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THE OPERATIONS OF THE 1st DIVISION ON THE BELGIAN COAST IN 1917.

By Bt. Colonel W. G. S. DOBBIE, C.M.G., D.S.O., R.E.

The General Situation.—The year 1917 was a very busy one, both for the British Army and Navy. The failure of the French attack in Champagne in the spring, and the serious effect on the French Army of that failure, imposed on the British Army the formidable task of keeping the whole of the German Forces on the Western Front so busily employed that the French Army should be given the opportunity to recover without interference from the enemy. This obligation, great as it was, was accepted and fully met, though at the cost of severe and continuous fighting from April to November. Major operations succeeded one another with startling rapidity; attack followed attack at Arras, Messines, Ypres and Cambrai, with the result that all the German Divisions were drawn into the fight one after the other, and the whole of the energies of the German higher command were directed to stopping the holes punched in their lines by the successive British attacks. The French were thus given the breathing space they needed so sorely, and were able to reorganize their armies without interference. The Italians also reaped the benefit of the British activity, since it prevented the Germans from detaching more than about six Divisions to assist the Austrians in their attack on the Italians in the autumn. If the number of German Divisions in Italy had been doubled, it is not pleasant to contemplate what would have been the result on the course of the war.

The Naval Situation.—The British Navy, meanwhile, was also faced with a very difficult task. The German submarine campaign was becoming more and more difficult to deal with, and was taking a continuous and ever-increasing toll of the shipping on which we depended for our supplies of food and the sinews of war. Our ships were being sunk considerably faster than we could build, and it was only a matter of time before a situation of the utmost gravity would arise.

The German submarines were greatly helped in their operations by the proximity of their bases on the Belgian coast, and it was the opinion of the British Admiralty that the situation could not be materially eased until these bases were neutralized.

The Problem Stated.—This result could be achieved by operations either from the sea, the air, or the land. As regards an attack

from the sea, the strength of the German Coastal Batteries made this operation hazardous in the extreme. The whole of the Belgian coast in enemy occupation was protected by guns of the largest calibre, and in great numbers, covered by the strongest and most up-to-date defences, and the shooting of these guns, as our ships knew to their cost, was unpleasantly accurate and effective. An attack from the sea, therefore, was not an operation to be lightly undertaken. An attack from the air was also not likely to achieve the success desired. The German anti-aircraft defences were extraordinarily complete, and most efficiently organized, and in the nature of things no *decisive* result could be obtained from any air operations which were at that time possible. It was therefore decided that an attempt should be made to approach these bases from the land side, and this provided a special objective for the Army.

It was considered that the desired result would be sufficiently achieved if the land forces could gain enough ground on the coast so that heavy railway guns and howitzers could be mounted within effective range of the submarine base of Zeebrugge, and thus keep it under more or less continuous fire. By this means it was anticipated that the activities of the submarines would be so much hampered that the value of the port to the enemy would be almost altogether discounted. For this reason the northern operations of the British Armies in 1917 were invested with especial importance, in that they enabled the British Army to fulfil its two functions, *i.e.*, assisting the French by occupying the attention of the Germans and assisting the British Navy by threatening Zeebrugge.

The Land Operations in 1917.—The British attacks commenced at Arras, and were continued later in the Ypres salient, the battle of Messines being in the nature of a preliminary operation to the more serious undertaking further north. One of the objects of the third battle of Ypres was the neutralization of Zeebrugge. With this end in view it was intended that the Fifth Army should push north-eastwards from Ypres in the direction of Staden, and that when that point had been reached a further movement in a N.E. direction should be carried out by the Fifth Army in conjunction with a movement on Ostend by a British Force in the coastal sector.

The Coastal Sector.—Up to the beginning of June, 1917, the Coastal Sector had been held by a French Corps, with the Belgian Army on its right, but in order to prepare for the operation above outlined it was necessary for British Troops to relieve the French on the coast. This was done by the dispatch of the XV British Corps (1st and 32nd Divisions), which relieved the French in the latter half of June, the French being withdrawn to the French zone proper. The 1st Division occupied the sector on the coast, and the 32nd Division the sector on its right which included the town of Nieuport.

The situation in the 1st Division sector at the time was roughly

as follows. The line ran some 600 yds. or 800 yds. east of the River Yser, which was an extremely formidable obstacle, swift-flowing, deep, wide and tidal. When the British relieved the French there were only three floating bridges in the 1st Division sector, and these three bridges were close together near the mouth of the river. No preparations had been made to throw any other bridges, and the insecurity of the two battalions occupying the defences east of the river was obvious. During the period of the French occupation a policy of "live and let live" had apparently been in force, and although the British were assured that the sector was delightfully quiet, it was obvious that our existence east of the river for the moment depended on sufferance. The defences east of the river also were quite unable to withstand a bombardment even of moderate severity, and altogether the situation was far from satisfactory. However, steps were taken immediately to improve matters. Stores were collected for the construction of additional bridges which could be thrown at short notice in an emergency. Dug-outs were begun, and the defences improved generally. Raids were initiated in order to obtain identifications. Additional artillery was installed and the air defences put on a more satisfactory footing. But all this took time, and it was fully realized that until these improvements had been completed the security of our advanced positions depended to a great extent on the goodwill of the enemy, who would be sure to realize that the relief of the French by the British boded no good for him. It was, however, decided that it was necessary to accept the risk for reasons which are set forth below.

The General Plan of Advance by XV Corps.—As has been already explained, the British Troops in the coastal sector were to co-operate with the Fifth Army when the latter reached Staden. It was thought that by that time many of the German Reserves on the coast would have become involved in the fighting further south, and the advance along the coast would be thereby facilitated. This advance, in any case, was likely to be a difficult operation, as the frontage on which the advance could be made was extremely narrow, and the low-lying and water-logged country on the right made manœuvre a matter of the greatest difficulty. It was, therefore, important that the bridgehead east of the Yser should be maintained, as the loss of it would render an advance infinitely more difficult, since it would involve the forcing of the passage of the river. It was, moreover, decided that the advance along the coast should be synchronized with an attack on the enemy's communications by a Division moving round the enemy's right flank and landing in rear of his landward defences. The 1st Division was selected for this operation.

The 1st Division in the Coastal Sector.—The 1st Division was put into the line in the coastal sector, presumably because no other

Division was at the moment available, and perhaps, also, in order that it might become acquainted with the lie of the land on the coast in view of its subsequent rôle. But this rôle demanded a lot of special training of various natures, and in order that it might be ready to carry out its task during the first half of August, it was decided to keep it in the line only until the 16th July, and then withdraw it and concentrate it in a special camp west of Dunkirk, where the training could be carried out without interruption. The significance of the relief of the French by the British in the coastal sector had not been lost on the Germans. It was obvious to them that it portended the initiation of some active measures on our part. It is doubtful whether they realized at this time the full significance of the change, but at any rate they very wisely decided to make our expected operations as difficult as possible by seizing the bridgehead on the right bank of the Yser. This they proceeded to do on the 10th July at a time when our improvements to the defensive system were still incomplete, and before our full allotment of heavy guns had arrived. The German guns commenced a bombardment about 9 a.m. of the area occupied by the two Battalions of the 1st Division east of the river, and of the bridges near the mouth of the river. These latter were soon destroyed, and all attempts to repair them proved fruitless. The bombardment increased in intensity until it exceeded anything the writer encountered at any other period of the war. The weak defences were destroyed, rifles, Lewis guns and Vickers guns were rendered useless by the all-pervading sand, and when, at length, the German Infantry advanced, they were able to overcome without difficulty the remaining opposition. The two Battalions concerned, the 2nd K.R.R.C. and the 2nd Northants, were almost completely destroyed—only about 100 men of the two regiments altogether escaping. The situation had to be accepted, as no counter-attack was possible with the resources available—nor, indeed, was it advisable to re-occupy the right bank of the river (even if it had been possible), as there was nothing to prevent the same thing happening again until the whole of our material resources on the coast had been very largely increased. *Photo* No. 1 shows the area occupied by the left Battalion (2nd K.R.R.C.). It was taken some days after this attack. The wreckage of the bridges can be seen in the river.

Withdrawal of the 1st Division for Special Training.—The only advantage of the whole episode was that, when the 1st Division was withdrawn from the line six days later, according to plan, the Germans no doubt connected its relief with the severe handling experienced by the two Battalions, and did not then grasp its true reason. Meanwhile, preparations had been made for the construction of a camp for the Division on the coast near Le Clipon, about six or seven miles west of Dunkirk. A large area was carefully fenced off,

a light-railway system was installed to facilitate the handling of stores, and an adequate water supply was arranged.

These preparations were completed by the 16th July, when the Division marched westwards after it had been relieved in the line by the 66th Division, and occupied the camp. It was fully realized that the success of the projected operations depended on absolute secrecy being maintained. Should the least whisper of the plan leak out, that success would be gravely jeopardized. Consequently the plan was told to no one until the Division was safely within the fenced camp. Elaborate precautions were then taken to prevent any leakage of information to the outside world. Those inside the camp had no intercourse whatever with those outside. Rations and stores were delivered to the camp through a system of "locks," whereby those who brought the stores did not meet those who received them. Special pickets were always on duty at the entrances to the camp, while the perimeter of the camp was constantly patrolled. All letters were dealt with by a special staff of censors at the base, and all leave was stopped. And last, but by no means least, it was explained to the troops that the success of the operations, to say nothing of the safety of themselves and their comrades' lives, depended on their loyal co-operation in keeping the projected operations completely secret. And one may say here that right well did they respond, indiscreet letters were amazingly scarce, and it is certain that if the secret did leak out, it was not through any of the troops detailed to take part in the operation. Inside the camp were only those who were going to accompany the expedition—all the rest, including all the horses of the Division, were outside. Units were thus to some extent split up, but in spite of all the inconvenience caused, the isolation of those within the camp was rigidly enforced. It was on account of this complete lack of transport within the camp that the system of light railway had to be installed to deal with the carriage of stores, water, rations, etc.

Space will not admit of a description of the R.E. work undertaken in connection with this camp by the 1st Divisional Engineers, under the direction of the C.R.E., Lieut.-Colonel C. Russell-Brown. Its extent and variety made it extremely interesting, and perhaps Colonel Russell-Brown may be inclined to write a description of it for the benefit of his brother officers in the Corps.

The Plan of Operation.—It is now necessary to consider the plan of operation in some detail. The task of landing a Division in rear of the enemy's landward defences was not an easy one. Many factors contributed to its difficulty. In the first place there was the enemy to be reckoned with. Ever since the early days of the war, when we had landed troops on the Belgian coast, he was nervous of his right flank. He had consequently established fixed seaward defences all along the coast and these defences were of the most

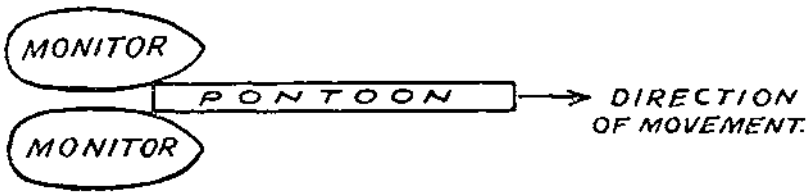
formidable character, both in quality and quantity. These fixed defences were supplemented by mobile forces to the extent of two Naval Divisions stationed permanently on the coast. Further, the air defences were, as previously mentioned, extraordinarily complete and effective. In addition to the formidable difficulties provided by the enemy, there were those which Nature provided. The coast is absolutely straight; there are no headlands and bays to afford any cover; the sea is too shallow for large vessels to approach close to the shore—there are numerous sandbanks which are continually shifting, and the contour of the shore below high-water mark frequently changes. The tides are very strong and an on-shore breeze very soon raises an ugly sea on the beach. Such were some of the difficulties, and it now remains to indicate the way in which it was intended to solve them.

The difficulties provided by the enemy must be overcome by surprise, the surprise to cover, if possible, the *fact* of the projected landing, and at all costs the actual place and time. The methods employed to ensure surprise have already been referred to, but they were to be supplemented by other methods to blind and mislead the enemy as the time drew near.

Owing to the shallowness of the sea, the only Naval vessels which could support the attack were shallow-draft monitors. These vessels, although carrying heavy guns, had little or no protection, and a very low speed. They could not hope to compete successfully with the powerful coast defence batteries with which the coast bristled. It was therefore necessary for the security of the monitors that the movement to the landing-place should take place during the hours of darkness, which should be supplemented by smoke screens, under cover of which the monitors should withdraw when their task was done. The necessity of the smoke-screen fixed another essential condition for the success of the operation. The wind had to be on-shore, but it must not be too strong, or an ugly sea would be running on the beach, making any operation there very difficult. Then came the question of how to ensure a rapid landing of the attacking troops, as, when once the attack started and the alarm had been given, speed in landing was all-important.

This problem was solved in a most ingenious manner by Admiral Bacon, who was then in command of the Dover Patrol, and with whom the military were to co-operate in the operation. He devised a structure called a pontoon—some 600 ft. long and 30 ft. wide. The draught in front was about 1 ft. 6 in., and the draught behind about 4 ft. 6 in. Three were built, and on these were to be carried all the vehicles, guns, bicycles, etc., which were to accompany the Division, while a gangway 10 ft. wide was left down the whole length of the pontoon, in which troops could be accommodated, and by which they would reach the shore. These pontoons were each

to be pushed by two monitors fastened abreast of each other against the rearward end of the pontoon, thus :—



Three of these pontoons were to be provided, together with six monitors, forming altogether three composite units, each carrying one brigade of infantry with the necessary complement of other arms.

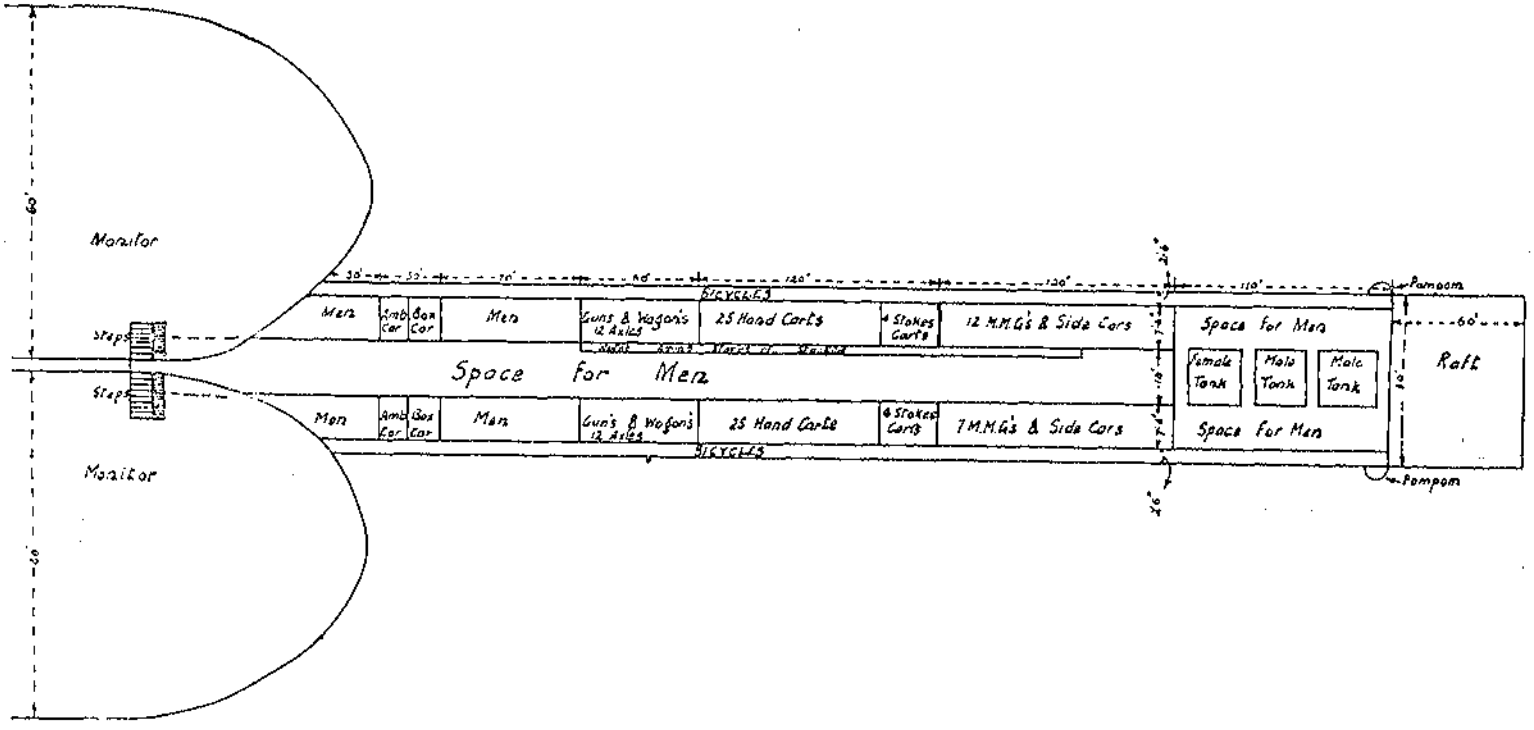
The plan then, very generally, was for these three pontoons, together with their attendant monitors, to be pushed under cover of darkness, on a suitable date, so as to reach the selected site of the landing at a suitable time; to run the pontoons ashore, and allow the attacking troops to rush ashore, overcome the defences, and establish themselves before the enemy could collect sufficient troops to stop them.

The Selection of the Landing Places.—Such was the general plan, but there were, of course, very many details which had to be thought out and arranged. It was necessary first of all to decide on the point of attack, as the detailed arrangements would naturally be somewhat affected by the points chosen for the landings. This presented a pretty problem—the further to the east that the landing was made, the greater would be the effect, in the event of success, but the greater the danger to the Division in view of its increased isolation. It was, however, important that the landing should be effected within reach of (*a*) the Raversyde Coast Batteries, and (*b*) the bulk of the landward guns covering the German line on the Yser. As regards (*a*), it was necessary to silence and destroy the German guns in the Raversyde Batteries, as, until this was done, the movements of the naval ships would be greatly hampered when once the smoke-screen was finished, and the sea, as a line of supply for the 1st Division, would be made very insecure. As regards (*b*), the destruction of these guns was necessary in the interests of the troops of the XV Corps, who were to attack along the coast. The bulk of these guns were in the neighbourhood of Westende. These various conflicting claims were taken into consideration and it was decided that one landing should take place at Middlekerke (see *Photo* 3), and the other two between that place and Westende. It was hoped that it would be possible to dispatch a flying column to deal with the Raversyde Batteries from the Middlekerke landing, and preparations were made accordingly.

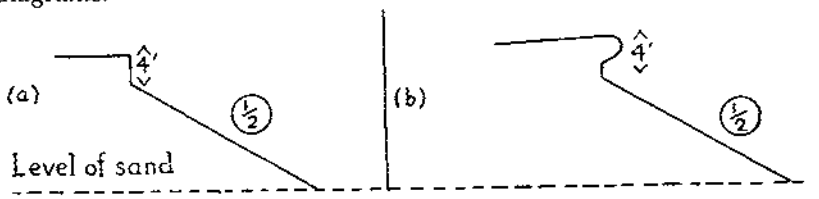
The Sea Wall.—In the area selected for the landings the coast was protected by a concrete sea wall of formidable dimensions. The

PLATE I.

(Not to Scale.)



face of the wall was set at an angle of 1 in 2, and the top of the wall was some 30 ft. or more above the level of the sand. The top portion of the wall was of two different patterns. On part of the front there was a vertical rise of about 4 ft. to the level of the esplanade beyond, and at other parts there was a large overhanging coping. The two patterns were therefore as shown in the following diagrams.



The height above the level of the sand, of course, varied in different places—and was also subject to fluctuations due to weather. In certain places the sea at high tide reached the foot of the wall, but mostly there was always a strip of sand to be negotiated before reaching the wall.

