore have some effect on such conductors. The E. m.f.'s thus set up are

comparatively small, but there are types of aerial (*e.g.*, Beveridge aerial) in which they are all-important.

(2) It is true that a distinction between the electric and magnetic fields of a wave is somewhat artificial, since they are really but two aspects of the same thing; but many people find it easier to think in terms of the electric field for vertical aerials and in terms of the magnetic field for frames.

Yours faithfully,

F. A. ILES.

"THE INFLUENCE OF FIELD DEFENCES IN THE GREAT WAR: WESTERN FRONT, 1914-1918."

In May last Major-General Sir Reginald Buckland addressed the following letter to the Secretary, Institution of Royal Engineers:—

MY DEAR SKEY,

Apparently it has not yet been possible to find anyone who will undertake to write the Fieldworks volume of the "Work of the R.E. in the European War, 1914-1919," and it is not difficult to imagine the difficulties that would confront anyone who had the time to undertake such a vast work.

Probably a good deal of information as regards what was done could be found in the official diaries kept by units and formations, which are now at Audit House, but to collect it would necessitate the perusal of all such documents, and a close study of those that contained useful matter, and the necessary plans, but these original documents cannot be removed from Audit House. Possibly a monumental series of plans, and various tables of men, time and material might be forthcoming, but my contention is that such a compilation would be as dry as dust, and of very little use as a guide for similar work in the future.

The volumes already published are admirable, especially those dealing with Bridging and Water Supply, and it is quite clear that an officer who had studied those volumes would be well equipped to deal with any problem of bridging or water supply that he could meet with in the next war. Each of such problems is complete in itself. If a bridge is required, some R.E. officer gets out a scheme, the bridge is made to comply with the prescribed requirements, and both the designer and the officer responsible for its erection see it used, and the thing is done with. As regards water supply, a good deal of preliminary consultation may be necessary, but in the end some R.E. officer produces a scheme, which is carried out, and the responsible officer sees the satisfactory result.

With fieldworks it is very different. It is not a matter in which the R.E. only are concerned, and whatever share they take in planning or carrying out the work, it is only rarely that an R.E. officer will see tested the work for which he is responsible. The real test of all defensive works, taken as a whole or as regards details, is whether they afford to the troops the assistance they were intended to give. By assistance I mean, not only protection from hostile fire, or the obstacle provided against charging infantry or tanks, but the facilities afforded for the delivery of fire (fire trenches and machine-gun emplacements suitably sited), and for moving supporting troops, and counter-attack. It is to be borne in mind that

troops hurriedly thrown into, or suddenly driven back on to, a system of defences with which they are not familiar, cannot be expected to make full use of what has been provided for them. In such circumstances even a well-designed and well-carried-out scheme of defences may fail to be of use, but is not necessarily to be condemned.

One argument against writing any history of the field defences executed during the Great War is that the new manuals on the subject are the result of the experience gained during the four years that the war lasted, and contain all that is necessary for future guidance. The information circulated from time to time by the E. in C. was, during the war, of the greatest value, and no doubt the present manuals are largely based on his circulars and pamphlets, and it seems to me that the funds of the Institution would be ill-spent on going over, as a matter of history, the various stages through which the authorised procedure of the present day has been evolved.

Field defences are always part of a tactical problem, and the human element is really the predominant factor therein. Would it not be a matter of great historical interest, and extremely useful in the future as showing how the principles and details of defensive works were actually applied in war, if we could collect a large number of instances of what happened in connection with them on the field of battle? Instances of failure would be quite as instructive as those of successful resistance, but in all cases the causes of success or failure, as far as they were affected by field fortification, are what we want to get at.

If the Publications Committee could see their way to the compilation of such a volume, many of our officers would be able to contribute their own experiences, and second-hand information, i.e., what they have been told by officers on the spot, would be almost equally useful. Possibly by giving some publicity to the undertaking, such as notices in the leading newspapers, officers of other branches could be encouraged to send their experiences. Maps or plans need not be perfectly accurate, provided that they illustrate clearly the narrative, but it is possible that in many cases originals could be turned up at Audit House, if officers could say in what diary they were recorded, and approximately on what date.