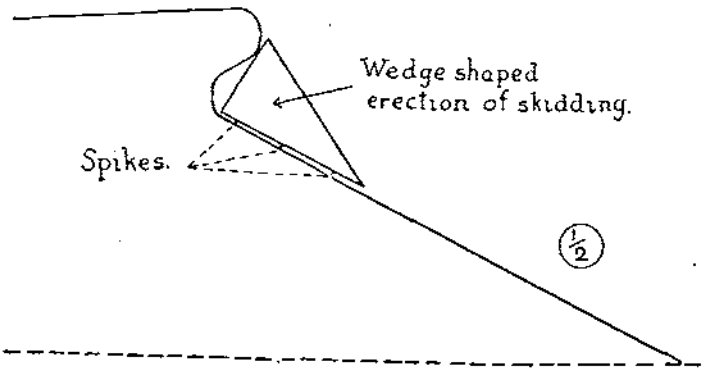
This wall constituted a serious obstacle to the assaulting infantry, tanks, guns and vehicles—all of which had to surmount it. In order to find out what could be done, full-sized models of both types of wall were made both in camp at Le Clipon and at the Central Tank Workshops. Tanks were then actually tried over the obstacle, and it was found that they could surmount the type (*a*) wall without any special preparations, but that they were stopped by type (*b*). The difficulty in this latter case was overcome in an ingenious manner. A wedge-shaped erection of strong skidding was made, designed to fit more or less into the recess under the overhanging coping of the upper part of the wall. This was carried on the end of a pole which projected in front of the nose of the tank, and could be disengaged and cast loose by the crew from within the tank. The idea was that the tank should carry this erection up the wall until it came to the coping. It would then push it into position under the coping, and after the crew had cast it loose, the tank would then climb over it and so on to the top of the wall. This was actually tried over and over again on the model wall at the Tank Central Workshops with invariable success, and this method of surmounting the coping was then embodied in the scheme of operations.

The diagram on the opposite page illustrates the method above described.

The model wall in Le Clipon Camp was used for training the assaulting infantry, who were practised daily in running up it, first without, and then with, their full loads. It was most interesting to note the way they improved in this particular exercise. At first

they were all at sea, and could barely stand on the face of the wall, let alone move upwards upon it. Before long the majority were absolutely at home upon it, and were able to move up and down the wall with the greatest freedom, even though carrying heavy loads, such as bicycles, ammunition, etc.

To assist the less agile men, or those carrying especially heavy or awkward burdens, it was arranged that some of the leading men should carry with them ropes fitted with a grapnel at one end. The grapnel was to be secured at the top of the wall and the rope left to hang down along the face of the wall and thus help those who needed it.



The question of getting the guns, etc., up the wall had still to be considered, and the difficulty was solved in the following manner. Of the three tanks detailed for each of the landings it was arranged that one should be a "female" tank, fitted with winding gear. This tank would follow the two male tanks, climb the wall, establish itself on top, and as soon as the local situation was suitable and the infantry had established themselves on shore, it would devote itself to the task of hauling the guns, etc., up the wall. For this purpose it carried a wooden ramp, up which the wheels of the guns would travel, and they would, in this way, be able to negotiate the cornice at the top of the wall.

So much for the sea wall and the problems it raised.

Composition of Landing Force.—It is now necessary to refer to the composition of the landing force. The following troops were available:—1st Division complete; 2 Cyclist Battalions; 3 Motor Machine-gun Batteries; 9 Tanks; Mechanical Vehicles as required.

In deciding on the composition of the landing force the following factors had to be considered:—

(*a*) No horses could accompany the landing force.

(*b*) The space provided by the Navy for the transport by sea of the force was strictly limited.

(*c*) The force had to be prepared to be independent of outside assistance for at least 48 hours.

In these circumstances the following decisions were taken :—

(*a*) All the infantry (including trench mortar batteries) to be taken, but without horsed transport.

(*b*) A composite artillery man-handled battery to accompany each infantry brigade—to consist of :

4 18-pdr. guns and limbers.
2 4·5 in. howitzers and limbers.
6 ammunition wagons and limbers.

(*c*) One Field Company, with 1 company Pioneer Battalion attached, but without horsed transport, to accompany each landing.

(*d*) One motor machine-gun battery to be allotted to each landing.

(*e*) Cyclists to be divided among the landings in the following strength :—

Left Landing : 1 battalion.
Centre Landing : 1 battalion (*less* 1 company).
Right Landing : 1 company.

(*f*) A small medical detachment with two motor ambulances to each landing.

These were in addition to the medical personnel with units.

(*g*) A certain number of hand-carts to be allotted to each unit, to take the place of horsed transport left behind. These were intended to carry ammunition, grenades, tools, water, reserve supplies, etc.

(*h*) Special signal arrangements to be made. These are described later on.

(*i*) Three tanks to be carried on the fore part of each pontoon, in single file—two male tanks and one female, the latter being the rearmost of the three.

Arrangements for the Landing Force on the Naval Ships.—Having settled the general composition of the force, it was then necessary to ascertain the best method of disposing it on the pontoons and monitors, with a view to getting it ashore in the quickest possible time, and without confusion. It was, of course, necessary that the leading troops should establish themselves ashore as quickly as possible, as surprise was the first condition of success. It was also important that the remaining troops and impedimenta should be landed without delay, and clear the beach, as the monitors were likely to come under heavy fire as soon as the smoke-screen was dissipated. In consequence, experiments were carried out on shore in the camp at Le Clipon to ascertain how these ends could best be achieved. Full-sized plans of the monitors were marked out on the sand, with the various obstructions on the decks indicated, such as guns, ventilators, funnels, etc. By this means the available

deck space was ascertained, and by actual trial accurate information as to the number of men which could be carried was obtained. Similarly, a model of a pontoon was marked out in camp, and packing trials for the various vehicles were practised on it, and, after much thought, the arrangement shown in *Plate* I was adopted. It was also decided that the centre gangway of the pontoon should be occupied by the troops of the two leading Battalions, arranged abreast of each other, so that as soon as the tanks had moved, the two leading Battalions could rush ashore simultaneously and extend outwards, so forming an ever-enlarging bridgehead. Practice was then given to the troops in getting ashore quickly, by actually carrying out this manœuvre over and over again from the model of the pontoon in the camp. The way in which the operation was speeded up by these practices was nothing short of marvellous. Competitions were held among the three Brigade Groups and as a result of these, the time taken to clear the pontoons and the attendant monitors was reduced to about ten minutes.

It had at one time been intended to use lorries (F.W.D.) for the haulage of guns and carrying ammunition and stores, but so much difficulty was experienced in getting these over the sand that it was decided to do without them, and to revert to man-haulage for the guns and ammunition wagons of the artillery.

Stores to be Taken by the Landing Force.—The question of what stores should be taken with the landing force was one that demanded very careful consideration. The space for stores was strictly limited, as were also the means of carrying them, *i.e.*, the hand-carts. It was therefore necessary to discard everything which was not vitally essential. Ammunition for rifles and M.G.s was, of course, the first requirement, as the Division, when landed, might have to hold its own against repeated counter-attacks without being able to replenish its stocks of ammunition. Another essential was water, a reserve of which had to be carried, as it was by no means certain that an adequate local supply would be forthcoming on shore. Tools, reserve supplies, sandbags, etc., had all to be considered and provided for. The tool question was, of course, especially important in the case of the field companies, and very careful discrimination had to be exercised as to what was to be taken and what left behind. Explosives also formed a very important item, as they would be required to deal with the Raversyde Batteries. Some water supply stores, *e.g.*, pumps, had also to be taken.

After deciding what could not be left behind, it was found that the number of available hand-carts was not sufficient to carry all that had to be taken. It was therefore decided that certain stores, such as reserve supplies, water and ammunition, which would not be required immediately on landing, should be stacked on the pontoons and dumped on the beach as soon as all the troops had disembarked.

These stacks measured about 240 ft. long by 1 ft. 6 in. wide by 4 ft. 6 in. high on each pontoon.

Information about the Landing Area.—The next necessity was to instruct the troops as to their action on landing. To this end an elaborate model of the coast was prepared in a hut specially built for the purpose in camp. In this model every house was shown, the shape and colour being reproduced as exactly as possible. The collection of the necessary information on which to construct the model was a matter of some difficulty, but the details were gathered from many different sources, and it is believed that in the end a fairly high degree of accuracy was obtained. Some information came from direct observation, powerful telescopes being mounted at points within our lines from which the coast could be seen about Middlekerke and Westende. Other information came from photographs and picture postcards taken before the German occupation; others came from air photographs taken in many an unpleasant trip by No. 34 Squadron, R.A.F., which produced oblique photographs, taken from a height of less than 100 ft., of the coast between the River Yser and Middlekerke, together with other vertical photos of the area from a greater height. These air photographs were mainly responsible for the information about the positions of the hostile batteries. The oblique photos were taken in three trips. On the first trip the aeroplane flew along the coast at full speed from our lines, and after reaching Middlekerke turned straight out to sea, and thence returned to its aerodrome. The enemy were taken completely by surprise and the aeroplane was unmolested. The next trip, necessitated by some gaps in the line of photographs, was carried out in the opposite direction, and the aeroplane approached Middlekerke from the sea and worked along the coast towards our lines. It came under a very heavy fire and was eventually brought down on the beach about two hundred yards east of the River Yser. The pilot and observer, who were unhurt, extricated themselves and ran to the river, pursued by Germans. They threw off their clothes and swam the river (though one of them had to leave his one remaining garment on some barbed wire in the river), and were then accosted and eyed with great suspicion by a British soldier, who took them off, as they were, to his Commanding Officer. They were eventually rescued.

As the model was confined to the area of the intended landings it was obviously important to guard it carefully, so that no information of this vital matter could by any possibility leak out. The hut was therefore guarded closely by sentries, who refused admission to anyone who was not provided with a special pass from Divisional Headquarters. At first only senior officers were allowed to study it, and it was decided that the men should only be shown it at the last moment, when it was intended that each section should be

brought into the hut, and its exact rôle on landing pointed out to it and explained on the model. By this means it was hoped that every man would understand clearly what was expected of him, and hesitation and confusion would be avoided.

Tactical Training of the Troops.—The training of the troops for open warfare had also to be undertaken. The vast majority of them had had no experience of anything but trench war, and a war of movement was an entirely new conception. However, they threw themselves with a will into this new form of training, and before very long a great improvement was noticeable. The task was rendered somewhat easier by the fact that the country round Le Clipon camp was very similar in its characteristics to that in which they would be called to operate. Schemes were prepared for the various Brigades and Battalions which reproduced with a fair degree of accuracy the actual tasks they would have to perform, and in this way the scope of the training was narrowed down and kept within reasonable bounds.

It has already been pointed out that it was important to destroy the Raversyde Batteries as early as possible. These were four in number and each consisted of four 6-in. naval guns and were situated between Middlekerke and Ostend. It was decided to dispatch a flying column as soon as possible after landing to deal with them. The column was to consist of a battalion of cyclists, a motor-machine-gun battery, and a detachment of a field company mounted on bicycles, all from the left column. These troops were able to rehearse in the vicinity of Le Clipon camp a very similar undertaking to that they would be required to carry out. It was intended that they should rush the batteries from the direction of Middlekerke, destroy the guns and then withdraw. The batteries were, so far as could be seen, unprotected from the landward side, and it was thought that they could be captured by a *coup de main*, provided the attempt were made without delay. The whole manœuvre was rehearsed more than once by the troops concerned on suitable ground near Le Clipon.

The method to be adopted in actually destroying the guns had to be carefully considered. It was important to keep the weight of explosive, etc., to be carried down to a minimum, and it was considered that if the guns could be rendered ineffective for a few days the object would have been achieved. Consequently, it was decided to experiment with thermite, and some captured German guns were provided by G.H.Q. in order to give the Divisional Engineers some experience of it. It was found to be sufficiently effective to justify its use; the weight required was decidedly less than that of gun-cotton; it was quick to work with, and safe in its action. It was therefore decided to use it, but to supplement it, if time permitted, with some gun-cotton in order to increase the damage done.

It will thus be seen that the amount of training, both general and special, to be undergone was very considerable.

Framing the Orders.—In addition to the training, there was also a great deal of work required in connection with the framing of the actual plan and orders, which involved many consultations with the Navy. The orders to be issued had perforce to be very detailed and it was found convenient to prepare various schedules as appendices to the general order, each schedule dealing with one particular matter or phase. In describing the plan of operations here, it will be convenient to deal with it in its five main phases, as under :—

1. Embarking the landing force.
2. The sea voyage.
3. The landing.
4. Operations of the XV Corps.
5. Exploitation.

Embarking the Landing Force.—It was decided that the embarkation should take place at the Dunkirk Docks and the Naval vessels were to rendezvous there during the night before the date fixed for embarkation. It was, of course, necessary to reduce to a minimum the period when the monitors and pontoons should be in the vicinity of Dunkirk, as their presence was likely to become known to the enemy. To reduce this danger to a minimum, arrangements were made by the Navy to camouflage the pontoons while they were lying in Dunkirk Docks. It was desirable that the loading of the pontoons and the embarkation of the troops should take place after dusk, so as to attract as little attention as possible, but in view of the fact that the whole operation, as far as the Navy was concerned, had to be completed by dawn the following morning, it was found necessary that the loading of the vehicles and stores on to the pontoons, which was a somewhat lengthy process, should take place in daylight. The troops were to embark after dusk, and the flotilla would get under way as soon as possible after the embarkation was complete. Since the troops would be very much crowded on board the ships, it would not be possible for them to have any substantial meal while on board. It was therefore necessary to give them one just before leaving camp, and the Navy agreed to serve out hot chocolate to them at some time during the voyage. This was all that could be done, beside the provision of food carried by the men on their persons.

Divisional Headquarters was to be conveyed by a small monitor (M.25) independently of the rest of the flotilla, and was timed to start some time after the other ships.

The Sea Voyage.—The voyage itself was timed to commence after dusk. The Naval arrangements, together with a list of the ships detailed to take part in the enterprise, are fully given in *The*

Dover Patrol. The monitors and pontoons were to be preceded by a number of small craft, whose duty it was to make the smoke-screen to cover the landing. In order to mislead the enemy it was intended that smoke-screens and feints by other ships should be made in the neighbourhood of Zeebrugge for some days preceding the day fixed on for the actual landing, and on that day there should be intense activity all along the coast as far as the Dutch frontier. Thus it was hoped that the enemy would be mystified, and would be kept in ignorance of the actual place of landing.

During the voyage a telephone cable was to be paid out by the M.25, so that Headquarters 1st Division might be in continuous telephonic communication with Fourth Army H.Q. near Dunkirk. Arrangements were also made for one of the monitors in each group to pay out a cable from a central point marked by a buoy, and that these cables, together with the one laid by M.25, should be brought together into a junction box and eventually taken ashore. By this means Divisional Headquarters would be in constant touch with the three Brigades by means of submarine cable, both before the landing and after it had taken place. Supplementary means of communication were provided by W/T to the three Brigades and the Fourth Army, and by pigeon to the latter. Visual signalling would also play its part as soon as the smoke-screen had dissipated.

The Landing.—The landing itself was timed to take place at dawn. It was also necessary that it should take place more or less at high tide, so that the troops should have the shortest distance to cross before reaching the wall. These two conditions naturally limited very greatly the number of suitable dates on which the landing could take place, and, as has already been pointed out, the conditions of wind and weather had to be favourable, *i.e.*, there had to be a sea-breeze in order to drive the smoke-screen forward, but not strong enough to raise a rough sea on the beach. Finally, it must be remembered that the enterprise was only to be attempted if and when 5th and 2nd Armies at Ypres had made sufficient progress and had reached Staden. It is clear that the chances of focussing all these conditions on to one date were not too great—and, as it turned out, the enterprise was never attempted, owing to the non-fulfilment of the last condition. It was, however, necessary to fix beforehand the earliest date on which the first two conditions would be fulfilled, *i.e.*, high tide about dawn, and to make all preparations for landing to be carried out on that date subject to the other conditions being favourable. As regards the weather conditions, which played such an important part in the success of the enterprise, it was, of course, impossible to count on this beforehand, although full and frequent "Meteor" forecasts were arranged for; and it is of interest to note that on none of the successive dates which were chosen as satisfying the "time and tide" condition was the weather

really favourable, though perhaps just possible on one or two dates. On the majority of the dates it was frankly impossible.

The plan for the actual process of landing was simple. The monitors, after making the cable telephonic communication with the M.25, as has already been described, were to go straight to their respective stations and push their pontoons directly towards the shore. As soon as the monitors got within a certain distance (about 300 yards) of the shore they were to open as rapid a fire as possible with all their guns, which could bear, 12-in., 6-in., 12-pdr., etc., on the houses and defences on the immediate sea front. It must be remembered that the movement of the flotilla towards the shore was to be covered by smoke along the whole length of coast-line—so that the shooting of the naval guns would perforce have to be blind. The range, however, was extremely short, the firing was absolutely point-blank, and it was confidently expected that the fire would be effective. It was, moreover, more on the moral effect of this fire than on the material effect that reliance was to be placed, and it was felt that the moral effect was bound to be tremendous. The number and weight of guns employed (four 12-in. and several 6-in. in each group) the smoke, the time of day, would all combine to this end, and it was hoped that the morale of the German machine-gunners would be seriously shaken before ever the infantry attack was launched. This naval bombardment was timed only to last a few minutes, five at most, and then the infantry and tanks were to pour ashore. The two male tanks, followed by the female tank, would climb the wall and deal with centres of resistance in an ever-widening area, while the infantry secured their footing ashore, " mopped up " and consolidated.

It must be borne in mind that every infantry section had its allotted task, and knew exactly what was expected of it, thanks to the model in Le Clipon camp.

Parties of R.E. were detailed to accompany the leading waves, in order to deal with any unexpected obstruction met with on the wall or beyond.

It was believed that the wire defences on the wall had been electrified, and the R.E., and some of the leading infantry as well, were provided with rubber-handled shears with which to cut the wire. Incidentally, it may be mentioned that arrangements were made to deal with the power-house, which was thought to have been located, by means of heavy gun-fire from the XV Corps area a day or two before the date selected for the landing.

The Pioneer Company in each landing was at first given the task of clearing the pontoons of all vehicles and stores, so that the naval units could withdraw before the smoke-screen came to an end.

The objectives given are shown in *Map* No. 2. The first objective, as will be seen, was very close, and consisted merely in gaining a

footing ashore. There was, however, to be no pause on the first objective, but the troops were to push on as rapidly as possible to the second.

The Attack of the XV Corps.—At the same time as the 1st Division landing was to take place, or rather, shortly afterwards, the XV Corps was to attack in a N.E. direction from Nieuport and Nieuport Bains. Some of the ground to be covered by this attack is shown in *Photo* No. 4. The attacks of the XV Corps and the 1st Division would naturally afford each other a great deal of mutual help. The XV Corps had a difficult task, involving the crossing of the Yser on part of their front, but the 1st Division landing, and especially the right and the centre landings, were expected to neutralize almost entirely the fire of the German batteries supporting the Yser front, since these batteries were mostly located in the area immediately affected by these landings. As a matter of fact, the Germans had but little choice in the matter of the siting of their batteries. They were practically tied up to the little strip of raised and undulating ground on the coast, as the ground inland was very flat and water-logged. This fact constituted a real weakness of the German position, and it was hoped that the 1st Division would be able to turn it to very good account, and render comparatively easy what would otherwise have been a very difficult task for the XV Corps to accomplish.

Exploitation.—The left Brigade of the 1st Division, as has already been mentioned, was to send a flying column as soon as possible after landing to deal with the Raversyde batteries between Middlekerke and Ostend, since it was necessary to silence these batteries in order to give to the naval vessels liberty of action, and thus secure the sea communications of the 1st Division.

The flying column consisted of one cyclist battalion, one motor machine-gun battery, and a detachment of R.E. on bicycles.

The R.E. carried with them thermite and gun-cotton for the purpose of putting the 6-in. coast defence guns out of action, and, as has been explained, had been practised in their use. The flying column was to return as soon as possible after completing its task, as it was considered necessary to avoid any dispersion of force, in view of possible counter-attack by superior forces of the enemy. Nor was there any reason why the flying column should stay out at Raversyde, as the batteries would be innocuous even after the column had withdrawn. This column would also be required for exploitation, which would take place in an easterly or south-easterly direction, with a view to threatening the line of retreat of the German Divisions further south. There was no intention of moving direct on Ostend, but rather of isolating it by a movement to the south of it. These were the reasons for the intended immediate withdrawal of the flying column as soon as its task had been accomplished. The withdrawal

was to be assisted by a battalion moved out from Middlekerke towards Raversyde in support of the column.

As soon as the second objective had been gained, strong patrols of cyclists with motor machine-guns were to be pushed out towards Leffinghe and Slype with a view to occupying the bridges over the canal and the various road junctions. The country was of such a nature that movement had to be very largely confined to the roads, and the occupation of the points mentioned would have important results. But the 1st Division would not be in a position to go very far afield, on account of the total absence of horsed transport. It could not, therefore, hope to do much more than gain the second objective and carry out the other tasks mentioned above, until it was joined by its transport. It was hoped that this would be possible on the first night after the landing, and it was intended to pass the transport over the Yser near its mouth and to move it along the beach to join the Division. It was not possible, of course, to count on this, and for this reason the Division had to be prepared to carry on without its transport, but it was fully realized that so long as its transport was absent its mobility would be greatly impaired, and anything like exploitation would be out of the question. It would also have very meagre artillery support—a matter of only 12 18-pdrs. and 6 4·5-in. howitzers, and for these the ammunition supply would be very strictly limited.

The replenishment of supplies by sea also could not be counted on unless the Raversyde batteries had been silenced, although the Navy did intend to attempt to run barges ashore loaded with various stores. However, in view of the importance of exploiting success without any delay and the big results that might have attended that exploitation, it was decided to make every effort for the horsed transport to rejoin the Division *via* the beach the first night after the landing. To this end arrangements were made for the horsed transport to move up to some convenient place in the neighbourhood of La Panne, and from there move forward as early as circumstances would allow to cross the Yser at Nieuport Bains.

Divisional Control of the Operations.—The question of Divisional Control of the operations was a difficult one. It will be remembered that Divisional Headquarters on the M.25 was to be connected by submarine cable with the three infantry Brigades both before landing and after it had been effected, and after Divisional Headquarters had gone ashore it would still have the communication, as the ends of the cable would also have been taken ashore. In view, however, of the great congestion likely to occur on the shore at the points of landing immediately after the landing had taken place, and of the difficulty of controlling the operations of the Division as a whole in such circumstances, it was decided by higher authority that Divisional Headquarters should not land until a firm

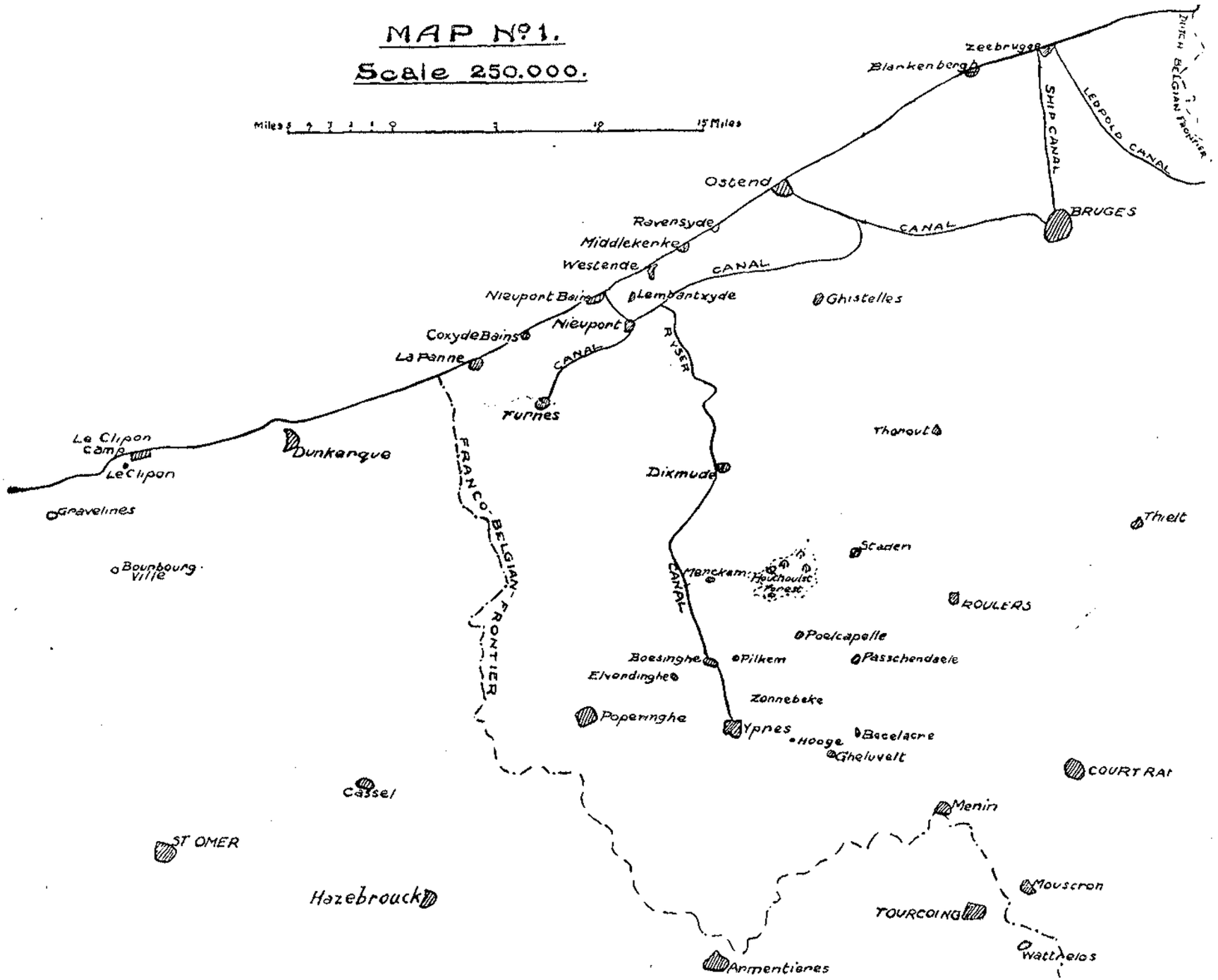
footing had been gained on the shore, and that it would then move to some point in the centre Brigade area. This decision involved a certain amount of delay, and it was calculated that the movement ashore of Division Headquarters could not take place until the supply of smoke-producing materials for the smoke-screen had been exhausted. The landing, therefore, would have to be carried out in view of the guns of the coast batteries towards Ostend, a prospect which was not relished by those concerned.

The Divisional reserve was at first to consist of one battalion of the right Brigade, and it was hoped that, as the advance of the XV Corps progressed, it would be possible to pinch out the whole of this Brigade, which would then form the Divisional Reserve.

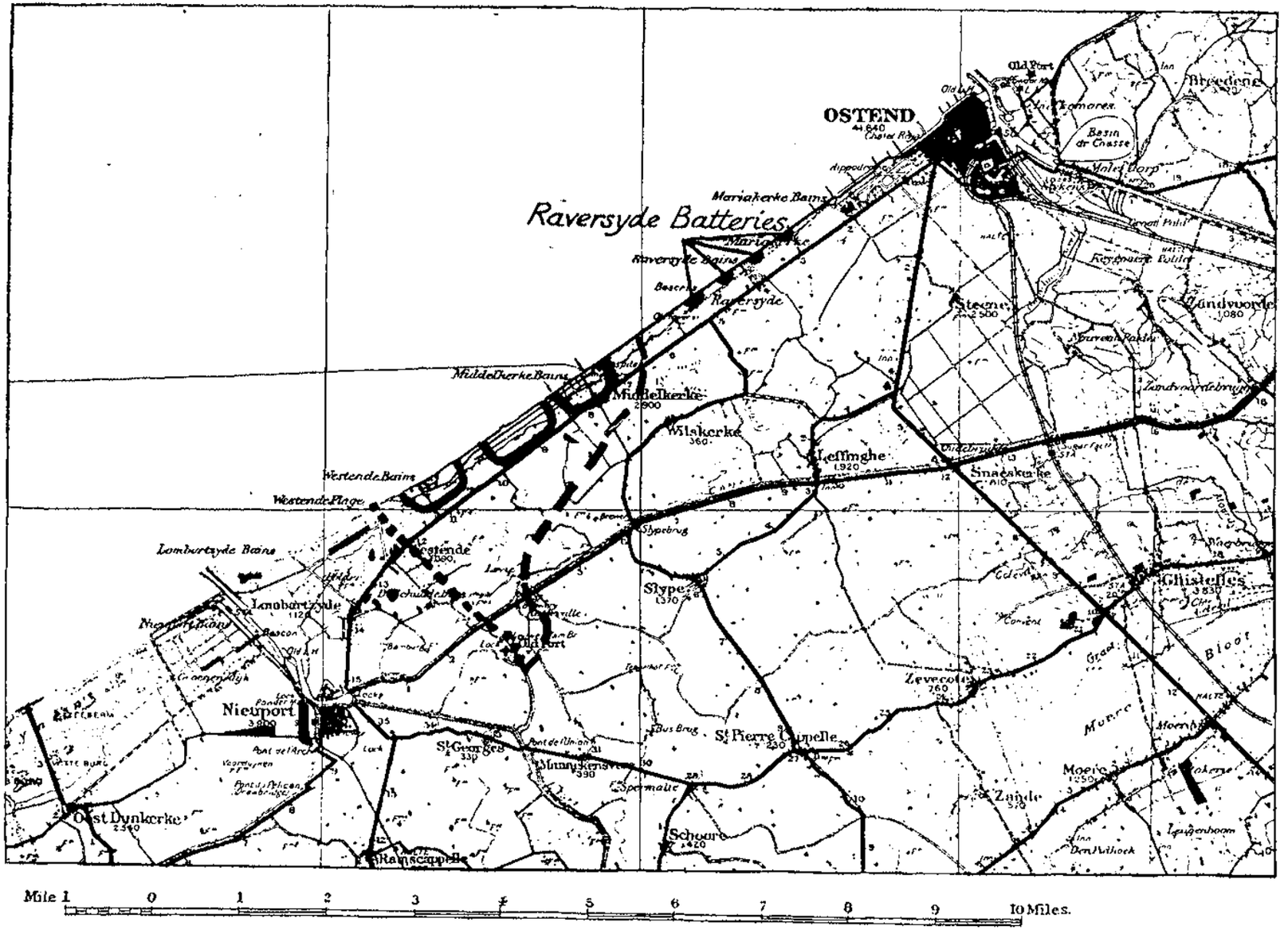
Conclusion.—Such generally was the scheme of operation and the method by which it was intended to prepare for it.

It was never put into execution, since the progress of the 2nd and 5th Armies east of Ypres was not sufficient to justify this being done. One can therefore only conjecture what would have happened had the project been carried out. It is evident that the chances of success depended very largely on the element of surprise. It was believed at the time that that surprise would have been absolute had the landing been made on the first date arranged for it. After that time the Germans were probably aware of the fact that a landing was contemplated, but remained in ignorance as to the time and place. Thus even at a late date it is probable that a local surprise would have been effected. If so, it is barely conceivable that the Division would have failed to get a good footing ashore, and, if once that was done, it was felt that it would have been able to hold what it had gained. It must be remembered that the area of possible enemy counter-attacks would have been very much restricted by the marshy ground, and that his mobile artillery would have been largely put out of action by the very fact of the landing. Further, the attack of the XV Corps would have inevitably taken up a large proportion of the energies of the German troops. For these reasons, to say nothing of the splendid fettle the men were in, the 1st Division was sanguine of success. The results of success would almost assuredly have been very far-reaching. It was not too much to hope that the diversion on the coast would have very materially assisted the operations of the 2nd and 5th Armies. Ostend would probably have fallen into our hands, and Zeebrugge would have been neutralized if not captured. Thus a large portion of Belgium would have been recovered, the naval aspect of the war entirely changed, the morale of the allies raised, and that of the enemy lowered. The effect in Germany of such a tangible result might have anticipated by fifteen months her realization of failure. But this is all surmise; the fact remains that the landing was not attempted, and the war dragged on for more than another year.

THE OPERATIONS OF THE 1ST DIVISION ON THE BELGIAN COAST IN 1917.



THE OPERATIONS OF THE 1ST DIVISION ON THE BELGIAN COAST IN 1917.—MAP No. 2.



1st Objective of 1st Div. ——————

2nd " " " " - - - - -

Objective of XV Corps. .....

THE OPERATIONS OF THE 1st DIVISION ON THE BELGAIN COAST IN 1917

Photo No. 3.—Middlekerke—the Site of the Proposed Left Landing of the 1st Division.

MIDDLEKERKE

Photo No. 4.—Looking East—showing Area of Proposed Attack of XV. Corps.

PHOTO 4

THE DHILWAN CREOSOTING PLANT

By MAJOR H. L. WOODHOUSE, M.C., R.E.

FOR many years the North-Western Railway of India depended entirely on deodar for its wooden sleeper supply. Before the war, prices were gradually rising as the demand increased and the most conveniently situated forests were worked out, but during and after the war they rose to prohibitive heights. There are many other trees growing in the Himalayas which are quite suitable for conversion into sleepers so far as their mechanical strength goes, but liability to decay, or to attack by white ants, renders them useless unless some method of treatment is applied. In 1920 it was decided to make use of these trees for sleeper supply, and the Dhilwan plant was designed to overcome their defects by creosoting them.

2. The effect of creosoting sleepers is to force creosote, either pure or mixed with some cheaper oil, into the pores. A penetration of about three-quarters of an inch into the sides is sufficient to preserve the sleepers from decay or white-ant attack till their mechanical life comes to an end, either by the rail seat failing or the spikes losing their grip. By the time such a penetration into the sides is attained, the creosote has worked up the fibres at the ends for about six inches. Penetration into sap wood is much easier than into heart wood, and into any decayed wood easier still. The creosote stops the decay, and sleepers with slight decay are not seriously injured, though any decay is, of course, objectionable. Owing to this limited penetration, spike holes should be bored before treating the sleeper, otherwise untreated wood is exposed when the boring is done. Unfortunately experience has shown that the width of the rail flange varies enough to disturb the gauge, when boring is done before treating, and experiments are still in progress to overcome this trouble. It seems probable that one rail seat only can be bored before treating, and the spike holes for the other rail seat will have to be bored after the sleeper is put in the line; in which case all that can be done is to swab the holes after boring with creosote; a partial protection, but nothing like so effective as if creosote at a high temperature and pressure had been forced into the hole while the sleeper itself was being treated.

3. Dhilwan is on the N.W.R. main line where it crosses the river Beas. The site is not ideal, but was chosen in the belief that the majority of sleepers for treatment would be floated down the river.

This expectation has not, so far, been justified. The depôt is about half a mile from Dhilwan station, on the river bank, and the level of the subsoil water is so near the surface in the flood season that there have been considerable difficulties with the underground tanks. Dhilwan station itself is only a small wayside station, hence shunting of sleeper and creosote wagons into the depôt has either to be done by train engines, causing delay to traffic, or by a special shunting engine whose cost is considerable. This trouble will be overcome when the petrol shunting engine now on order arrives. On the other hand, owing to the soil being chiefly fine river sand, there have been no difficulties as yet from white ants attacking the untreated sleepers while they are seasoning.

4. The treating plant consists of a cylinder 75 ft. long by 7 ft. 6 in. diameter. This accommodates eight trucks at a time or about 360 sleepers. Below the cylinder is a low-service tank about 70 ft. long, 8 ft. wide, and 6 ft. deep. This tank was built of brick and concrete, to which a lining of lead sheeting has been added. Both cylinder and tank have steam pipes running through them for heating purposes. They are covered by a corrugated-iron shed with brick side walls and open ends, while the space between the cylinder and the tank is filled in with wooden shutters to keep dust out of the tank. Outside the shed is an iron high service tank on iron staging about 10 ft. above the top of the low service tank. The pump and boiler house abuts the shed, with which it communicates by a door. It contains a Lancashire boiler, a water feed pump, two pressure pumps and two vacuum pumps. A control board is now being fitted, on which all the dials and gauges connected with the cylinder will be concentrated, thus making the pump-house the control centre.

5. The treating mixture of creosote and fuel oil is stored in five double tanks of brick and concrete near the cylinder shed. These are buried in the ground, and have had to be lined, in some cases, with lead sheeting, in others with iron sheeting, and in others with canvas and pitch. They are not really satisfactory, even with the linings, and steel tanks above the ground would probably have been cheaper and certainly more efficient. A siding runs alongside these tanks and the creosote or oil is run in direct from the tank wagons. An iron pipe joins the tanks to the pumps. The distance from tanks to pump is rather great and it may be found necessary to install another pump nearer the tanks to assist. The holding capacity is about 650 tons of mixture, rather more than one-and-a-half month's supply when the cylinder is working at full speed. Each tank has a nest of steam pipes, fed from an independent boiler for the row of tanks, to keep the creosote liquid in cold weather and to prevent it from depositing its heavier constituents as solids. Napthalene is received as a solid in barrels and is added to the mixture in the low

service tank. If sent up as part of the liquid creosote, it would be liable to separate out in the travelling tanks in any but the hottest weather.

6. An adzing and boring machine, made by Robinson of Rochdale, cuts the ends off sleepers over 9 ft. long, adzes, and bores them. Its capacity, sawing and adzing only, is about 1400 sleepers a day, but if boring is to be done, the output falls to about 800. Power is supplied by a portable engine and the whole plant is covered by a shed. A second machine of older pattern, which cannot trim the ends of the sleepers, is now being erected in a similar shed about 100 ft. away and on the opposite side of the trolly line. The space between is required for stacking sleepers which are too wide to go through the machine and have to be adzed by hand.

7. Near these machines a large shed is being erected in which a month's supply of sleepers will be kept. This will ensure that sleepers treated during the rains are dry—an important matter.

8. Further proposals are the installation of an incising machine to make incisions in the top and bottom of certain kinds of sleepers, particularly fir, which have difficulty in absorbing the mixture, and a saw-sharpening machine.

9. A system of 2 ft. 6 in. tramways is laid all over the depôt. They interlace with the broad-gauge fan of sidings. Two small engines are in use at present and a third is expected shortly. Ordinary four-wheel trucks are used for moving sleepers about the depôt, and special trollies with 4-in. wheels are used for running sleepers into the cylinder. These trollies have projections which engage with two bars running the length of the cylinder and hold the trollies on the rails. Otherwise, when the mixture enters the cylinder, the sleepers floating in it would lift the trollies off the line. In common with the rest of the plant, these engines burn a mixture of coal and wood blocks trimmed off the ends of the sleepers. Transhipping platforms of earth, revetted with corrugated iron are placed between each broad-gauge siding and its corresponding narrow-gauge siding. A Simplex petrol tractor for the broad gauge is being ordered for shunting in the yard and between the yard and Dhilwan station.

10. With anything up to 450,000 sleepers in the depôt, fire protection is very important. A steel 12,000-gallon high-service tank stands on a brick tower in the middle of the depôt. It is fed by two independent pumps, each driven by a Petter oil engine. The latter were installed in preference to steam-driven pumps, owing to the rapidity with which they can be set to work. In a bad fire, such as might result from incendiarism, the tank would be empty before steam could be raised to start steam pumps. A series of hydrants are dotted about the depôt, fed from the high service tank, and hoses are kept ready for immediate use. The sleepers themselves

are stacked in lots, each containing sixteen piles of 125 sleepers. Between the lots wide fire lanes are left, and piles of sand, each with four fire-buckets full of water, are distributed along the lanes. Fire drills are held at least once a fortnight, and special men are detailed for duty at night.

11. It is necessary to ensure that sleepers are thoroughly seasoned before treatment. Supply is arranged to ensure that all sleepers spend six months in the depôt before they are used. Owing to the practical cessation of deliveries between August and November, ten months' supply has to be in hand at the beginning of August. At the present time there are considerably more in stock, owing to various factors, but the surplus is being steadily worked off. In the hot weather very dry and hot winds blow at Dhilwan, which season the sleepers most effectually. Difficulties occur through the liability of fir to rot, and of *chir* to warp while seasoning.

12. At present fir and *chir* are the principal sleepers being treated. The former are rather soft, are apt to split, are rather difficult to treat, and are liable to decay while seasoning. Their spike-holding qualities are not too good, and their useful life probably not so long as *chir*. On the other hand, they are very cheap. *Chir* is more expensive, but is known to be satisfactory. Its principal defect is liability to warp while seasoning. *Kail* and *asna* are also being treated in small quantities. They are rather expensive, but are known to be very good. The difficulty of treating fir will be reduced when the incising machine is in use.