The field before us is extensive, and I can put forward here only a few suggestions as to where useful examples might be discovered.

1. The retreat from Mons and the first Battle of Ypres.
   Instances of a fire trench, or small post or defended locality, which held out, or proved indefensible.
2. Trench warfare.
   Why a certain portion of the line suffered from frequent raids, or was always able to defeat them easily. Examples of good and bad assault trenches.
3. M.G. emplacements.
   Examples of well-sited emplacements, the fire from which produced good effect, or emplacements which were easily knocked out.
4. Tanks.
   Examples of apparently small obstacles which defeated them, or of elaborate ones which failed to do so.

5. Battery positions.
   Instances in which protection afforded proved particularly efficacious, or in which badly designed or badly executed protection failed.
6. Camouflage.
   Examples of good and bad work.
7. Defensive lines.
   Instances in which the general lay out proved to be good, or where it contributed to failure.
8. Communications.
   Instances of a well-thought-out system which produced good results.
9. Counter attack.
   An example of a prepared field for counter attack, which repaid the labour expended on it, giving details of the work done.
10. Attack.
   Examples of work done on captured positions, which successfully resisted counter-attack, or failed to do so.

The above are merely suggestions, but what we want to get at in each case are the causes of success or failure.

I should be much obliged if you would lay this letter before the Publications Committee.

Yours sincerely,
R. U. H. BUCKLAND.

The scheme proposed by Major-General Sir Reginald U. H. Buckland was unanimously recommended by the Publications Committee, and the Council of the Institution of R.E., at their meeting on the 26th July, 1927, approved of the scheme and voted funds to cover the cost of the undertaking. General Buckland was asked to undertake the compilation of such a volume, and has consented to do so, provided that it meets with the support of the officers of the Corps.

It is obvious that without generous support such a scheme could not be carried out: what is wanted is a compendium of the practical experience in Field Defences of all officers who served on the Western Front. Polished literary productions are not necessary: any officer can write a bald narrative, with plans or sketches, and free criticism is invited. Any suggestion as to sources from which information might be acquired will be welcome. It is possible that there may exist in Regimental Histories or other published books on the war, passages which contain suitable material, and references to such would be most useful.

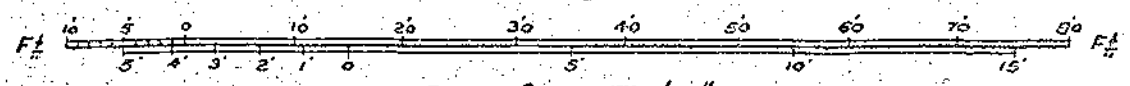
It is hoped that officers will give the above letter their careful consideration, and do all that they can to make the volume a success.

All communications should be sent to Major-General Sir Reginald U. H. Buckland, K.C.M.G., C.B., at The Locks, Hurstpierpoint, Sussex.

F. E. G. Skey,
Col. (ret.),
Secretary, Institution of Royal Engineers.

DESIGN OF BRIDGES
ON GRAND TRUNK ROAD

Scale for Fig: I & II. 16=1



Scale for Fig: III. 4=1"

Fig: I

PLAN

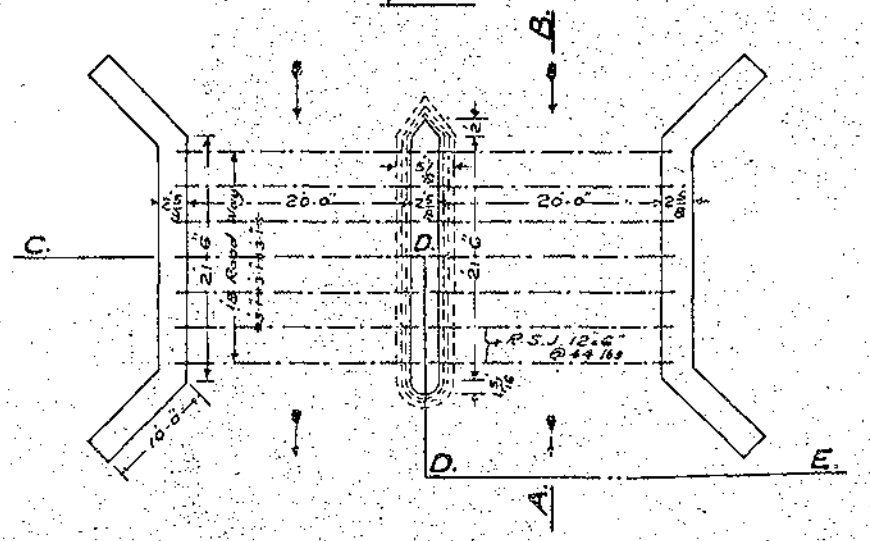


Fig: II

SECTION & ELEVATION ON LINE C.D.E.

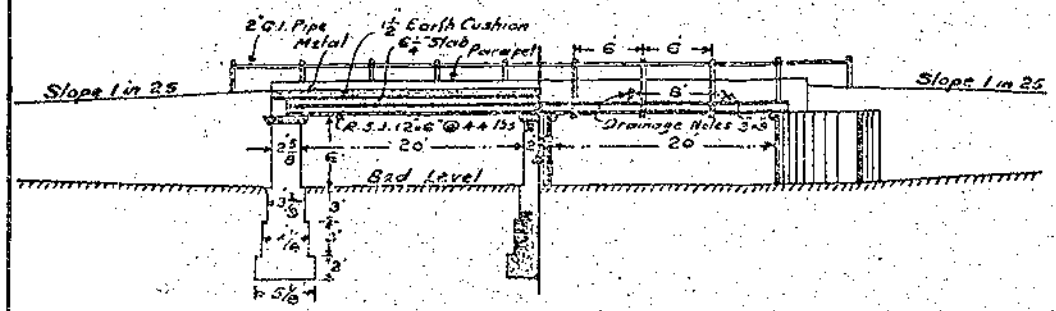
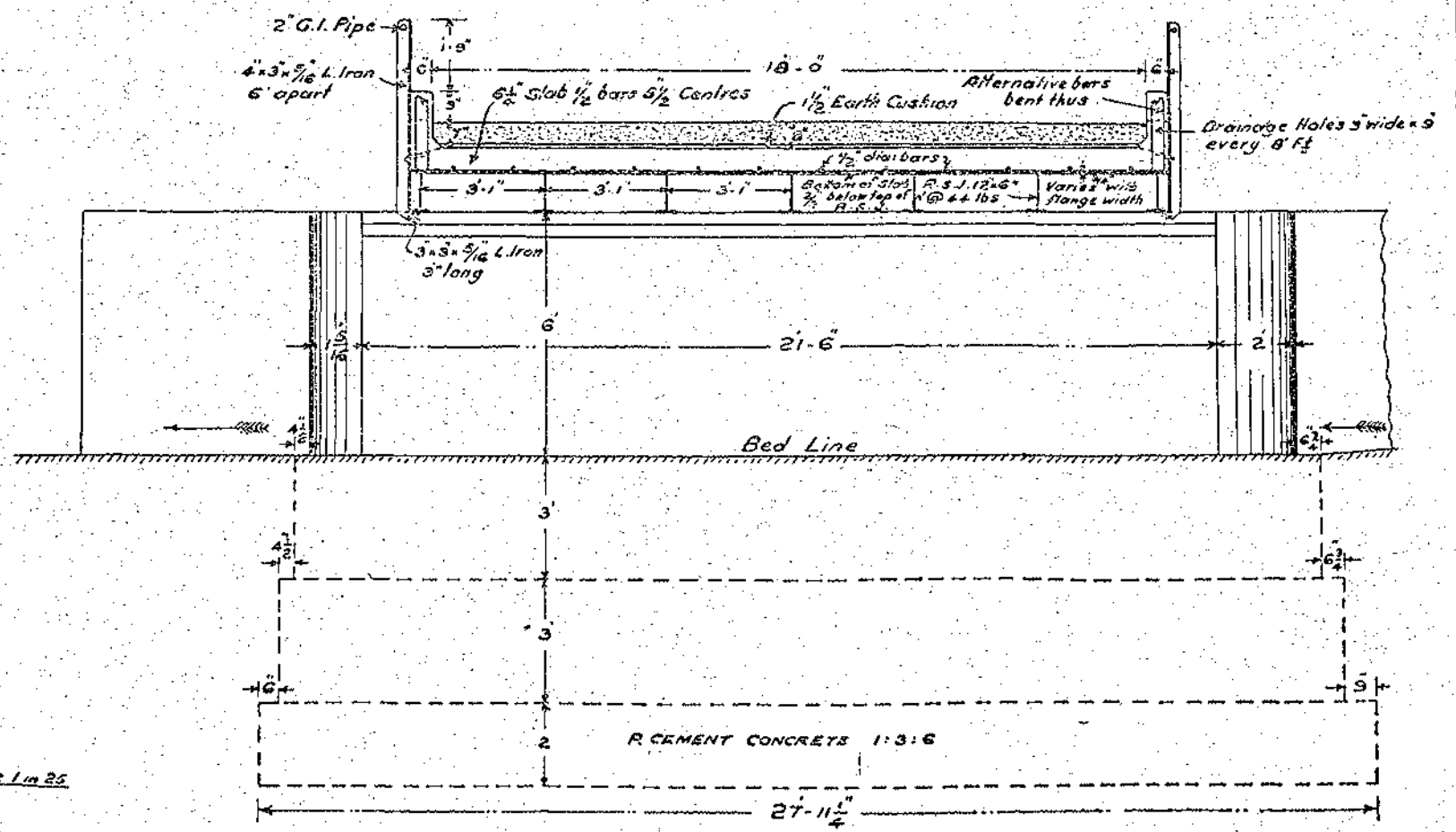