13. The sleepers are received from contractors at various stations on the N.W.R., of which Marala and Jagadhri are the principal. They are passed by sleeper-passing officers and sent by rail to Dhilwan, where they are unloaded and stacked for seasoning. They are then loaded on narrow-gauge trucks and run to the back of the adzing and boring machine. Having passed through this machine, they are loaded on cylinder trollies as they emerge, and these trollies are then pushed into the cylinder in rakes of eight. The door is closed and a vacuum created to dry out any moisture, and to open the pores of the timber. Ten to fifteen minutes later a valve is opened and mixture sucked in from the low-service tank. When no more can be sucked in the valve is closed, and more mixture run in from the high-service tank, after which still more is forced in by the pumps. All this time the mixture is kept at the requisite temperature by the steam pipes. The pressure is maintained for about half an hour, the time varying with the particular sleepers being treated. The pressure is then released, the bottom valve opened and what is left unabsorbed of the mixture allowed to run back into the low-service tank. An arrangement of valves is now being fitted which will allow of air being pumped into the top of the tank to expedite the expulsion of the mixture. When the cylinder

is empty, a vacuum is again applied for a short time to clean the sleepers of mixture hanging on the surface, or in some cases to withdraw a certain quantity from the interior if too much has been forced in. The far end of the cylinder is then opened and the rake of trucks withdrawn, and taken to one of the transhipping platforms, where the sleepers are piled and later on loaded into broad-gauge wagons to be conveyed to their destination. The amount of mixture absorbed varies with the temperature and pressure, and with the time during which the pressure is maintained. It is measured by the difference in level in the high and low pressure tanks before and after the process, after making corrections for the difference in temperatures. A further check is ensured by weighing a few marked sleepers in each load before and after the treatment.

14. The actual mixture to be used has not been settled: at present equal quantities of creosote and fuel oil are mixed. Some sleepers have been treated with a mixture of 2 creosote to 1 oil. In America experiments are being tried with 30 per cent. only of creosote. As the creosote is considerably more expensive than oil, the less creosote required, the cheaper the treatment. The whole object of treating being to give the sleepers a physical life equal to their mechanical life, any creosote used beyond that required for this life is wasted. About twelve years is the life at present expected, and to give this, 28 lbs. of mixture are pressed into fir and 24 lbs. into *chir* sleepers. The time required to press in this quantity is such that in a nine hours' day four rakes are treated, or about 1,400 sleepers.

15. As sleepers emerge from the adzing and boring machine they are branded with a letter showing their species, and a figure showing their year of treatment. After they have been treated it is impossible to say to what species they belong without cutting them up. A register is kept showing details of treatment of each batch, amount of mixture absorbed and composition of mixture, and destination to which the batch is sent. From this it will be possible to give the history of any sleeper at any time in the future. Certain experimental sleepers have a second letter added to their identification marks to facilitate their identification when in the line.

16. In addition to the creosote treatment two other methods are to be or have been tried. The first was the use of settled wood tar from the Mysore Distillery in place of creosote. This, mixed with fuel oil, gave trouble owing to the pitch in solution in the wood tar being precipitated by the fuel oil, tending to block the pipes and valves. The red lead joints of the piping also suffered, being attacked by acetic acid in the tar. The penetration into the sleepers was not so good as that of the creosote mixture, as the pitch tended to block up the pores. A second method which is to be tried shortly is Durol treatment. This is a salts treatment used in Italy and France. It has long been known that impregnating timber with

various salts is an effective means of preservation. In the past, however, no salts treatment has been able to withstand the heavy Indian rains, as the preservative has gradually been washed out of the wood. Durol is said to overcome this defect.

17. The cost of treatment with creosote and fuel oil in equal proportions averages about Rs. 2. 4. 0. per sleeper. This includes all charges, including interest and depreciation. Creosote itself costs Rs. 9. 13. 0. a cwt., f.o.r. Calcutta, and a further 14 annas a cwt. for carriage charges. Settled tar costs only Rs. 5 a cwt. but carriage charges are larger. Durol, if successful, will cost about Rs. 1. 8. 0. or thereabouts per sleeper, so far as can be judged. It is very indefinite as yet. Assuming a twelve-year life for treated sleepers, which seems reasonable, the creosoted soft wood sleeper at its present contract price works out somewhat cheaper economically than deodar. There is no reason to suppose that the difference in price between the two sorts of sleeper will be reduced, so the trial of soft wood appears to have justified itself.

NOTES ON THE EARLY YEARS OF THE ORDNANCE SURVEY.

(*Continued.*)

II. The Beginning of Accurate Surveys. 1783–1790.

Scheme for a General Survey.—In the *Philosophical Transactions* of the Royal Society for the year 1785, Roy writes an *Account of the Measurement of a Base on Hounslow Heath*, and in the introduction to this account he remarks that, if a country has not actually been surveyed, or is but little known, a state of warfare generally produces the first improvements in its geography. He goes on to say that, "on the conclusion of the peace of 1763 it came for the first time under the consideration of Government to make a general survey of the whole island at public cost. Towards the execution of this work, whereof the direction was to have been committed to my charge, the map of Scotland was to have been made subservient, by extending the great triangles quite to the North extremity of the island, and filling them in from the original map." He then points out that the American war put back this scheme. He continues, "in the course of my ordinary employments, wherein the best opportunities have offered of acquiring a thorough knowledge of the country, I have not failed to observe, at least in a general way, such situations as seemed to be the best adapted for the measurement of the bases that would be necessary for the formation of the great triangles."

After the peace of 1783 official business detained him in or near London the whole of that summer. He took the opportunity, "for my own private amusement," to measure a base about a mile-and-a-half long across the fields between "the Jew's-Harp near Marybone and Black Lane near Pancras; as a foundation for a series of triangles, . . . for determining the most remarkable steeples and other places in and about the Capital."

He was engaged in making some computations for the purpose when he learnt of an important scheme for the execution of a triangulation to connect the observatories of Greenwich and Paris. The history of this scheme deserves to be put on record in some detail, for here we have the origin of accurate mapping in the British Isles.

The Third Cassini.—The third Cassini, Cassini de Thury (1714–1784 came of a line of astronomers and geodesists. He was a genuine

enthusiast in matters geodetical, and we may picture him as having the same driving force as Gill, in later times. In the year 1783 he wrote a "Mémoire," which was transmitted to Mr. Fox by the French Ambassador, Count d'Adhémar. The British Government referred the matter to the President of the Royal Society. There is a copy of the "Mémoire" preserved by that Society, and that copy has a docket on it, "*From Ct. d'Adhémar, 7 octr. 1783*"; but the "Mémoire" was not printed in *Philosophical Transactions* until 1787. The following is the text of it :—

Cassini's Mémoire.—*Sur la jonction de Douvres à Londres. Par M. Cassini de Thury, Directeur de l'Observatoire Royal; de la Société Royale de Londres, etc.*

"Il est intéressant pour le progrès de l'astronomie que l'on connaisse exactement la différence de longitude et de latitude entre les deux plus fameux observatoires de l'Europe; et quoique les observations astronomiques faites depuis un siècle offrent un moyen assez exact pour parvenir à cette recherche, il parait cependant que l'on n'est point d'accord sur la longitude de Greenwich à onze seconds près, et sur la latitude à quinze seconds.

L'on a reconnu par les opérations trigonométriques exécutées en France, au Nord, et au Pérou, que sur l'étendue d'un degré du méridien ou de 57 mille toises, l'on se trompait à peine de dix toises, ce qui a été prouvé par des bases mesurées à l'extrémité des suites de triangles; ainsi sur la distance de Douvres à Londres, qui est de 49,800 toises ou environ, on ne pourrait se tromper de 120 toises, qui repondent à onze seconds en longitude.

M. Cassini a déjà publié, dans le livre de *La Méridienne Vérifiée*, les opérations par lesquelles l'on a déterminé la distance de Calais à la grosse tour de Douvres de 18,241 toises par un premier triangle, et de 18,243 toises par un second triangle; on aurait cette distance avec une plus grande exactitude en observant les angles conclus à Douvres, qui sont fort aigus. M. Cassini a découvert des côtes de France plusieurs objets sur les côtes d'Angleterre, qui seront visibles de la tour de Douvres; et sur cette première base on établirait une suite de quelques triangles jusqu'à Londres, dont le nombre et la grandeur dépendent de l'exposition des objets compris dans la direction de Douvres à Londres.

M. Cassini ne doute point que ce projet ne soit agréé d'un Souverain qui aime les sciences, qui, non content des découvertes du célèbre Cook, vient d'ordonner un second voyage autour du monde, et que la Société Royale ne charge un de ses membres de l'exécution; et dans le cas où ses occupations l'empêcheraient de s'y livrer, qu'elle ne permît à M. Cassini de s'en charger. L'honneur qu'elle lui a fait de l'associer à un corps aussi respectable serait un titre pour lui accorder sa confiance. M. Cassini a profité du voyage du Roi en Flandres en 1748 pour joindre les triangles de la méridienne à ceux de Snellius en Hollande; en 1762 il a prolongé la perpendiculaire de Paris jusqu'à Vienne en Autriche. La branche qui s'étendra jusqu'à Londres sera la troisième, et formera la jonction des deux plus belles villes de l'Europe.

Effect of the Mémoire.—This communication was made at a very opportune time, but it must be confessed that its first paragraph is tactless to a remarkable degree. It states roundly that the latitude of Greenwich was in doubt by some fifteen seconds, and that in order to determine the correct value it was desirable to connect Greenwich geodetically with Paris! To such a statement objection was naturally taken by the Astronomer Royal, Dr. Maskelyne, who wrote an answer which was published in *Philosophical Transactions* immediately after the Mémoire—but not until 1787. Maskelyne says that "the latitude of the Royal Observatory at Greenwich is firmly established by Dr. Bradley's observations and my own at 51° 28′ 40″, probably without the error of a single second."

He further says: "The extensive geometrical operations recommended by the late M. Cassini de Thury [Cassini died in 1784], and commenced under the direction of Major-General Roy, F.R.S., by his exact measures of a base on Hounslow Heath, may also, when completed, determine the difference of meridians of Greenwich and Paris to great exactness. But they do not seem to me likely to throw any new light on the difference of latitude of the two observatories, because the uncertainty we are still under about the true figure and dimensions of the Earth, and the irregular attractions . . . would prevent us from drawing any accurate conclusions."

There can be no doubt that Maskelyne was entirely right, and that Cassini was mistaken when he advocated the execution of a geodetic connection between Greenwich and Paris, in order to ascertain the latitude of the former observatory. But he may well be forgiven, for his memorandum was used as a most effective lever by those who desired to put the surveys of this country on a better footing. King George III., to whom the memorandum was submitted, was anxious to oblige the French; the Royal Society was willing to assist in the project to ascertain the difference of the longitude of the two observatories; and Roy, to whom the execution of the scheme was to be confided, looked upon it chiefly as a means of providing an accurate framework for map-making, and stated that the chief and ultimate object "has always been considered of a still more important nature [than the mere joining of the observatories], namely, the laying the foundation of a general survey of the British Islands." There were, thus, several motives at work, political, scientific and practical, and all contributed to the adoption of the proposal.

The King himself took a personal interest in the matter and defrayed the cost of the necessary instruments. The Royal Society undertook the general direction of the work; and the services of Major-General Roy were lent by the military authorities. It was decided to observe the angles with "a large circular instrument,"

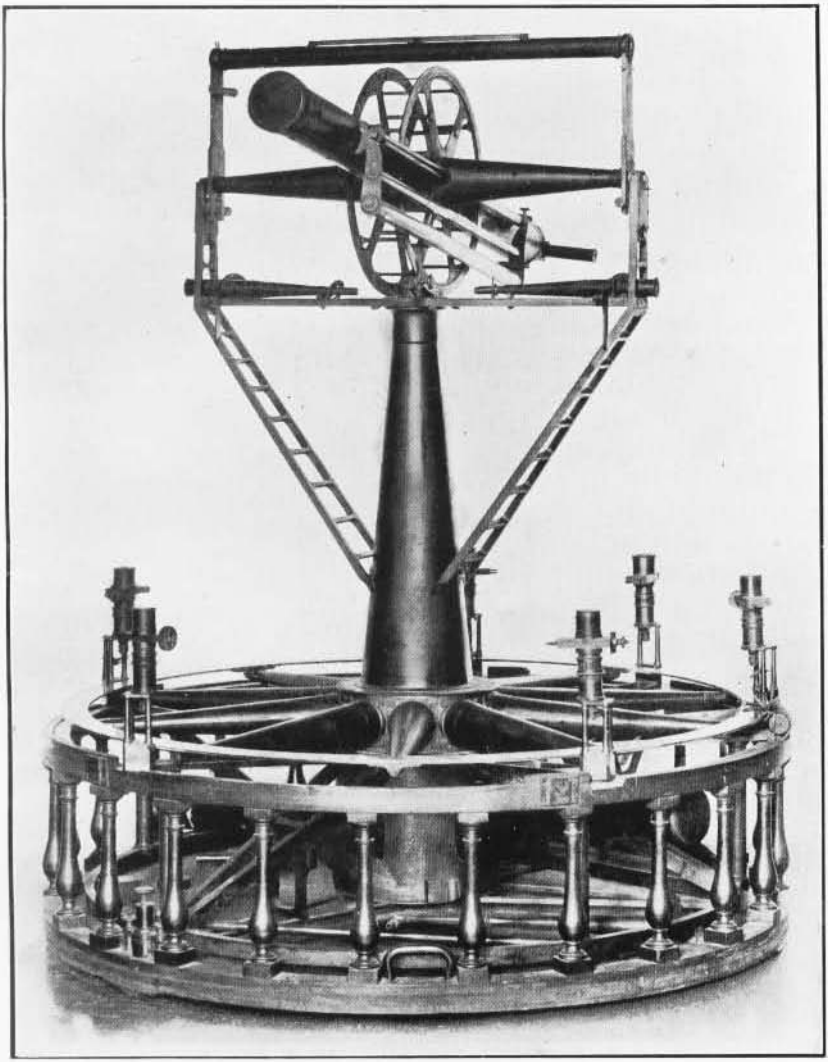
or theodolite, and Jesse Ramsden, the finest instrument-maker of the time, was entrusted with its construction.

Ramsden.—According to the *Dictionary of National Biography*, Jesse Ramsden was born in 1735, his father being an inn-keeper at Halifax, Yorkshire. He was apprenticed to Burton, a mathematical instrument-maker in the Strand, in 1758. In 1765 he married the daughter of John Dollond, the optician. He was a man of marked ability, and the "artist's genius disdained time restrictions." Later on we shall see how great a trial this dilatory artist was to Roy. "On one occasion he attended at Buckingham House precisely as he supposed at the time named in the royal mandate. The King remarked that he was punctual as to the day and hour, while late by a whole year." In 1777 the Commissioners of Longitude published the description of his *Engine for dividing Mathematical Instruments*. He made large numbers of the finest astronomical instruments of his day. "The demand from all parts of Europe for his incomparable instruments was greater than could be satisfied by the constant labour of 60 workmen." Delambre styled him "*le plus grand de tous les artistes*." He was elected a Fellow of the Royal Society in 1783, and in 1795 he received the Copley medal. He died in the year 1800, leaving behind him the memory of an upright, kindly man of genius, absorbed in his work. His portrait by Robert Hume is in the rooms of the Royal Society.

The Great Circular Instrument.—The great three-foot theodolite, which was presented by the King to the Royal Society, (no doubt after discussions as to its design between Sir Joseph Banks, Ramsden, Roy and Maskelyne), was apparently ordered in August, 1784. It is the father of accurate theodolites. The horizontal circle of brass, 3 ft. in diameter, is divided by dots into spaces of ten minutes; there were originally two micrometer microscopes for reading this circle; angles can be read to tenths of seconds. This was the first instrument capable of detecting spherical excess. It weighs about 200 pounds, and was carried when travelling in a four-wheeled spring van. It is now preserved at the Ordnance Survey Office at Southampton. It is known as the 3-*ft. Theodolite R.S.*, to distinguish it from a similar instrument, ordered subsequently by the Board of Ordnance, and known as 3-*ft. Theodolite B.O.* The former instrument was first used in 1787 and was last used in 1853; having thus been in use for 66 years.

Hounslow Heath Base.—Roy says that "a generous and beneficent monarch, whose knowledge and love of the sciences are sufficiently evinced by the protection which He constantly affords them, and under whose auspices they are seen daily to flourish, soon supplied the funds that were judged necessary." Having thus the goodwill of the highest authorities in the State and in the scientific world, it was not long before a beginning was made. Roy suggested that

NOTES ON THE EARLY YEARS OF THE ORDNANCE SURVEY.



Present state (1924) of Ramsden's 3-ft. Theodolite.

Presented by King George III. to the Royal Society. In use by the Ordnance Survey from 1787 to 1853.

a base should be measured on Hounslow Heath, and on the 16th April, 1784, a day much to be remembered, the President of the Royal Society, General Roy, Dr. Blagden and Mr. Cavendish, began the examination of the ground at King's Arbour and finished at Hampton Poor-House, near the side of Bushey Park, a distance of some five miles. "Chiefly with a view to the more effectual execution of the work, it was judged to be a right measure to obtain and employ soldiers, instead of country labourers, in tracing the base, clearing the ground, and assisting in the subsequent operations. They would furnish the necessary centinels for guarding the apparatus. . . . Accordingly a party of the 12th regiment of foot, consisting of a serjeant, corporal and 10 men, was ordered to march from Windsor to Hounslow Heath, where they encamped on the 26th May."

Volunteers, for assisting in the preliminary measurement, were Lieut.-Colonel Calderwood, F.R.S., of H.M. Horse Guards, Lieut.-Colonel Pringle of the Corps of Engineers, Mr. Lloyd, F.R.S., and Ensign Reynolds, 34th Regiment, who also made a local plan.

It had originally been intended, in accordance with what was then the almost universal custom on the Continent, to measure the base with deal rods, and a set of them was prepared for the purpose. The greatest care was taken in the construction of these rods, but experience showed that variations in humidity caused considerable changes in their lengths, and, after exhaustive trials, the idea of using wooden rods was abandoned.

At the outset of the operations a steel chain had been ordered from Ramsden, "the best that he could make." It is not quite clear why this chain was ordered, for Roy states that it was not intended to accept the result of measurement by its means; he also says that the chain, after some alterations, may be "advantageously applied to ordinary measurement on the surface of the earth." However, the chain was made and used in the rough measurement of the base, which was begun on the 16th June and completed on the 22nd.

The definitive measurement of the base was carried out by most unusual means, namely, by glass tubes. The idea of using these was due to Lieut.-Colonel Calderwood, who "was accordingly requested to make the trial at the glasshouse, as soon as possible after his return to town. Next day he succeeded in getting a fine tube drawn, eighteen feet long and about one inch in diameter." Several tubes were made, one being no less than twenty-six feet long; and Ramsden was entrusted with the work of making them suitable for use in measurement. Very full details are to be found in *Philosophical Transactions*, or in Volume I of the *Account of the Trigonometrical Survey of England and Wales*.

The final measurement was commenced on the 17th August, 1784,

and was finished on the 30th of the same month. The work excited very general interest. On Saturday, the 21st of August, "about noon, his Majesty deigned to honour the operation by his presence, for the space of two hours, entering very minutely into the work of conducting it, which met with his gracious approbation." The gentlemen who assisted in the last day's operation were "Captain Bisset, Mr. Greville, Sir William Hamilton, Mr. Lloyd and Dr. Usher, Professor of Astronomy in the College of Dublin."

"The respectable and very worthy President of the Royal Society, ever zealous in the cause of science," repeatedly visited the Heath, and in the final stages of the measurement gave his attendance from morning to night "and with that liberality of mind which distinguishes all his actions, ordered his tents to be continually pitched near at hand, where his immediate guests, and the numerous visitors whom curiosity drew to the spot, met with the most hospitable supply of every necessary, and even elegant refreshment."

The length of this base, after applying corrections for temperature and reduction of sea-level, was 27,404·01 ft.

The base was re-measured in 1791, after Roy's death, by Lieut.-Colonel Edward Williams, then Director of the Survey. This time the measurement was carried out with two new chains made by Ramsden. The new value of the base was found to be 27,404·32 ft.

The mean of the two results was thereafter taken as the true length, *viz.*, 27,404·2 ft.