Fig: III

SECTION ON LINE A. B.



this country, before they got a decent foundation. This was soon settled however, as we ordered up a Merryweather steam pump which subsequently proved invaluable on the job.

Having spent about three hours on the bridges, we ate our sandwiches and went along to the rendezvous for shooting.

SHOOTING.

12.00 noon.—A Pathan shooting party is inclined to be a somewhat dangerous amusement. When we arrived at the appointed place a large concourse of people awaited us. There were one double-barrel hammer gun, three single-barrel guns, two country-made rifles, three revolvers and one flintlock gun (*circa* 1870). I think all these weapons were loaded and carried at full cock with no regard to the direction in which the muzzles pointed. I suggested that, as we hadn't much time, we should move off at once and asked them to show the way. This they did and we so managed it that the majority at any rate of the firing party were in front of us. We were then told that *seesi* were plentiful and that we might expect a covey to get up at any moment. Our hosts suggested a drive, but I vetoed this out of sheer terror. As the scheme was to drive towards me in a semi-circle, I really did not relish the prospect. If a covey got up at close quarters I would have had a poor chance of escape. So we spread out and walked up the birds in a line.

Seesi are a perfectly maddening kind of bird. They are like small partridges, but they can run like hares and invariably do so. It is very hard to put them on the wing. The Pathans shoot them at sight on the ground. Another method of attack is to mark a covey in a bush, stalk the bush and brown it. The Pathans can get quite a number of birds in this fashion. Even when on the wing these birds are extremely difficult to hit. They fly low and fast and are exactly the same dirty brown colour as the ground, so they are hard to see. The partridges in this country give good shooting but there are not many of them. We got a few shots at them. Two of our hosts were with me when we saw a partridge running along the ground. They told me to fire, but I explained that in our country we did not fire at birds either sitting or running and that we preferred to shoot at them flying. At that moment the partridge got up and I missed him, so the laugh was against me.

After we had given the *seesi* a good dusting, we went into some low hills where there were some *chikor*. These birds are bigger than partridges and though they possess the same irritating habits as *seesi*, they are a much more sporting proposition. They generally run up hill at a very fast pace and then fly down hill at a still faster pace. We went up a deep nullah and about half-way up we saw a covey of *chikor* looking at us from some rocks above. I put my dog on to them and he went up the hill at a gallop. A good dog is most

useful for *chikor* and if the birds will lie to him some good sport can be had. It is however very hard work, as the going is very bad, the hills being covered with sharp loose stones. Between us, however, we brought the covey to book and my pointer set them stone dead after going half-a-mile and didn't put them up till I arrived somewhat out of breath. We bagged a brace. Our hosts were greatly pleased, as they had never seen a pointer working before, and could not understand it. I then had to tell them all about the dog, how he was trained and his breeding. This was rather difficult, as his breeding is not above suspicion, but he is an excellent pointer and invaluable in this country.