Standard of Length.—With regard to the standard of length, Roy states that "at the sale of the late ingenious optician Mr. James Short, I purchased a finely divided brass scale, of the length of 42 inches," reading by verniers to the thousandth of an inch. The scale originally belonged to Graham, the celebrated watch-maker"; has the name of Jonathan Sisson engraved upon it; but is known to have been divided by the late Mr. Bird, who then worked with Sisson. (Bird, an instrument-maker, as deservedly celebrated as Ramsden, died in 1776.) This brass scale was compared with the scale belonging to the Royal Society, which had engraved upon it the length of the standard yard from the Tower, that from the Exchequer, and also the French half-toise. This R.S. scale had been made by Sisson, and a duplicate had been sent to Paris for use by the Royal Academy of Sciences.

Instrument Makers.—A recital of the names of these great instrument-makers calls to mind the immense debt which all explorers and surveyors owe to them and to their successors. English instrument-makers were, and are still, for most purposes, the most competent and ingenious in the world. Too often it is forgotten how greatly the success of a geodetic operation depends upon the exquisitely fine construction of the instruments used; too often the observer, whose work, though tedious, is to some extent mechanical,

is apt to attribute to himself a success which is largely due to the maker of his instruments. Indeed, in this matter it is hard to say which of the trio deserves most credit: the mathematician who devises the theory, the laborious observer who accumulates the facts, or the instrument-maker, whose skill in design and minute accuracy of execution principally contributes to the reliability of the result. These old instrument-makers have had worthy British successors in Troughton, Simms, Cooke, Watts and others.

The Base Terminals.—In Roy's time the terminals were marked by wooden pipes, a foot in diameter, with a bore of four inches. In 1791 the wooden pipes were found in a very decayed state and were replaced by guns, placed vertically, muzzle upwards and carefully centred. The guns were selected at Woolwich, by order of the Master-General, and were sent to Hampton by water. Wooden plugs were fixed in the bores, with centre dots marked on them, and iron caps were screwed over the muzzles. These guns still remain in position (1924), the western gun being enclosed by a railing; but the plugs and caps have disappeared.

Roy, in the last communication made by him to the Royal Society —he was correcting the proofs when he died—spoke strongly of the desirability of making indestructible terminals. He said, "these should be low circular buildings, rising but a few feet above the surface of the Heath, composed of the hardest materials such as granite . . . they would resemble those basements of ancient crosses we often meet with. . . . In the interior of this little building, metal tablets would be inserted, containing the name of that much-beloved monarch in whose reign the operation was begun . . . the distance from one another, the angle of the base with the meridian, and also the magnetical variation."

In 1926 we shall be able to commemorate the second centenary of Roy's birth. Perhaps the little circular buildings imagined by him might be built then. They would be appropriate memorials to the founder of the Survey.

Delays.—After the measurement of the base on Hounslow Heath the official records have little to chronicle for nearly three years. It was, in fact, impossible to get to work on the observation of the angles of the triangulation, which was to connect London with Paris, because Ramsden took all this time to construct the "great circular instrument." Some useful work was, however, carried out by Lieut. Fiddes of the Engineers, who was permitted by the Duke of Richmond, Master-General of the Ordnance, to be employed, under General Roy, in making a very accurate plan of that part of Romney Marsh where the base of verification was to be measured. This was during the summers of 1786 and 1787.

Roy's Later Letters.—We can get some idea of Roy's own activities during this (to him) very trying period, from some of his later letters.

Thus, on the 10th September, 1786, we find him writing a letter, probably to Dr. Lind at Windsor, which shows that the King continued to take an interest in the work. The letter also shows how much Roy felt the delay caused by Ramsden's dilatory proceedings.

"Having left London yesterday afternoon, it was not till this morning that I received at this place your letter of the 9th; and it gives me great concern that, owing to this accidental circumstance, I could not have the Honour of obeying the Commands therein signified. . . . I could easily have transported myself to Hampstead from whence I should certainly have seen the lights exhibited there. The truth is that my presence was necessary to forward some parts of the apparatus for the Triangular operation, which, notwithstanding every effort of mine, I fear we shall not be able to begin this Season.

"It will be yet some days before Ramsden can possibly finish the Division and after that the semicircle for the uppermost telescope is to divide, the levels to adjust, and a number of other small things to do, all of which require time, and it will certainly render it too late in the season to think of taking men into the Field to encamp. . . . It is hard upon me to have this operation hanging over my head for another year, without any fault of mine; But with such a man as Ramsden there is no help for it.

"The experiments formerly made with the White Lights were perfectly satisfactory with regard to the use that we may derive from them, particularly in taking the angles across the Channel between Kent and Piccardie. I nevertheless think that it may be proper to try them once more between Shooter's Hill Tower and Nettlebed Windmill, a distance of about 47 miles, by reciprocal observations. This I took the liberty to mention to H.M. . . . Even the preparations for this sort of experiment require time. . . . I will supply you with the angles for pointing the Telescopes at Windsor on the two extreme objects; as it is not unlikely that H.M. may choose to look out from thence."

And here are two more letters addressed to Dr. Lind:—

From William Roy (to Dr. Lind at Windsor).

Argyll Street, 8th March, 1787.

I wish you would be so good as to supply me, as nearly as you can, with the distance between the center of the Devil's Tower (which henceforth I shall call the Maiden Tower) and the Flagstaff of the Castle. . . .

The object I have in view is to shew how nearly the longitudes of places may be determined by means of Ramsden's Instrument; and in the Duplicate of my Paper (which will be read this day at the R. Society) prepared for H.M. I mean to give an example of the computations of the Longitude of the Tower of Flagstaff from Greenwich. . . .

From William Roy (to Dr. Lind, Windsor).

Argyll Street, 2nd July, 1787.

Although, when one has, unfortunately, to do with such a man as Ramsden, it is altogether impossible to answer for what may happen;

yet I hope we shall be able to try the Instrument in Hyde Park on Wednesday or Thursday next.

Perhaps H.M. may not like to have the Signal Staff on the Wardrobe Tower remain there for any length of time. If the Staff itself, Two Deals, and Four upright pieces are prepared, it may be put up any morning, and you can easily describe to the workmen entrusted with the execution in what manner they are to be joined together. . . . and if you are so good as to go up at that time you will be able to tell me how the trees on St. Anns Hill appear?

During the time of waiting, the selection of stations for the triangulation was completed and a diagram was submitted to the Royal Society In the spring of 1787, Sir Joseph Banks, President of that Society, communicated, through the Secretary of State, with the French Academy of Sciences, in order that the French geodesists might be ready to co-operate with the British in observing the rays crossing the Channel And all this time the necessary preparations were being completed for the erection of scaffolds and the showing of "white lights." The composition for these lights was burnt in a copper retainer. The light apparently did not last long.

The Duke of Richmond, Master-General of the Ordnance, gave every assistance, both in the preliminary operations and during the actual observations, by "furnishing an officer and a detachment of artillery-men for the work; ordering the laboratory at Woolwich to supply whatever fireworks might be wanted for signals; and temporary scaffolds to be erected at Greenwich Observatory, Shooter's Hill and Dover Castle, for the reception of the instrument."

In Roy's next letter there is an interesting reference to operations "westward of Windsor," showing that he always kept in mind, as the chief object in view, the triangulation of the whole country.

William Roy (To Dr. Lind, Windsor).

Argyll Street, June 23rd, 1787.

I always intended to apply to you for assistance, in any thing respecting the Signal proposed to be erected in the Center of the Platform of the Wardrobe Tower at Windsor. But I did not think it necessary to give any trouble of this sort, until we were just ready to begin.—At the instant that I write the Instrument is not finished. But Ramsden has been for some time past and at present is close at work upon it with every hand that he can employ. . . . I mean to adjust the line of collimation of the Transit Telescope, and see whether, by inversion to the Pole Star when it is stationary, it sweeps the vertical arches? . . .

When our observations have been made, the Staff, if H.M. shall please, may be removed; but the socket at Bottom should remain, as the point over which the Instrument is afterwards to be placed, when H.M. may please to order the operations to be continued to the westward of Windsor.

. . . You will no doubt come and see us at the Hampton end of the base where I mean to begin, and then I can show you our Flagstaffs.

Execution of the Triangulation.—At length the instrument was finished, 35 months after it was ordered, and was placed on the 31st July, 1787, at the station at the end of the Hounslow Heath base, near Hampton Poor House. It was agreed that the British and French observers should meet about the 20th September. Between 31st July and that date the triangulation was pushed forward, working from the Heath south-eastwards and, before the meeting with the French, ten stations, as far as Wrotham Hill inclusive, had been observed from.

From William Roy to (Dr. Lind at Windsor).

St. Ann's Hill, 17th August, 1787.

It has blown so hard all day long and still continues to do so, that we have not been able to make any observation.

. . . If you please, one of the Lights may be fired about a quarter before 8 o'clock. As there is so small a prospect of calm weather I think it will be useless to throw away more of them. Our other Lights will be fired as I mentioned in my last.—But Artillery men's watches may probably (be) as bad as my friend Bisset's was on a former occasion.

The French representatives were three distinguished members of the Academy of Sciences, Comte de Cassini (the fourth Cassini), Mechain and Le Gendre. They arrived at Dover on the 23rd of September, and the two parties amicably settled the details of the operation. "A great number of white lights, fitted for long distances, and several reverberatory lamps had been previously provided." The French party, accompanied by Dr. Blagden, left for Calais on the 25th. The trigonometrical connection was successfully accomplished by the 17th of October.

It now only remained to complete the gap between the coast of Kent and Wrotham Hill. The season was getting late and Roy speaks feelingly of the tempestuous weather. "Perched on the tops of high steeples, such as Lydd and Tenterden, ... we sufficiently experienced that operations of this sort, where the most important observations could only be made at night, by means of the white lights, should never be undertaken in the latter season." The use of luminous signals agrees with modern practice. Some difficulty was found in observing to them, for the lights did not burn for long and sometimes two would show up at the same time, "from the irregularity of the rates of the watches of the artillery-men." Two stations in the chain had to be left to the next season.

The distance covered was only some eighty miles, but the country was not particularly easy to triangulate. The chain of stations was: Hounslow Heath base, St. Ann's Hill, Hanger Hill, Norwood, Greenwich Observatory, Shooter's Hill, Botley Hill, Wrotham Hill, Hollingbourne, Frant, Goudhurst, Tenterden, Fairlight, Lydd, Romney base, Allington, Paddlesworth, Folkestone and Dover

Castle. The distance between Greenwich and Dover is about 60 miles.

Base in Romney Marsh.—This base of verification was measured with Ramsden's hundred-feet steel chain in the autumn of 1787. Lieut. Fiddes of the Engineers was in charge of the work, and Roy says that "it was impossible for any person to fulfil the duties entrusted to him better than he did." Lieut. Bryce* of the Artillery, subsequently transferred to the Engineers, "an attentive officer and mathematician," was appointed to assist Lieut. Fiddes. We need not go into the details of this measurement. The base, as then measured, was 28,535·7 ft. long; as deduced from the Hounslow Heath base the value came out as 28,533·3 ft., a difference of 2·4 ft. or about 1 in 12,000. These values are given by Mudge. But Roy, in 1788, thought that the accordance was closer, for on the 7th February he writes to Dr. Lind :—

> It will give you pleasure to be informed that our trigonometrical operation answers to a wonderful degree of exactness. The base in Romney Marsh, between 28,000 and 29,000 feet, deduced from that on Hounslow Heath, agrees with the measurement within less than a foot.

The actual discrepancy found between the measured and calculated lengths of the base in Romney Marsh appears to be due, almost entirely, to errors in the measurement of this base. It is stated that there are reasons to suppose that it was not measured as accurately as the Hounslow Heath base. The latter, when tested by the definitive nineteenth-century triangulation, has only an error of $\frac{1}{158000}$, or 2 inches in 5 miles. Moreover, Roy's angles, as tested by the triangular errors of the 16 fully observed triangles, are wonderfully good, the mean triangular error, independent of sign, being just over one second.

The agreement between the distances across the Channel, derived from the English and French triangulations respectively, was good. Thus, taking the distance from the station at Dover Castle to the spire of Notre Dame at Calais, using only the Hounslow Heath base to compute from,

The English value was 137,449 feet.
The French ,, ,, 137,442 ,,

The derived difference of longitude, Greenwich–Paris, was 2° 19′ 51″.

No angles observed by Roy are incorporated in the Great Triangulation as reduced by Clarke; in fact, there is only one eighteenth-century set of angles included, namely, those observed by Mudge at St. Ann's Hill in 1792. But Roy's work deserves all

* Afterwards Sir A. Bryce, Inspector-General of Fortifications.

praise. It was the first accurate triangulation carried out in this country and set a remarkably high standard; it amply fulfilled its original scientific purpose; it provided, for the first time, a thoroughly reliable framework for map making; and it led directly to the formal founding of the Ordnance Survey.

Isaac Dalby.—Dalby was born in Gloucestershire in 1744, and after a struggling career, in which he always showed his preference for scientific occupations, he became, in 1751, mathematical master at the Naval School at Chelsea. In 1787 he was recommended by Ramsden to Roy. The latter, in describing the operations of that year, remarks, "it is proper that I should mention that Mr. Dalby, who had been recommended as an assistant, has acquitted himself throughout the whole perfectly to my satisfaction." In 1788 we find him making astronomical observations in the field. He contributed an addendum to Roy's *Account* of the Triangulation, which was published in *Philosophical Transactions* for 1790. He continued to be employed on the field work of the Survey until 1799. Captain Mudge writes, in the Introduction to Volume II of the *Account of the Trigonometrical Survey*: "I am to announce that Mr. Isaac Dalby, no longer able to endure the fatigues incident to the service, has retired from it; and it would be a matter of injustice, if I were not to acknowledge the extent of his services, his unremitted labour, and attention."

Dalby was the author of a celebrated geodetic formula, known as Dalby's Theorem,* and was responsible for much of the mathematical work of the Survey in those early days. On leaving the Survey he became Professor of Mathematics at the Royal Military College, then at High Wycombe. He resigned this post in 1820 and died at Farnham in 1824. He was an original member of the Linnean Society.

Roy's Last Days.—Roy and his assistants completed the trigonometrical connection in 1788, and during the same year a considerable number of intersected and secondary points were observed in Kent and Middlesex, Roy having always in mind the mapping of the country. In his last paper he says, "the writer of this account cannot help considering it as being incumbent on him to recommend that the trigonometrical operation, so successfully begun, should certainly be continued, and gradually extended over the whole island. Compared with the greatness of the object, the annual

* If λ, λ' be the latitudes of two points on the surface of a spheroid, ω their difference of longitude, α, α' their reciprocal azimuths,

$$\tan \frac{\omega}{2} = \frac{\cos \frac{\lambda' - \lambda}{2}}{\sin \frac{\lambda' + \lambda}{2}} \cot \frac{\alpha' + \alpha}{2}.$$

expence to the publick would be a mere trifle . . . The honour of the nation is concerned in having at least as good a map of this as there is of any other country."

In September, 1788, he returned to London in very indifferent health. In November, 1789, he went to Lisbon for the winter. In April, 1790, he returned to England and was engaged in correcting the proofs of his *Account of the Trigonometrical Operation* for *Philosophical Transactions*. He died suddenly in Argyll Street, in July, 1790, having corrected the proofs of all but the last three pages of this account.

During the later years of his life the fame he had won as a geodesist rather tended to eclipse his reputation as an antiquary; and on the whole we may be certain that, if a choice had to be made, this is what he himself would have wished. By the faithful, however, he was still rightly regarded as the leading authority on Roman Scotland."*

Soldier, geodesist, antiquary, the Ordnance Survey has every reason to be proud of its founder. And may all Survey officers aim at the same reputation!

* *General William Roy and his Military Antiquities, etc.*, by George Macdonald, C.B., F.B.A., LL.D. Society of Antiquaries of London, 1917.

(*To be continued*).

SOME EXPERIMENTS ON THE VALUE OF SODIUM SILICATE IN CONCRETE WORK.

By CAPTAIN J. C. P. TOSH, M.C., R.E.

IN the September issue of the *R.E. Journal* a Professional Note on the use of silicate of soda in concrete was published. Some experiments on the effect of sodium silicate on tensile specimens have since been made at the School of Military Engineering, Chatham.

All tensile tests were made on mortar briquettes consisting of one part of cement to three parts of Standard Leighton Buzzard sand by weight. It was considered that tests on mortar were of more practical value than tests on neat cement, since the silicate depends for its action, to some extent, on its penetration into the surface which, in the case of neat briquettes, would be very small.

The objects of the tests were to demonstrate the effects of sodium silicate on the strength of the briquettes and to see how the treatment could best be carried out. The results are shown on the subjoined table. Columns A and C give the strengths of ordinary briquettes cured in plain water and in a 5% solution of sodium silicate respectively; the latter show a marked increase in strength of about 35% at both ages. Column B shows the effect of adding the sodium silicate to the gauging water; this pronounced loss of strength is particularly unfortunate, as sodium silicate has the valuable property of increasing the rate of set of the cement. For example, a slow-setting cement taken from store was found to have an initial setting time of 270 minutes and a final setting time of 325 minutes; when gauged with a 5% solution of sodium silicate the initial setting time was reduced to 132 minutes and the final to 265 minutes.

The remaining columns show the effect of the silicate when applied under practical conditions. Columns D, E and F show the effect of 7 days' immersion in silicate solution, a method of application which could be used for concrete blocks and which has been common practice for some time in the manufacture of artificial stone. Columns G, H and I show the effect of dipping the blocks three times at 24-hour intervals in a 20% solution, a method analogous to that recommended for the treatment of roads and pavings where a 1–4 solution is sprayed over the surface. A strict comparison of the strengths given in the last six columns and those in column A is not possible, since the briquettes in the latter case were kept soaked in

TENSILE TESTS ON 1:3 MORTAR BRIQUETTES.

ULTIMATE STRENGTH IN LBS. PER SQUARE INCH (AVERAGE OF FOUR BRIQUETTES).

	A	B	C	D	E	F	G	H	I
	Briquettes gauged with plain water and cured under water in usual manner.	Briquettes gauged with 7% soln. sod. silicate and cured under water.	Standard briquettes cured in 5% soln. sodium silicate.	Standard briquettes immersed for 7 days in 5% sod. sil. soln. and stored in damp sand when not immersed.			Standard briquettes dipped 3 times at 24-hour intervals in 20% sod. sil. soln. and stored in damp sand.		
				immersed for first week.	immersed for second week.	immersed for third week.	dipped during first week.	dipped during second week.	dipped during third week.
7 days	202	120	270						
21 days	301	190	419	323	368	350	321	342	359

water for the whole 21 days, while the former had to be kept fairly dry to enable the silicate solution to be absorbed. It must also be borne in mind that the increased strengths obtained by the use of the silicate solution are due to its effect on only a small proportion of the cross-section of the briquette round its outer surface, and that the gain of strength of the surface portion is very much greater than the gain of the briquette as a whole. It will be noted that the effect of either of the two latter forms of treatment is much greater when carried out after the first seven days, and the figures tend to show that the sodium silicate may be advantageously applied to old concrete surfaces.

A few concrete blocks were also made and treated with sodium silicate solution, and, although no definite tests could be made on them, the difference between treated and untreated blocks was very marked; in the former there was no trace of laitance or dustiness on the surface and the arrises were much harder than in the latter.

We are indebted to Messrs. Brunner, Mond & Co., Ltd., of Northwich, for a supply of their P84 Grade of silicate of soda which was used in these tests.

ANTI-AIRCRAFT METHODS IN VOGUE IN THE UNITED STATES ARMY.

By Lt.-Col. D. M. F. Hoysted, d.s.o., R.E.

The general principles of Anti-Aircraft Defence must, perforce, be similar, to a great degree, in the Armies of the various Powers, but a description of some of the details of the equipment and training which have been evolved by another State may be interesting as throwing light on the national characteristics which vary the angle from which the problem is viewed.

In the United States Army very great importance is placed on the attack of hostile aircraft from the ground by artillery and machine-gun fire, and this tendency seems to point to the evolution of an automatic gun which may combine the advantages of both those weapons. For the reason that anti-aircraft artillery is not generally employed at fuze ranges below 4 seconds, it seems to have been felt that some improved type of weapon was necessary to supplement the gun. Great store was set on the machine-gun, owing to the reputation it gained in France, though its abilities at present are too limited to fill the gap efficiently. A heavier machine-gun has already been introduced and a one-pounder Pom-pom with a satisfactory fuze is in contemplation.