4.0 p.m.—We saw no more *chikor* and as it was getting late we went back to our hosts' village where we found an enormous tea laid out for us. After this welcome refreshment I suggested a shooting match, as we had half an hour to spare. I wanted to see how the fellow with the flintlock gun worked it, so I put up a mark on a bank. The preparations for firing were somewhat lengthy. The gun was loaded with buckshot which struck the bank about three feet below the mark from a range of 15 yards. There was great applause from the whole village who had turned out to see the fun. My wife then suggested that we should throw stones into the air and fire at them, it being too easy with a proper gun to hit a stationary mark on the ground. This I thought might prove dangerous, but the idea was good. I threw the first stone, taking good care to stand behind the firer. The gun went off before the stone left my hand and the charge struck the ground five feet in front of the firer. I had promised a prize to anyone who could hit the stone, so we continued. The shooting was not very good and only one man scored a hit. The tip about it is to fire when the stone is at the top of its flight. It is then momentarily stationary and quite easy to hit. The Pathans did not cotton to this, and, as it was beyond my powers to explain it in the language and as it cost me less if they missed, I didn't put them wise to it. After this entertainment and having distributed the prizes we took our leave. It is not necessary to give a detail of the prizes, but it is worth noting that we brought no cartridges home with us. The complete bag was piled into our car. It was 12 *seesi*, 4 partridges, 2 *chikor* and 1 hare.

5.50 p.m.—It was dark when we left and we received a very pressing invitation to come again soon. It was explained that next time we would be provided with horses. Our hosts would also collect greyhounds and the usual firearms. We were to bring our own dogs and our own guns. The quarry would be deer, which come down from tribal territory, jackal or any living animal found. I think the idea is that if there is any chance of the deer, etc, escaping from the greyhounds and pointer, they would be taken on with

the rifles, guns, revolvers, etc. This is a form of sport which I have yet to sample. On the face of it, it does not sound particularly safe. We, being mounted, would presumably be between the deer and the rifles, the owners of which follow on foot.

6.30 p.m.—We arrived at 6.30 p.m. to find that my *Munshi*, who is trying to teach me Pushtu under great difficulties, had been waiting for half an hour. It is however very necessary for one's work to learn the language, and a knowledge of it adds immensely to one's pleasure both out shooting and on duty. It is also most useful if one gets into difficulties out hunting. It makes a considerable difference when dealing with contractors if one can understand their troubles and answer their questions without having to refer to a subordinate. It is also possible to get at the truth much more quickly and thereby forestall frivolous claims.

During the two days described above a good deal of work was got through and some very good sport enjoyed. The distance travelled in all was over 200 miles, of which about 25 miles were done on horseback and 20 on foot. Naturally one cannot afford the time to go out shooting and hunting every day, and it would be untrue to say that one is not very busy indeed with one's ordinary work in the M.E.S. The great charm of R.E. work in the North-West Frontier Province lies, however, in the great variety of work to be done, its interest and the fact that you have men to deal with. If one makes the most of the opportunities for sport which are offered, one can have an extraordinarily good time in Peshawar.

PROFESSIONAL NOTE.

INSTRUCTIONS FOR CLEANING PUBLIC STATUES.

THE following instructions have been supplied by the courtesy of H.M. Office of Works:—

For Cleaning Bronze Statues and Panels.—Bronze statues standing in the open should be swilled down about twice a year with an acid solution (two quarts of water to the acid of six lemons) and carefully brushed with a stiff hog's bristle brush. The solution may have more acid added if it is found necessary, then sponge down with clean water, and when dry, and the weather is suitable, rub the statue over with a *baize cloth*. Leathers are not to be used.

It is not desired to get an even surface over every part of the statue, but to allow the statue to mellow with age. The hollows and cavities need only have loose dirt removed.