As in our service, the methods employed in the United States for combating an attack from the Air are grouped generally under two main heads—Active Defence and Passive or Moral Defence.

The means by which they are fulfilled are :—

1. (*a*) Aerial defence by offensive aircraft.
   (*b*) Ground defence by anti-aircraft artillery, machine-guns and searchlights.
2. (*a*) Aerial entanglements consisting of captive balloons, wire aprons, etc.
   (*b*) Camouflage by means of smoke-screens, false area representation, confusing lights, etc.

It is realized that passive defence alone is of no value against a determined enemy, and they admit that the most effective defence is obtained by the use of aircraft equipped with offensive weapons, provided that they can be concentrated at the right time and place, but this efficient concentration seems to be their difficulty, which has caused much more responsibility to be thrown upon the ground defence.

In aerial warfare the time factor assumes even greater importance than in land or sea fighting, because of the speed at which aircraft can operate. The ground defence may have only four or five minutes at its disposal for its whole effort at any one station. The trend of experiment must therefore be in the direction of concentrating that effort, so as to obtain the maximum effect in the shortest possible time.

In the case of a high-flying enemy, the gun is the only ground weapon that is of any avail, but in the case of lower-flying craft, the practice, in the United States Army, is to make increasing use of the machine-gun. Their original machine-gun units were armed with a ·300-in. weapon, water-cooled and belt-fed, capable of firing 500 shots a minute to an effective anti-aircraft height of about 4,000 ft. The new weapon, however, is of a heavier type, though still water-cooled, as it was proved by experiment that an air-cooled gun cannot be kept sufficiently cool when firing more than a hundred rounds at a burst at the rate of over 500 a minute.

The ·500-calibre Browning weapon will entirely supplant for anti-aircraft use the lighter gun, which will be relegated to protective duties with organization of infantry or other arms. This heavier gun fires 550 shots a minute at a maximum anti-aircraft range of some 9,000 ft. and it is held that one hit in a vital part of the aeroplane at extreme range would incapacitate it.

The primary mission of anti-aircraft machine-gun units is to prevent the close-range bombing and machine-gunning of troop areas by low-flying hostile planes or "ground-strafing," as it was called during the latter period of the war. In the forward areas they are detailed to afford protection to trenches, strong points, and artillery positions, and in rear areas they assist in interfering with the bombing of the points they are told off to protect. A secondary mission is the protection of the anti-aircraft guns, searchlights and their necessary instruments from air attack, but great stress is placed on the primary mission, which should never be lost sight of. Just as anti-aircraft artillery is wasted if used for horizontal fire at a ground target, because the whole of the training of the unit has been devoted to effective fire on an aerial one, so the heavy machine-gun units of the United States A.A. Defence are not to be used for any but their legitimate purpose. This appears to have been entirely borne out by the records of the Army during the War. The 1st and 2nd Anti-Aircraft Machine-Gun Battalions, consisting of some 96 guns, during a period of two months in the front line, claim to have brought down 41 enemy planes, whereas only two planes are said to have been brought down by the remaining 1,500 machine-guns assigned to other units during the same period. Great stress is also laid upon the necessity of maintaining the M.G. Units intact, so that all their power should be concentrated on their primary

and legitimate object. To break up trained Anti-Aircraft Machine-Gun Units for the defence of isolated places is regarded as disastrous.

The general proposal for A.A. Defence is that it should be possible to establish effective A.A. barriers as follows:—

1. Along the entire front of armies operating in the field.
2. Round such important cities, towns or strong points in the areas as are of limited extent, but which are of strategic, commercial or economic importance.
3. Locally, at important industrial sections of large cities, important isolated manufacturing plant, aerodromes, headquarters, supply and storage centres, bridges and other sensitive points.
4. For the local security of fortified areas on the sea coast.

(1) is termed the Front Line Defense (*sic*) Barrier.

(2, 3, 4) are termed Rear Barrier Rings.

The Front Line Defence Barrier consists of Active Defence methods only, while Passive Defences may be mingled with the active forces in the Rear Barrier Rings.

In the forward areas the defence is organized in belts which must needs conform to troop movements.

1. (Furthest from the enemy). A continuous belt of illumination along the entire front to be defended.
2. Gun Area.
3. Defence Aircraft Area.
4. Belt of mutually assisting A.A. Machine-gun positions at distances of between 500 and 1,500 yards from the front trenches.

A rear barrier ring is divided into similar belts, but in inverse order, and a passive one is interposed. In this ring mobility may be sacrificed to accuracy.

1. Continuous belt of illumination about the locality to be protected.
2. Gun Area.
3. Defence Aircraft Area.
4. Balloon and Kite entanglement area.
5. Belt of mutually covering Anti-Aircraft Machine-guns completely round the locality.

The machine-gun belt is *the innermost element*, so as to be able to deal with the raiders as they descend to bombing or strafing height. The pious wish is also expressed that the hostile plane should be kept under M.G. fire throughout the entire defence ring, and not only in the actual M.G. belt. This suggestion might not be heartily endorsed by the defending pilots.

The general organization of the M.G. belt is the same as that of our Searchlight Units, the chain of responsibility and information descending from the headquarters of the higher formations, through battalion, company, platoon and section headquarters to the gun squad which consists of a Corporal and six men. The section is the smallest tactical unit of the organization, and consists of a Section Chief (N.C.O.) and two gun squads. A gun-emplacement is designed to consist of three parts, all of which are to be carefully camouflaged; the gun-emplacement proper, the ammunition supply trench and the belt-filling station about 50 yards in rear.

Considerable study is being given in the United States Army towards developing more efficient weapons for A.A. Defence. The greatest thinkers and the most daring experiments are striving to produce:—

(*a*) A gun with a very much increased rate of fire and higher muzzle velocity.
(*b*) A shell with a larger effective radius.
(*c*) A machine-gun with greater destructive power at a height of some 9,000 ft.
(*d*) A monostatic height-finder.
(*e*) An improved automatic fuze-setter.
(*f*) A clockwork or mechanical fuze.
(*g*) A quicker and more efficient data-collecting and computing machine and system.
(*h*) A practical and accurate sound-locator.

Below is a short description of the material in use at present:—

Guns.—Three A.A. guns were in use at the end of the war:—

(1) 3-in. gun, fixed pedestal, M.V. 2,600 f.s. Semi-automatic breech block, 360° traverse, 85° max. elevation, max. horizontal range, 12,750 yds.

(2) 75-mm. gun. Self-propelled truck, M.V. 1,800 f.s. Semi-automatic breech block, 240° traverse, elevation between 31° and 85°, max. horizontal range, 7,500 yds.

(3) 3-in. gun, trailer mounting to be drawn by self-propelled truck, M.V. 2,400 f.s. Semi-automatic breech block, 360° traverse, elevation between 10° and 85°, max. horizontal range, 8,000 yds.

The two latter were not as satisfactory as the first, owing to the poorness of the sighting, elevating and traversing mechanisms. Experiments, which were at once set forward, to find a light gun of about 75 mm. calibre (approx. 3-in.) and a heavier gun of about 105 mm. (approx. 4-in.), with a M.V. of about 3,000 f.s., yielded the following results which are in being:—

(4) 3-in. gun (with 15-lb. projectile) on self-propelled motor mounting, M.V. 2,600 f.s. Pneumatic loading, 360° traverse,

elevation up to 80°, max. horizontal range, 17,800 yds., operated by either direct or indirect fire control.

(5) 4·7-in. gun (with 45-lb. projectile), self-propelled mounting, max. horizontal range 20,000 yds. Other details as for 3-in. gun, but with specially designed automatic fuze-setter fixed near loading-tray.

Fuze-Setter.—The principal component of the fuze-setter which produces the actual alteration of setting is very ingenious. It consists of a great number of insulated metallic strips laid on edge and compacted into a solid vertical plane or control block. There is one separate strip for each setting, and each strip has a different curvature corresponding to the variation in fuze-setting for various angles of elevation at each altitude. The terminals of the strips are brought out into a cable which extends to the altitude controller. In operation at any altitude, the particular strip for that altitude is not itself electrified, but the altitude controller functions so as to make all the strips on one side of that particular strip positive, and all the strips on the other side negative. The boundary between the positive and negative regions has then a definite shape and curve, so that a contact point carried by a slide on the arm (which is rigidly attached to the trunnion of the gun and varies with the elevation) will automatically follow the boundary between the positive and negative regions as the arm swings to different angles of elevation. The slide carrying the contact point is moved along the arm by a longitudinal screw which is driven through gearing by a pair of small electric motors. These motors rotate in one direction or the other according as the contact point touches a positive or negative region of the control block. The motors are thus controlled by the curvature of the controlling strip and, as they operate a parallel train of gearing which extends to the fuze-setter, they continually alter the fuze-setting to conform with the curvature of the guiding control strip.

Height-Finder.—Experiments are being carried out with a 4-metre inverted Image Folding Range-Finder and a 4-metre Stereoscopic Folding Range-Finder, both by Goertz and equipped with height-finding attachment. Also with the 2-metre Barr and Stroud Height-Finder.

Fuze.—The accuracy of a composition fuze for more or less horizontal use was brought to a great pitch of perfection during the war by our munition factories. But, for A.A. work, such a fuze suffers from the inherent defect that the composition burns at varying rates when the atmospheric pressure is subject to greater changes. The rate of burning is retarded at high altitudes or with a lower velocity of the projectile, and *vice versa*. The mean rate of burning decreases appreciably the greater the height of the target. The general advantage of composition fuzes is that they

can be turned out much more quickly than other kinds in time of war.

A clockwork fuze is more regular and dependable for A.A. use It is independent of daily or periodic changes in atmospheric conditions, and need not deteriorate when stored in damp places, if properly constructed. Two or three different kinds are now under experiment in the United States, a German one driven by a spring in a similar manner to a watch, and another by a mechanism with centrifugal plungers combined with an escapement.

Data-Computors.—Those in use are much the same as in our Service, but the general feeling appears to be that electrical devices, as produced so far, are too delicate and unsuitable for the rough work of the field. They fail to give satisfactory results except in a few very favourable circumstances. The aim of such computors is to cut down the dead time of manœuvre, while the design of the gun should cut down the time of flight of the projectile. The more automatic such a device can be, the less chance there is of personal error creeping into the calculations, when the mind of each member of the personnel is intensely occupied with the work in hand, and subject to the irregularities of the nervous system of the individual. The chances of a hit are inversely proportional to the sum of this dead time of manœuvre and time of flight. For the greater this sum, the further ahead of the target must be the gun pointing when the shell is loosed, with the result that the hostile pilot has longer time in which to alter his height and direction, and thus nullify all the results of the computation. And although the data for fire must be most carefully prepared and continual preparation must be effected for each shot, the time interval between the shots must be reduced to a minimum.

The general conclusion that can be drawn from the foregoing account points to the fact that the United States Army is working on a slightly different line to ourselves. They are putting more of their effort into the ground defence.

It is interesting also to note that we appear to stand about half-way between the French and the Americans in this respect.

We are running true to form.

THE ADVENTURES OF A BRIDGING TRAIN IN MESOPOTAMIA.

By Major E. W. C. SANDES, D.S.O., M.C., R.E.

THE lecture delivered by Major F. V. B. Witts, C.B.E., D.S.O., M.C., R.E., on the 11th October, 1923, at the S.M.E., Chatham, on "Light Floating Bridges in Mesopotamia," has suggested that the experiences of the original Bridging Train with General Townshend's force may interest readers of the *R.E. Journal*. The history of this unit is one of initial success and final disaster. The tragedy of Kut is too well known to need repetition, and, to those who were involved therein, the memories of that tragedy and its aftermath are painful; but the victorious advance which preceded the disaster can be recalled with satisfaction, and even the retreat to Kut after the Battle of Ctesiphon had its compensations in the hard blows dealt to the pursuing Turks. My narrative tends unavoidably to be personal, and criticism is offered at times which I hope may be forgiven, yet without such criticism some points of technical interest may be lost and therefore it is included where necessary.

The Bridging Train of the 1st K.G.O. Sappers and Miners arrived in Mesopotamia from Roorkee early in 1915. It was placed under the command of Capt. M. G. G. Campbell, R.E., of the 3rd Sappers and Miners, and it then constructed a floating bridge across the Tigris at Kurna, some 48 miles above Basra. So small was the unit that never, from its first success to its final catastrophe, could it bridge the Tigris rapidly without assistance; and this assistance, however willing, was not always of the expert nature required for such very technical work. When I took command of the Bridging Train at Kurna in April, 1915, we totalled exactly two dozen men—1 B.O. (myself), 1 I.O. (Jemadar Sadar Din), and 22 Indian other ranks, including 1 Havildar. There was a fleet of 18 pontoons and a very elaborate equipment of stores, but no wagons or animals, as the country was flooded. Ten of the pontoons were of copper and the remainder of steel, some being of bi-partite pattern. We could thus make 95 yds. of light floating bridge, and, be it noted, the Tigris was nowhere less than 200 yds. wide and usually at least 250 yds. even at its lowest level. From this beginning grew the enormous bridging operations which developed later in Iraq.

The Bridging Train had 10 Weldon trestles, which were too heavy to find a secure footing in the slimy ooze of the lower Tigris, and

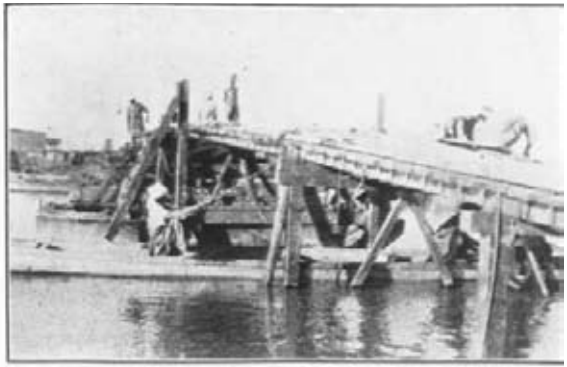
these had to be discarded during the rapid advance on Baghdad in the autumn of 1915. In their stead I gradually accumulated a stock of small wooden trestles with plank ledgers, ranging in height from 1 ft. to 6 ft. (by rises of 6 in.) and of the simplest possible construction. These trestles were most satisfactory and enabled us to bridge the treacherous shallows of the Tigris with great rapidity. Only the heights from 3 ft. upwards required any strutting when in position. The trestles were stored in the barge or *mahela* (dhow) which held all the surplus gear and accompanied the unit. Every trestle had its height marked clearly on it, and even the largest could be carried rapidly along the bridge by eight men.

On the 19th April, 1915, when I took command of the Bridging Train, the British outpost force at Kurna was surrounded by swamps as far as the eye could see and was under observation by Turkish outposts entrenched on various islands. The climate was villainous and the insects almost unbearable. Our defended area was protected from the rising floods by dams, and pumping engines served to keep it moderately habitable. The troops lived in reed huts or tents, protected by walls of sandbags from the bullets of the Arab snipers, who crept up close at night, or the occasional shrapnel from the Turkish light artillery by day. Two Germans lived in a *mahela* anchored some miles upstream, and there they followed the peaceful avocations of beer-drinking and mine manufacture. Just before I arrived one of their mines floated down to the bridge and demolished part of it, so the first job was to make a boom across the river to protect the bridge and the ships below it. The river was then about 250 yds. wide, with a current of four knots in places. There was unlimited telegraph wire available, some 1-in. steel wire rope, a few barrels, and plenty of spars, planks and light cordage; but no text-book gave any suggestions as to how such a boom should be designed or laid, and it was necessary that there should be a cut in it to allow large ships to pass when the force advanced. By good luck we hit upon a design in the form of a wire fence, 2 ft. 3 in. high, of four strands of wire or cable, supported by heavily-anchored barrel floats at intervals, laid diagonally across the river to collect mines only at the further shore, and plentifully supplied with a special form of spar float which kept the fence vertical everywhere.* The moral effect of this boom was so great that the Germans never sent another mine downstream.

General Townshend attacked from Kurna on the 31st May, 1915, and drove the Turks northwards beyond Amarah, and early in June the Bridging Train followed the 6th Division to Amarah, where it settled down for the summer. Very luckily it reached the place

* Details and diagrams of this boom are given in Appendix L of my book *In Kut and Captivity* (John Murray).

First Jahalla Creek Bridge at Amarah (Mahelas in foreground).



Trestles in Jahalla Creek Bridge at Amarah.

Old Arab Bridge at Amarah.

Bridge at Ali-al-Gharbi and Danacks.

BRIDGES

THE ADVENTURES OF A BRIDGING TRAIN IN MESOPOTAMIA.

Reed Hut at Kurna.

Bridge at Kurna.

Bridging Train, 1st K.G.O. Sappers and Miners, at Amarah.

Arabs in covered Bazaar at Amarah.

BRIDGING

undamaged, for there were many hard bumps on the way. The pontoons, however, proved their strength, and at that time the unit had no Arab boats.

At Amarah we worked as hard as the extreme heat would allow. The hours were from 6 a.m. to 11 a.m. without a break, and again from 5.30 p.m. to 7.30 p.m. At 11 o'clock the glare off the water was so terrific that all the men had to wear spine-pads and dark glasses, and even then several were knocked out. They had a comfortable house near the Jahalla Creek and kept fairly fit if they could avoid damage from the sun.

The first work at Amarah was to bridge the Jahalla Creek to allow a column, which was rapidly approaching from Ahwaz, to cross into the town. This bridge took four days to make, as we had to use *mahelas*, naval cutters, and all the Weldon trestles, to supplement the 18 pontoons, but it was completed in the nick of time, and the very weary column found rest in the palm groves on our bank. When the last man had crossed the bridge the Weldon trestles looked as if they had been under heavy artillery fire, for some had sunk a good 2 ft., and others had tilted to alarming angles—and this in spite of extra ledgers and careful strutting. We quickly realized that these trestles were useless for rapid work on the lower Tigris and that a maximum possible length of floating bridge was what was required. It was decided to buy Arab *danacks* (paddling boats covered with bitumen) for use in the bridge, so Capt. Leachman, the Political Officer, sent messengers throughout the surrounding country requisitioning all large boats of that type, and offering a liberal rate of compensation. I found that no *danack* of under 6 ft. beam was of any use for a light military bridge, and, if possible, I refused any boat under 6 ft. 6 in. beam. The largest which arrived was 7 ft. 6 in. in beam. Each *danack* was rapidly fitted with a central structure to support a saddle, and in this work the Arab carpenters were invaluable, for, if well paid, they would work at high pressure all day and were very quick to understand what was required.

My Sappers picked up a lot of Arabic from the carpenters, and some were instructed in the difficult art of repairing damaged *danacks*. This work was mainly the application of hot bitumen (Arabic, *jir*) to cracks in the bitumen skin of the *danack* by first heating the *jir* in a pot, and also the skin around the crack, and then applying the stuff with a rolling-pin. The bitumen had to be heated to exactly the right consistency or else it would not stick. My " Jir-Wallah " Sappers were so proud of their newly-acquired art that they earned the name of " Arabi Log," and used to talk Arabic at times to support their new rôle. Without their aid the boats could never have survived the wear and tear of the advance.

After the completion of the first Jahalla Creek bridge we had to

replace all the pontoons, Weldon trestles and *mahelas* in that bridge by Arab *danacks* and to manufacture the necessary baulks and chesses for a new roadway more than 200 yds. long. The men worked with a will, and, with the assistance of the Arab carpenters, a *danack* bridge had been completed by the end of June, 1915, and all the pontoon equipment removed. We next threw a pontoon bridge across the Tigris north of the existing Arab bridge opposite the centre of the town, and then proceeded to remodel the latter bridge. This crazy structure, which had no approaches or ramps for vehicles, was made of Arab *gissaras*—large bitumen-covered pontoons with gunwales 5 ft. above the water—carrying an unstiffened roadway of rubbishy spars and remnants of planking. It had to be altered to take vehicular traffic, including field-guns, and thus needed a new stiffened roadway with railings, a proper swinging cut and new ramps; in fact, a new bridge had to be built, except that it was possible to use the old pontoons. This was a big job and occupied the unit throughout the scorching heat of July, while the *danacks* for the advance were being steadily collected and fitted with saddles by the Arab carpenters.