For Cleaning Bronze Statues in a Bad and Neglected Condition.—Thoroughly scrub with a stiff brush and strong soda water to remove foreign matter and atmospheric deposits as much as possible. Then thoroughly wash with clean water to remove all soda. A 10% solution of sulphuric acid and water should be applied, the solution being brushed on with one hand and sponged off with clean water with the other hand, until the desired results are obtained. A stronger solution may be used if necessary, but it should be sponged off with strong ammonia instead of water.

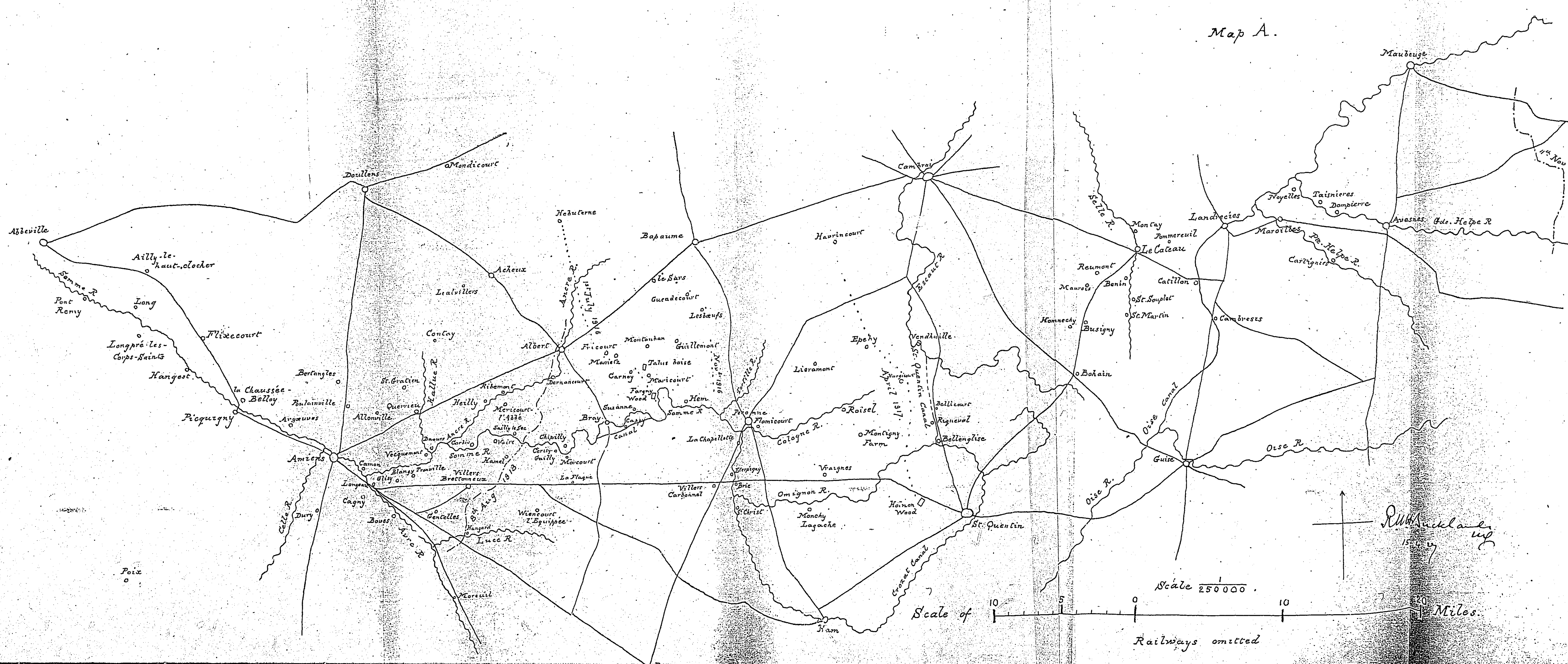
Solutions of sulphuric acid should not be used on bronze statues or panels, except under expert supervision. Such solutions are quick in action and are likely to affect the colour of the bronze and to erode it if proper precautions are not taken.