Amarah having been connected to the mainland in both directions by good bridges of local manufacture, the Bridging Train was ordered to prepare for an advance northwards. The beginning of August, 1915, saw the unit hard at work completing an auxiliary Bridging Train of *danacks* to supplement the 18 pontoons, and, by the middle of the month, it was ready to advance with 30 rafts fully equipped and sufficient for 305 yds. of floating bridge. Gradually, during the advance and retreat, most of the rafts were lost; but, aided by remarkable luck, the little Bridging Train always managed, somehow, to span the river when ordered to do so.

After the middle of August we began to leave Amarah for Ali-al-Gharbi, which General Delamain had occupied with the 16th Brigade as an advanced post. Early in September all the rafts had arrived at this place, where a bridge was made, and we settled down till the 6th Division had passed and had camped at Sannaiyat, preparatory to an attack on the Es-Sin position of the Turks below Kut. I did not enjoy the stay at Ali-al-Gharbi. The heat was atrocious, we were bitten to pieces by sandflies at night, and had no guard whatever, though on the borders of a town swarming with treacherous Arabs who could have rushed the bridge at night and cleared off before help could arrive. It was not the time, however, to demand protection, as every available man was being sent up to the front, and the few infantry a mile below the bridge were required there to protect the shipping.

The Arabs were most expert thieves. We had bought two excellent *danacks* at Amarah, which were sent up to Ali-al-Gharbi. The former owners followed them to that place, stole them at night

from under the rifles of a small guard, obliterated all marks, took them back by night to Amarah, and, I believe, re-sold them to the detachment at that place, as a couple of boats exactly like them reached me later as reinforcements. One cannot but admire such enterprise!

On the 20th September, 1915, the Bridging Train reached Sannaiyat, and bridged the Tigris, which was then 275 yds. wide at that place. Five days later it moved up five miles to Nakhailat, near the Chahela Mounds, and again bridged the river preparatory to General Townshend's attack on the Es-Sin position. This was a difficult spot, as the river curved sharply and the high banks were treacherous, but the bridge was only about 200 yds. long, so that the best boats could be selected. The R.N. Air Service arrived before us and occupied the only possible bridge site on the left bank where their sea-planes rested on a sandy beach. They refused to budge, so we then proceeded to debate the point. It turned out that they wanted planks to launch their machines, while I wanted a right of way through those machines. *I bought that passage for 20 planks.* The bridge was ready in five hours, but the white wings on all sides terrified the transport mules and ponies crossing the bridge, and luckily they were soon removed elsewhere.

General Townshend attacked the Turks at Es-Sin on the 28th September, 1915, and the next day the enemy was in full retreat north of Kut, which the 6th Division then occupied. The battle took place in rolling clouds of dust. The British victory depended largely on the success of General Townshend's feint on the right bank on the 27th, followed by the transfer of his maximum force to the left bank for an encircling movement on the 28th. The bridge was thus all-important. Practically the whole of the Division crossed without a check in 5½ hours during the evening of the 27th, and unknown to the Turks. I found, subsequently, that a Brigade with first-line transport took about 1½ hours to cross.

It was important to have due notice of the approach of troops at any time, so we made a single-spar portable observation post with wire-rope guys and a chair on top, and erected it about 150 yds. upstream of the bridge. On this perch I roosted for many hours, and could generally detect the approach of troops in spite of the haze. After the battle the Bridging Train was left behind and accumulated much wealth. All sorts of flotsam and jetsam came down the river, and we had eagle eyes. We got a first-class dinghy (most useful for soundings), two *bellums* with ornamental brass fittings which were flattering to our dignity, and sundry barrels, planks, pickets and large beams of wood. The letters *B.T.* were hurriedly painted on the new boats in case of subsequent dispute, but I knew we were fully justified in retrieving all abandoned craft and material for later operations.

The pursuit of the fleeing Turks was pushed as far as Aziziah, though with little success beyond the capture of Kut-el-Amarah, and we were then towed through the Es-Sin position and past Magasis till we reached Kut and moored along the right bank at Woolpress Village (liquorice factory) opposite the town. There we re-organized, repaired boats, sorted stores and awaited the order to follow the Division to Aziziah. Again there was no guard, though the rafts stretched more than a quarter of a mile along the bank. After a few days we moved on once more, but unfortunately the rafts had to be towed, mostly by large river steamers, as these became available, and consequently we reached Aziziah piece-meal. Some tows of rafts took nearly a week to make the voyage of about 90 miles, as the river was full of shoals.

On my arrival at Aziziah, in the middle of October, with some of the earliest tows of rafts, I found General Townshend in a defended perimeter camp on the left bank with no means of access in force to the right bank, and in touch with the Turkish outposts at El Kutuniah close upstream, whence the enemy could easily advance down the right bank and cut the river line of communication below Aziziah. It was imperative that the river should be bridged immediately, and half of the Bridging Train, including almost all the pontoons, had not arrived. Though the river was 280 yds. wide, we started gaily out from the left bank and hoped for the best. With extreme difficulty a single plank bridge was completed in two days, and a battalion crossed it safely in an hour. I wish there was a photograph of that bridge. It began with *danacks* near the left bank, continued with Wheatley bag rafts, barrel rafts, *bellums*, naval cutters and one pontoon placed broadside to the current to gain length, and it finished with a lot of small trestles which sank gradually in the ooze and tilted to all angles. The current in places ran at 5 knots. I was given *carte blanche* by the G.O.C. to prowl around the shipping and commandeer every *bellum*, private or otherwise, to which I took a fancy. I did so, and an avalanche of furious owners descended on my head within a couple of hours; but by that time the requisitioned boats were well—*very* well—lashed and anchored in the fantastic bridge, and the owners departed with imprecations. As the other tows of rafts arrived from downstream, the bridge was improved and completed, but it was as well that the purloined boats were never returned, for everything that could float was wanted during the later operations.

The 11th November, 1915, was the day on which the unfortunate 6th Division began the final advance on Baghdad from Aziziah. The 18th Brigade occupied El Kutuniah a few miles upstream and the Bridging Train followed on the 16th November. The unit was at last given a fleet of six launches, and the spare gear was transferred from a *mahela* to a small steel barge, in which I lived thereafter with

most of the men. The course of the river above Aziziah was very tortuous and the current so rapid in places that a launch could scarcely make any headway with more than six rafts; but, by sending my heaviest tow in the van and following in rear with the barge, I could keep the flotilla concentrated to about ¾ mile in length and maintained control by an improvised system of flag signals. Directly any launch grounded all the other launches stopped, and the two nearest anchored their tows of rafts and assisted in hauling the delinquent off the sandbank.

At El Kutuniah we completed a 250-yd. bridge between 5 p.m. and 10 p.m., assisted by a section of the 3rd Sappers and Miners, and General Nixon (the Army Commander) inspected it on the 17th November. He was much surprised that there were only 18 pontoons and ordered a telegram to India demanding 50 more pontoons at once. Possibly other Bridging Trains benefited by this order, though it was too late to be of use to us. The next day we dismantled the El Kutuniah bridge and formed up along the right bank preparatory to an advance; but at 7.30 p.m., just as the men had finished and had turned in dead-tired, an urgent order came to bridge the river again, and by 11 p.m. we reached the left bank once more. This was our best piece of work—a 250-yd. bridge completed in the dark in 3½ hours, when the men were already tired.

On the night of the 19th/20th November the Bridging Train followed General Townshend to Zeur and a bridge was made in the morning to allow a detached brigade on the right bank to cross again to the left bank and follow the main body to Lajj, near the Ctesiphon position of the Turks. Our luck held, for we managed to complete the Zeur bridge without mishap, but there were only *two* rafts of decrepit *danacks* in hand when the river had been spanned. Directly the brigade had crossed the bridge was dismantled and formed up into tows, and the flotilla was under way again after 11 hours of continuous labour. So fantastic a loop of the Tigris occurs above Zeur that 5 hours of steaming brought us back to a spot within half a mile of that place. This will give some idea of the complications of an advance or retreat by the river.

It was on the 21st November that the launches puffed and fought their way against a rapid current to Lajj, where the ships of the main body were already moored for over a mile along the left bank and the troops were just about to move out to their positions of assembly for the Battle of Ctesiphon. The Bridging Train got to work at once and a bridge was completed by the evening. It was a very difficult site. The left bank was steep and 25 ft. high, the current near it ran at 5 knots, ships were crowded close above and below the site, and the bottom was of hard and slippery clay in which anchors failed to hold unless kedged. Early on the 22nd November, while the din of the battle was incessant, I was ordered,

greatly to my surprise, to dismantle the bridge. We set to work, and at the very moment that the last raft had been taken out and the last anchor raised we were told to re-erect the bridge. It was heart-breaking. At last, at 8 p.m. the bridge was there once more, and the men got some food and rest.

The next day we dismantled again, but at 8.30 p.m. on the 25th, when the battle was over, we were ordered to bridge the river again at once. This we did and reached the well-known right bank for the third time as dawn broke on the 26th. No reason was ever given for these orders, though, doubtless, there was a good one in each case. On the 27th November General Townshend ordered a retreat southwards, and at 2 p.m. I was told to dismantle the bridge and be gone at all costs *by 4 p.m.*, abandoning boats if necessary. It seemed impossible to avoid losing many boats if we were to get away in two hours; but we were determined that, come what might, we would not abandon our boats, for this would have been disastrous to any further offensive operations on the right bank. The men worked like furies, we cut most of the anchor cables close up to the anchors, tumbled the spare gear anyhow into the barge, and on the stroke of four o'clock were dashing downstream in the wake of the other shipping, though with only four launches instead of six. Two launches had been taken for other work and the remaining four were sadly overloaded.

Along the heights on the left bank sat lines of Arabs, with rifles partly concealed under their clothes, longing to open fire but not daring to do so while the retreating British infantry were near. They had their innings later, when the wide bends of the river sent us out into the country to the west. The launches kept at full-speed, regardless of risk, and the Indian *Serangs* in charge of them had to guess the positions of the channels as best they could. They made no mistake till nightfall, when one launch ran down a back-water and piled herself and her rafts on a sandbank. The whole unit stopped and worked till near dawn in a vain endeavour to extricate the culprit, but without success, and I had then to make the unpleasant decision as to whether to abandon the offending launch with her rafts and crew or to leave General Townshend without a bridge at Aziziah where he had arrived. Rightly, as it turned out, we abandoned the launch and rafts, having first seen that the Royal Navy (as represented by one armed tug) had observed their plight. Directly we reached Aziziah a bridge was ordered, and, as it neared completion in the evening, the abandoned launch and rafts hove in sight upstream and soon enabled us to complete it. Again the luck of the Bridging Train had held.

At Aziziah on the 30th November urgent orders arrived again that the unit was to get away with the utmost speed and that nothing must be allowed to delay its departure. Many of the

danacks were now leaking badly, so we left those till the last and then sank them when there was no more time for work. General Townshend had halted his main body at Ummal-Tabul, a few miles below Aziziah, and there the Bridging Train moored for the night, under the high left bank and upstream of the large ships.

On the 1st December the successful rearguard action at Ummal-Tabul was fought. The British force checked the pursuing Turks and then continued the retreat towards Kut. My orders overnight had been that I was not to sail in the morning till all the other shipping had gone; but at daybreak a violent action developed and the large ships were so slow in getting off that the Bridging Train was being raked with shrapnel and several rafts were sunk. We hung on till only one tug with an ammunition barge remained below us, and then left without orders, as we were in imminent danger of capture by advancing Turkish infantry, under whose rifle fire we then were. Meanwhile, the British force on land was retiring in echelon of brigades inflicting heavy loss on the enemy with accurate gun-fire.

No orders for the Bridging Train were available, so it steamed its best and took its chances. The rafts narrowly escaped disaster by collision with the stranded and burning steamer *Comet* and the disabled gunboat *Firefly*, both of which were soon abandoned and were captured by the enemy. All that afternoon we steamed hard, running aground frequently, helping stranded ships at times, and being sniped from the right bank whenever a bend took us to the west. At last after dark all the launches, and the barge also, were aground somewhere in an impossible reach, so I ordered a halt till dawn, when the unit could perhaps concentrate if it had not been captured. As day began to break we were off once more, but were rapidly left behind by the fast river steamers and their only remaining escort, the armed tug *Sumana*. The sweeping bends of the Tigris prevented us from keeping pace with the retreating troops. On the left bank were many Indian stragglers, mostly camp-followers, who plodded aimlessly and wearily along or lay down exhausted to meet their fate. It was impossible to stop repeatedly to rescue all these men, nor had we space for them, but a good few found room in the launches. It seemed more than doubtful if the Bridging Train would get through even if the launches kept at full speed and the *Serangs* guessed the right channel every time.

About midday, when the launches were still some miles above Shumran, Arab cavalry pursued them along the right bank, rapidly overhauling them and firing on them from the saddle. The men on the rafts and launches returned the fire and emptied a saddle or two, but the *Serang* of the launch towing all the valuable pontoons left his wheel and the launch ran into the bank. Though she slid off unharmed, two rafts astern of her capsized and a *lascar* on the launch is believed to have then cut the towing ropes. Anyhow, the

pontoons went adrift and the Arabs were on to them in a trice, while the remaining launches with their cumbrous tows were whirled downstream by the rapid current. Thus the unit lost all its valuable pontoons almost within sight of Kut—a disastrous day, indeed. The British rearguard on land, hearing the fusillade on the river, sent some artillery to the bank and later provided a cavalry escort to assist us past Shumran, so that at last we reached Kut, though with only 12 *danack* rafts out of the 30 pontoon or *danack* rafts with which we had advanced from Aziziah just 17 days before. Many of these 24 remaining boats were sinking, as they were moored along the river front of the town.

Reinforced by many *danacks*, collected at Kut during the advance on Ctesiphon, the Bridging Train was able to recoup some of its losses, though the new boats were too small and were leaking badly. I think that the original demands at Amarah had cleared the country of all really satisfactory craft. However, on the 5th December, when all the large ships had sailed for Amarah, General Townshend ordered a bridge to be made to enable the 6th Cavalry Brigade to escape to Ali-al-Gharbi. This bridge was duly completed by the next morning and the whole brigade crossed unhindered. There were only sufficient boats to reach a sandbank on the right bank opposite the Fort—the narrowest part of the river—and most of the *danacks* were leaking to such an extent that I had to have a man in each boat to stop the jets of water with lumps of clay whenever a field gun and team crossed the bridge. Under such a load each new *danack* sank till its gunwale was just two inches above water. Not a shot was fired by the Turks during the crossing, not a ripple disturbed the water, not a baulk broke, and not a boat sank, which was fortunate as *there was not a single spare boat.* The sandbank, though apparently hard, suddenly became a quicksand while the bridge was fully loaded with traffic. All traffic had then to be halted on the bridge, and had to remain there till a causeway of small trestles, baulks and chesses could be made across the sandbank and so to the actual shore. For over an hour the bridge, crowded with men, horses, mules, wagons and carts, and with several boats sinking slowly, in spite of desperate bailing and plugging, was an ideal target for any Turkish field-gun, yet not a gun spoke. A few well-placed rounds would have sealed the fate of the bridge and consequently of the brigade. Shortly after the brigade had gone two *danacks* foundered hopelessly ; and while the bridge was being dismantled it was attacked by Turkish and Arab infantry and work had to cease till after dark. Never was there a greater piece of luck than the escape of the 6th Cavalry Brigade from Kut.

The men worked all night at dismantling this bridge. When the job was nearing completion in the early dawn, an order arrived that another bridge was wanted at once, for tactical reasons, nearer

to Kut town. With great difficulty the new bridge was finished on the evening of the 8th December. For this bridge it was necessary to use a number of the old Arab *gissaras* from a dismantled Arab bridge brought up previously from below the Fort, and to stiffen these boats with large beams. The bridge had to be made on a bend of the river where the current ran diagonally, and a cut was impossible. The roadway was of the flimsiest description in places, and altogether the structure was depressing in appearance, though I think it would have supported field guns if man-handled across. I presume that the purpose of this bridge was to enable the 6th Division and 30th Brigade to leave Kut even as late as the 9th December if occasion required; but on that day the Turks attacked the bridge with a brigade on the right bank, overwhelmed the small covering party and captured the bridgehead. The Bridging Train lay out all day on the left bank with a few infantry and prevented the enemy from crossing the river. After dark Lieut. A. B. Matthews, R.E., and a party of volunteers from the 3rd Sappers and Miners, accompanied by Lieut. Sweet of the Gurkhas and a squad of his men armed with *kukris* to cut the anchor cables, arrived with charges of gun-cotton between planks in order to demolish the bridge, which had now become a menace to the safety of Kut. The demolition was most gallantly and successfully carried out under the noses of the enemy, who were quite unaware of what was happening till the charges exploded. The bridge, which was cut in two places, and part of which was already sinking, broke into sections still held by a few anchors, and the remaining boats gradually sank in the next few days. The launches alongside the bridge were unable to steam past the enemy to Kut, though they made several attempts, so they had to be abandoned and sank gradually in the mud of the bank till they had disappeared altogether in about three months.

Thus ended the active operations of the Bridging Train, 1st K.G.O. Sappers and Miners, in Mesopotamia. It was a lamentable ending, but inevitable. The unit might have been sent downstream with the shipping before Kut was surrounded, but that would have bound General Townshend to operations on the left bank only, and probably to a passive defence. He has stated in his book that he contemplated an active defence, using the bridge to transfer his striking force from bank to bank, but the question must arise as to how long it was likely that the Turkish artillery would allow the bridge to exist. As it turned out, the Bridging Train was sacrificed to save the 6th Cavalry Brigade, and doubtless the exchange was sound. If Kut had been relieved, the unit might possibly have assisted in the river-crossing by means of flying bridges at one or two points. Beyond that, and perhaps the construction of a trestle bridge across the Shatt-al-Hai channel, the Bridging Train was powerless after the 9th December, for all hope of a floating bridge across the Tigris was then at an end.

During the siege we were first occupied on odd jobs in and near the town, and later in preparing bridging material to co-operate with the Relief Force, such as *mahela* rafts for a couple of flying bridges across the river, and trestles, baulks and decking for a Shatt-al-Hai bridge. This decking was made from the strong front doors of Arab houses, fastened together with dogs made from verandah railings. Over 200 doors were collected in the R.E. Field Park in Kut for this purpose. A test proved that they would stand the wear and tear of occasional field artillery traffic. I do not suppose that so expensive a decking has ever before been contemplated for a temporary bridge.

When the surrender came and the Arabs could retrieve their unused doors, the scene in the Field Park in Kut almost defies description. Around a huge bonfire of new manilla cordage, baulks, planks, trestles and a theodolite or two, which I made on the 29th April, 1916, the Arabs danced and screamed and fought for their doors, while the air was rent with the detonations of the gun-cotton charges which were destroying our guns and howitzers as the Turks marched in. The Bridging Train vanished into distant Anatolia, and many of the men never re-appeared. They had done their bit in the war, nevertheless, for they had made altogether 17 bridges across the Tigris in 9 months, and 7 out of that total were made during 13 days in November, 1915. They worked like Trojans, they were cheery, even in the most dire adversity and distress, and they were loyal to the end. In fact, they lived up to the traditions of their Corps.

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My account of the adventures of the earliest Bridging Train in Mesopotamia may, perhaps, be supplemented by a few remarks on the equipment and methods of work of that unit. If, in any of these remarks, I draw attention to points in which the equipment of the unit was unsuited to the conditions, it should be remembered that that equipment was hardly designed for a gigantic river such as the Tigris, and that the exigencies of the service in other theatres of the war prevented all our demands from being met. Both the men and the equipment of the little unit in Mesopotamia were excellent in quality, and the deficiency was chiefly in quantity.

Throughout the rapid advance we longed for a Barr and Stroud range-finder with which to fix the *exact* width of the river at any point. The pontoons formed only a portion of any bridge, and had always to be used for the swinging cut or where the current was very rapid, the remainder of the bridge being formed of *danacks* or *bellums*. The *danack* is a species of flimsy gondola, made, apparently, of matchwood and rubbish coated with bitumen; and the *bellum* is a paddling boat of inferior planking. One soon got to know the most reliable *danacks*, and it was necessary to use these in the more

difficult parts of the bridge and to employ the inferior boats as little as possible and only in slack water. With an exact and early estimate of the number of 5-yd. spans required for the bridge, it would have been possible to detail the boats at once for use in its sections of varying difficulty, sending them out to the bridgehead in the correct order according to the numbers painted on their bows and sterns.