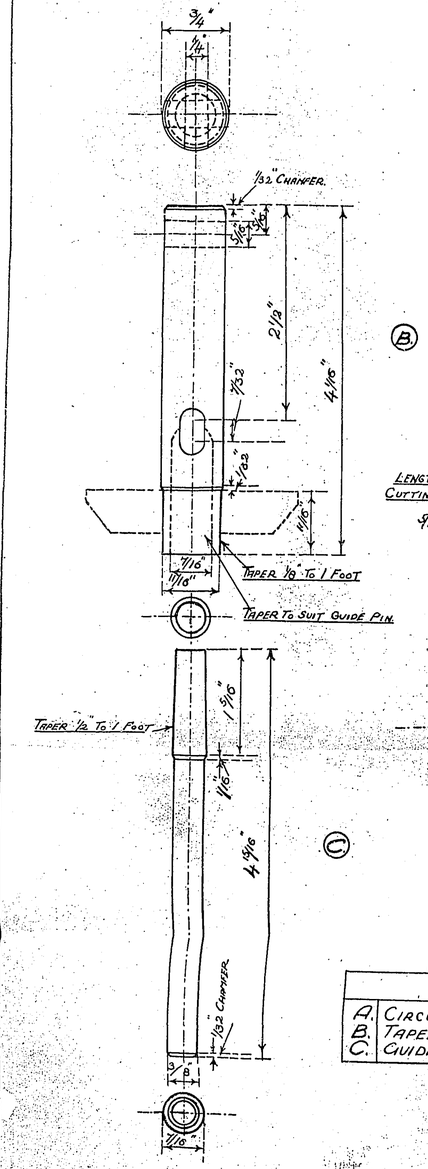
Removal of Green Discoloration from Portland Stone Pedestal under a Bronze Bust or Statue: 1. The portion of stonework under treatment to be lightly brushed, previous to being well wetted with clean water.

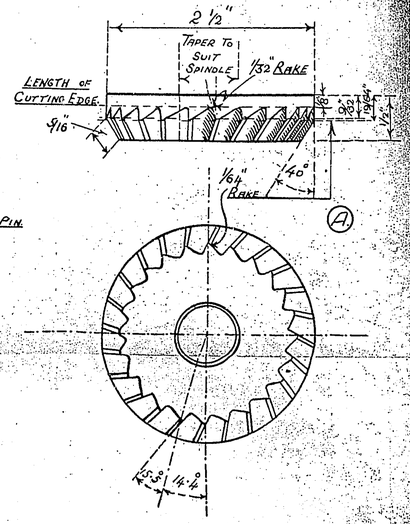
2. Whilst the stone is wet, a piece of flannel of a convenient size, saturated with ammonia (diluted to one part of ammonia to five parts water) to be applied to the surface and allowed to remain for about ten minutes.

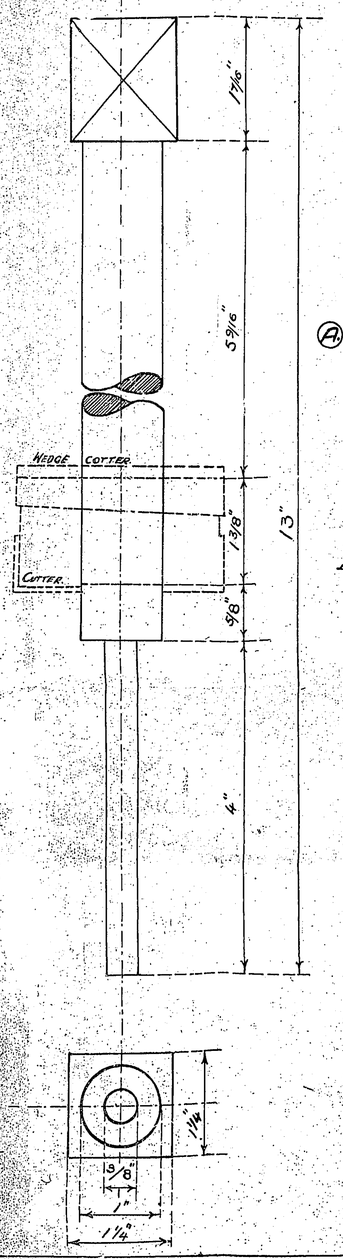
3. On removal of the flannel or pad, the stone should be washed with clean water, and the procedure repeated as frequently as considered necessary to effect the partial removal of the discoloration.

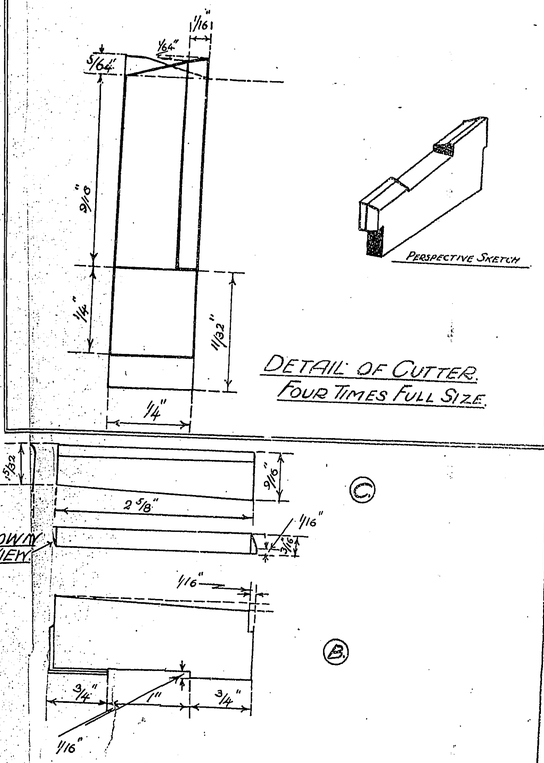
After a series of applications, an interval of twenty-four hours


Map A.
Maubeuge
Cambrai
Doullens
Mondicourt
Abbeville
Ailly-le-haut-clocher
Somme R.
Pont Remy
Long
Longpré-les-Corps-Saints
Flixecourt
Hangest
La Chaussée-Belloy
Picquigny
Hebuterne
Bapaume
Acheux
Lealvillers
Contay
Albert
Ancre R.
1st July 1916
Le Sars
Gueudecourt
Lesboeufs
Fricourt
Montauban
Guillemont
Mametz
Talus boisé
Carnoy
Maricourt
Bertangles
St. Gratien
Hallue R.
Poulainville
Querrieu
Allonville
Argoeuves
Heilly
Ribemont
Dernancourt
Méricourt-l'Abbé
Bray
Suzanne
Cappy
Hem
Somme R.
Somme Canal
Amiens
Camon
Vecquemont
Corbie
Somme R.
Hamel
Chipilly
Cerisy-Gailly
Morcourt
Blangy
Tronville
Villers Bretonneux
La Flaque
8th Aug 1918
Longueau
Glisy
Cagny
Boves
Gentelles
Hangard
Wiencourt l'Equipée
Luce R.
Avre R.
Moreuil
Celle R.
Dury
Poix
Havrincourt
Epehy
Liéramont
Péronne
Flamicourt
Cologne R.
Roisel
La Chapellette
Montigny Farm
Vraignes
Villers Carbonnel
Omignon R.
Monchy Lagache
Holnon Wood
St. Christ
Escaut R.
St. Quentin Canal
Vendhuille
April 1917
Bellicourt
Riqueval
Bellenglise
St. Quentin
Crozat Canal
Ham
Selle R.
Montay
Pommereuil
Le Cateau
Reumont
Maurois
Honnechy
Busigny
Bohain
St. Souplet
St. Martin
Catillon
Cambresis
Landrecies
Noyelles
Taisnieres
Dompierre
Maroilles
Pte. Helpe R.
Cartignies
Avesnes
Gde. Helpe R.
11th Nov 1918
Oise Canal
Oise R.
Guise
Oise R.
Scale 1/250000.
Scale of Miles.
10
5
0
10
20
Railways omitted









LIST OF PARTS.			
A.	Circular Cutter.	T.S. M.S. M.S.	Temp: Straw. C. Hdd. —
B.	Taper Spindle		
C.	Guide Pin.		

LIST OF PARTS.		
Holder. Fly Cutter. Cotter.	M.S. T.S. M.S.	Temp Straw.

Report	P.E. Lorry I.C. Engine Valve Reseating Cutter & Fly Cutter.	Drg No. 393.

FIG. III.