The copper pontoons were more satisfactory than the steel ones. The paint soon got rubbed off the latter and rust appeared. There was no time to re-paint any pontoons during the advance or retreat. The copper pontoons rarely leaked, and withstood many hard bumps when being towed behind large river steamers.

The chesses of the standard equipment were of finely-planed teak and very durable. They had the disadvantage, however, that in stormy weather, when they were wet, they became so slippery that no horses, and few men, could maintain a foothold on them while the pontoons were pitching. In the improvised equipment made in Mesopotamia we used pine or deal chesses, made from unplaned planks. These did not last nearly so long as the teak chesses, but gave a better foothold and were lighter to carry—an important point with tired men.

The baulks of the regular equipment were beautifully finished, tapered longitudinally, and of girder section. With the whole personnel fully trained, they would probably have given complete satisfaction. Unfortunately, we did not always have the assistance of Sappers, and the baulks were often fitted incorrectly in the saddles. They then tilted sideways and broke. We reverted to a more primitive type of baulk of ordinary rectangular cross-section, guaranteed to stand rougher usage, if rather heavier, and these gave good service.

The usual pattern of anchor generally failed to hold securely in the greasy clay of the river bottom, so the grapnel type used by the Arabs was adopted. The bottom, however, varied so much that we never knew whether an anchor dropped three days before could be recovered. It was often buried several feet deep in the clay by that time, and so few men were available that it was impossible to spare any for raising several anchors every day. Many anchors were recovered, which no amount of ordinary hauling would budge, by the use of tackle attached to the anchor cable after the cable had been passed over the bow of a pontoon, one block being attached to the cable and the other made fast inside the stern of the pontoon. Six men then seated themselves in the stern and hauled in unison, thus giving a regular and gentle pitching motion to the pontoon, whose loaded stern acted as a lever, with the bows as fulcrum. I can imagine the gasp of horror of the pontoon manufacturer who reads this, but experiment showed that a pontoon of the type with us

suffered no damage from such usage, and many anchors were thus recovered after 10 to 20 minutes of "rocking and heaving" which would otherwise have been lost.

Throughout the advance on Baghdad the unit was much hampered by the lack of accurate large-scale maps of the Tigris, though such maps would have needed constant revision, owing to the rapidly changing direction of the currents.

In the earlier operations, river transport was so deficient that the rafts had always to be towed astern of large river-steamers, and the unit was lucky not to lose its pontoons in consequence. Often the towing-steamer bumped into the bank at a good five knots, slid off, regained speed, and caused the towed rafts to attempt an overland journey before they could regain their native element. Desperate fending off by the Sappers on the rafts alone prevented a disaster. When going downstream, a large steamer, towing rafts, often took the wrong channel and ran aground. Immediately she would be encircled by heaving and grinding rafts and shouting men. Our excellent pontoons stood this buffeting in a marvellous way, but we lost many a useful *danack* and *bellum* raft through such collisions. The truth is that, for towing a Bridging Train on the Tigris, a special form of fast launch of not more than 2 ft. 6 in. draught is required. For the final dash on Baghdad from Aziziah we were given six Bombay harbour launches of 4 ft. 6 in. draught when loaded. There were altogether at that time 9 pontoon rafts and 21 *danack* or *bellum* rafts—sufficient for about 305 yds. of light floating bridge. Five launches towed 6 rafts each, and the sixth towed the barge. But the 4 ft. 6 in. draught of the launches was far too great and they were always grounding. Every raft was cross-braced for towing with $\frac{5}{8}$-in. steel-wire rope, if enough was available.

The demands of the Bridging Train in cordage, wire rope, and timber were insatiable, and its efficiency was considered so important that I was given first call upon all material arriving in the Field Park during and before the advance. For anchor cables, 3-in. manilla cordage was in great demand, though sometimes 4½-in cordage was used for important anchors. A coil of 6-in. cordage, forming part of the regular equipment, was soon left behind as unsuitable and unwieldy. For light lashings we used a considerable length of 1-in. manilla cordage; but we swallowed the 3-in. cordage as quickly as it arrived and could never get enough. As regards steel wire rope, the unit used a quantity of 1-in. or $\frac{5}{8}$-in. circumference for operating the swinging cut, and a still greater amount of $\frac{5}{8}$-in. size for horizontal cross-bracing throughout the swinging cut, and sometimes for rafts when being towed. We had a coil of 3-in. wire rope, but left it at Amarah, as there seemed no prospect of its use.

The lack of mauls for driving pickets caused much trouble. The few excellent mauls in the regular equipment wore out in time or were lost, and there was no hard wood for the manufacture of

new ones. In all spare moments our carpenters were making mauls of the only wood obtainable, and binding them with wire, but the supply could not keep pace with the demand. In the retreat from Ctesiphon we were reduced to using sledge-hammers which were disastrous to the pickets.

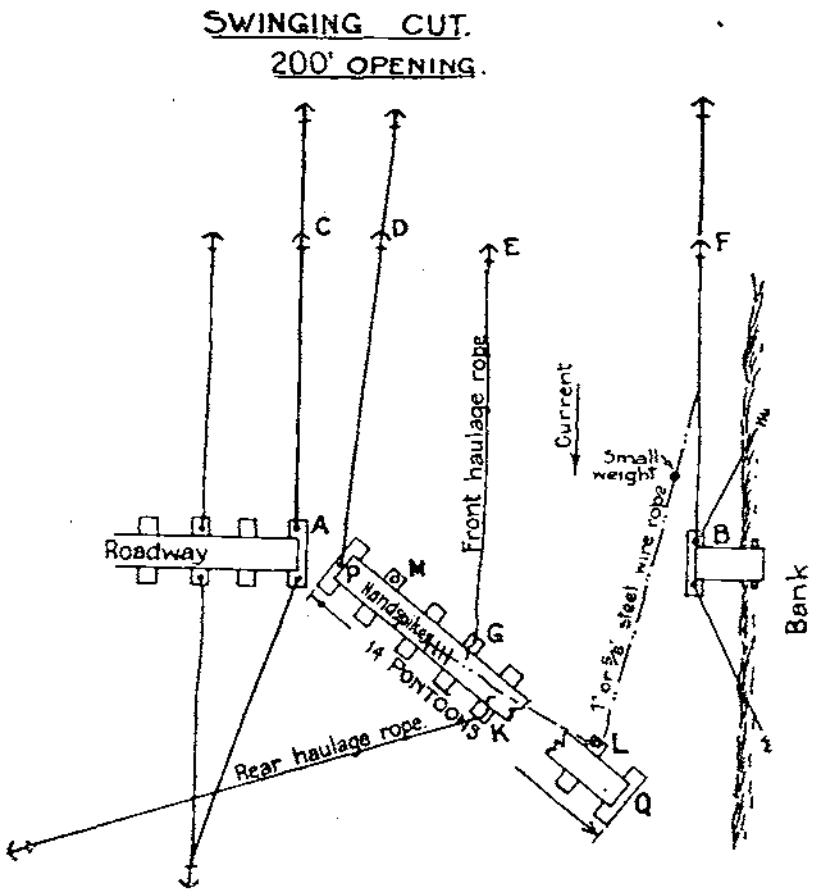
The supply of carpenters was never sufficient to cope with the work, unless the unit was at some large town where good Arab carpenters could be hired. By far the greater part of the work was carpentry. My letters to Headquarters in India were full of supplications for carpenters and still more carpenters, but our life as a unit was too short for these requests to have full effect.

As I have already mentioned, the Bridging Train had to be assisted by other units if rapid work was essential. Usually we were lucky enough to have the help of half a company or one section of the 3rd Sappers and Miners, attached to us for a short time, but the men were frequently changed. Sometimes Pioneers were substituted for the Sappers. The new men, whoever they might be, did not know our methods of work and had not had the experience on the river necessary to make them expert watermen. My own Sappers had become very skilful in handling boats in a rapid current when the final advance started, and consequently I had to keep them almost entirely for anchor-laying during rapid work, for the speed of construction depended mainly on the rapidity with which the anchors could be laid. Rowing in the pontoons for hours at a stretch was very exhausting, though the splendid physique of the men stood the strain well.

In conclusion, a short description of our system of swinging cut may be of interest. The cut was usually fairly near one bank, though its position was governed, of course, by the main channel. A cut of 200 ft. width was usual, with 14 pontoons in the swinging portion, and this sufficed to pass a river steamer of the " P " Class with a steel barge on each side. About 18 men were required to operate the type of cut used by us, if speed of opening and closing was essential. A squad of that strength opened the cut complete in two minutes in fine weather, working at the double; and they closed it and joined up the roadway in four minutes by the watch. A squad of 10 men, however, could open or close the cut slowly. I admit that this type of cut could not be used in very rough weather, as the strain on the anchors holding the 14 pontoons when the cut was open would then be too great, and they would drag. But during the fairly calm weather of the advance and retreat in 1915 this cut was most successful.

Referring to the diagram, it will be seen that the point P is the pivot of swing, and the anchor cable PD is laid at a very slight angle to the direction of the current, so that it tends to swing pontoon P clear of pontoon A when the cut begins to open. The amount of this clearance is controlled by ropes between these two pontoons.

The steel wire cable for the haulage of the cut is attached to the anchor cable FB, runs through a block at L, and has 4 handspikes attached to its end. There is a snatch block at M. To close the cut, the handspikes are manned by a team of 8 men who march along the cut from L towards M. On arrival at M, when the cut is about



half closed, the team turns about and marches back towards L, and, as they turn at M, a man slips the haulage cable into the snatchblock on that pontoon so that the tension continues. Two men assist by hauling on the rope EG, and make it fast later at the centre of the swinging portion. Four men are posted at A, and two at B. The whole swinging portion is cross-braced horizontally with §-in. steel-wire rope under the decking, and is quite stiff in a current of three knots. Cut baulks are used for the connections at A and B. All anchor cables are of 3-in. manilla cordage, except DP, which is of 4½-in. cordage. The small weight on the steel haulage cable sinks that cable when the cut is open, and a similar weight can be attached to the cable EG.

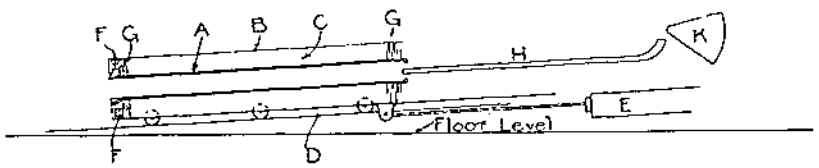
"SPUN" IRON PIPES.

(STANTON DE LAVAUD.)

By E.M.S.

THESE pipes are now being used by the War Department (*vide* D.F.W. Contract Circular No. 843) and it is thought that the following notes on the process by which they are made may be of interest.

A very diagrammatic sketch is given, which it is hoped will be sufficient to give a clear idea of the essential features and arrangement of the plant and the method of using it.



A – Turned and bored cast chromium steel mould revolving in
B – Hollow carriage forming a water Jacket C around A.
D – Inclined rails along which carriage B is moved backwards and forwards by hydraulic ram E.
F – Pelton wheel bolted to revolving mould.
G – Piston rings making water Joint between mould and carriage.
H – Inclined grooved chool cantileveted out along axis of mould.
K – Sector shaped ladle of capacity exactly equal to quantity of metal in pipe to be cast.

A chromium steel mould of the exact size and shape of the outside of the pipe required is so mounted in a water-jacketed carriage that it can be revolved at a high speed, while being traversed with the carriage at a definite speed parallel to the axis of rotation of the mould.

The traversing of the carriage is effected by means of a hollow hydraulic ram, working parallel to the axis of rotation and to the inclined rails on which the carriage runs.

The rotation of the mould is effected by means of a Pelton wheel mounted on it near the socket end, pressure water being brought to it through the hollow ram previously mentioned.

The carriage has a longitudinal axial travel of somewhat more than the length of the pipes to be cast, viz., 12 ft.

When the carriage is at the lower end of the inclined track, the spigot end of the mould, which faces up the track, just clears the

outlet of an inclined, grooved shoot, so mounted and cantilevered out from the frame of the machine at the upper end of the track as to project downwards along the axis of rotation of the mould. This shoot is a trifle over 12 ft. long and the open end discharges to the side, *i.e.*, radially to the mould.

It will be clear that when the carriage is pulled up the track the outlet of the shoot is in a position to discharge its contents into the socket end of the mould.

Molten iron is brought by a Telfer transporter from the cupola and poured into a special sector-shaped ladle, which holds the exact quantity of metal required for one pipe, and is mounted on a horizontal axis about which it can be tipped at a constant angular speed. As the sector-shaped ladle is tipped, the surface of the iron has always the same shape and therefore uniform speed of tipping gives a uniform rate of flow of iron into the mould by way of the inclined shoot.

The inclination of the track, axis of rotation, and shoot are determined so as to give a suitable flow of hot metal through the grooved shoot.

The method of operation is as follows :—

The hollow mould has first to be completed by the insertion of a baked-sand annular socket core, mounted on a cast-iron supporting ring, which fits into the lower or socket end of the mould.

This core is required, as will be evident from the sketch, to form the socket of the pipe. There is no core for the main barrel of the pipe.

Water is then turned on to the Pelton Wheel, speed of revolution being about 500 revs. per minute. The carriage is meanwhile drawn up to the top end of the track.

The sector-shaped ladle is then tipped by hydraulic power at a predetermined speed, and the movement of the carriage down the track starts automatically at the moment when metal is first poured into the rotating mould.

The tipping of the ladle and the traversing downwards of the carriage are carefully synchronized, the thickness of the metal in the pipe barrel being obviously inversely proportional to the rate of movement of the carriage.

Every movement is, however, effected by water pressure and, after valves are once adjusted to suit a particular diameter of pipe, the process is quite automatic.

After the ladle has discharged its contents there is still sufficient iron in the shoot to make about two feet of the pipe barrel. It is found that the rate of flow of the metal at this stage slows down to a certain extent. This is compensated for by means of a trip valve, which slows down the speed of the carriage for the last portion of its travel.

In order, however, to make quite certain that the thickness of metal is not deficient in the spigot end of the pipe, the carriage speed is reduced somewhat more than is necessary so as to compensate for the decreased flow of metal.

The lower or socket end of the pipe is now gripped by a pair of expanding tongs, the carriage is drawn upwards, and the newly cast pipe is drawn out on to rails, along which it is rolled to the annealing furnace. Each pipe is kept 40 minutes in the annealing furnace and slowly rolls through it at a uniform speed.

The time taken to pour a 12-in. pipe 12 ft. long is only 16 *seconds*, and the pipe reaches the annealing furnace in two or three minutes from the commencement of casting.

Temperature of pipe leaving mould, 800° F.

Temperature of hottest part of annealing furnace, about 1,800° F.

Temperature of exit from annealing furnace, 400° F.

After passing out of the annealing chamber, the sand core of the socket is removed and a wrought-iron band is shrunk on the spigot end to act as a bead. The pipes are then dipped in Dr. Angus Smith's solution and, when cooled, are tested hydraulically up to 600 lbs. per square inch.

The thickness of the pipe for similar pressure is about 25 per cent. less than would be the case in ordinary vertically cast pipes. The metal produced by this process is extraordinarily dense and the centrifugal action ensures remarkable uniformity of thickness. No air holes or imperfections of any kind are found, and the tensile strength varies between 18–20 tons per square inch. The resistance of the pipe to corrosion, owing to its dense character and the absence of any defects, is said to be considerably greater than that of an ordinary cast-iron pipe.

The form and general dimensions of the "spun" pipes follow the British Standard Specification, the external and internal diameters of the pipe and of the socket end respectively being of equivalent dimensions. They will therefore socket up with ordinary sand-cast pipes and specials without difficulty.

OSBORNE.

THE HAVEN FOR CONVALESCENT OFFICERS.

THE object of this description, written during convalescence at Osborne, is to draw the attention of British officers of the Forces, and of the Civil Service, to one of their most splendid inheritances, the inheritance of Osborne, which King Edward relinquished, 22 years ago, for the well-being of those who were sick and sorry, and which has produced such a wealth of blessings, and such a measure of gratitude as even the thoughtful donor himself could never have foreseen.

The transformation of this royal residence into a convalescent-home for officers was based on a wise and simple plan. Wisdom is continued in the welcoming of every degree of convalescence (whether from wounds operation, serious illness, or even from mere over-work or general debility), and simplicity is exemplified in the procedure of admission, and in the modest scale of charges, as shown below.

Before studying the details of admission, etc., officers who contemplate restoring their health by "Leave-Home," may wish to know what Osborne and its surroundings and resources are like.

The chief glory is the great domain of garden and park, with its beautiful woods and dells, its wide acres of turf and gracious undulation, its noble cedars, ilex, evergreens and groves, and its ever-changing and magnificent views over the Solent and away to the Hampshire and Sussex downs. All these are a perpetual joy to the eye, and a solace to the spirit of a worn man.

With the exception of some of the "Royal Apartments," the whole of this spacious palace is at the disposal of the officers in residence. Consequently, even inclement weather fails to cause *ennui*, for one can study the pictures and statuary, the furniture and decorations, peculiar to what is called "Victorian Art," and, even if these splendours pall, recourse may be had to the excellent library and billiard-room, or to the wireless-concerts and the cinema in an adjacent room.

For those who begin to grow robust, there are, in the grounds, several tennis-courts, and an excellent 9-hole golf-course (provided with a professional), and even a rifle-range. Furthermore, all officers convalescing at Osborne are honorary members of the

Royal London Yacht Club, Cowes, the Royal Victoria Yacht Club, Ryde, the Island Sailing Club, Cowes, and the Seaview Yacht Club, Seaview.

The whole of the Isle of Wight, with its wonderful natural beauties and its archæological and geological interests, is made " available " by means of the house Daimler, which can be hired at a moderate rate.

Life indoors is also agreeable, from the large, well-warmed and electrically-lighted bedrooms to the admirable bathrooms, from the most distant corridor to the nearest fireplace. The excellent, well-cooked meals are served in the fine dining-room, near which are the library and the billiard-room. The gorgeous smoking-room was formerly the Privy Council Chamber, and possesses a first-class floor, which is greatly appreciated during the Saturday-night dances.

The Resident Staff is presided over by the House Governor, Sir Warren Crooke-Lawless, K.C.V.O., C.B., C.B.E., C.I.E. (who made many friends in India when he was Surgeon to Lord Minto). He is ably assisted by a Matron (Miss Ormsby-Smith) and several skilled Sisters, and they by adequate valets, waitresses and house-servants, who, one and all, seem to have been selected for their " obligingness " (a virtue that pervades the whole of the House, and is extremely pleasant to meet).

Hence, the comfort of every officer is studied, just as carefully as his health—probably the former is a potent aid to the latter.

It should be borne in mind that the rigidity of " Hospital Regulations " is neither necessary nor enforced at Osborne, where a considerable amount of freedom is allowed (subject to the discretion of the House Governor), and where the hours for meals and for getting-up and going to bed are those of normal life in a country house, which Osborne greatly resembles.

Osborne is open for the reception of British officers of the following Services :—

(*a*) Navy.
(*b*) Marines.
(*c*) Army.
(*d*) Air Force.
(*e*) Civil Servants serving under the Foreign, Colonial, and India Offices, who are required to serve in tropical, sub-tropical or unhealthy climates, outside their country of origin.
(*f*) Officers of the Retired and Demobilized Lists of the above fighting forces (provided that retirement has occurred during the five years preceding the application for admission, but precedence is, of course, given to serving officers).

The total daily charges (which include medical attendance and

convalescent nursing, medicine, fuel and light, and baths) are as follows :—

(i) For officers on the Active Lists of the Forces ... 6s. od.
(ii) For Half-Pay, or Retired Officers of the Forces ... 4s. 6d.
(iii) For Officers of the Civil Service detailed above ... (Under consideration.)

The following is the simple and direct procedure for an officer's admission to Osborne :—

The candidate, if an officer of the Forces, applies by letter to the Director-General of the Medical Service of the Force concerned (at the Admiralty, War Office, Air Ministry, India Office), and if a Civil Servant, to his Secretary of State. After a few days permission is given (if the candidate is suitable), and all that remains to be done is for the applicant to arrange with the House Governor as to the date and hour of arrival at Osborne.

In other words, everything is done to facilitate a convalescent's search for a peaceful, comfortable and interesting home, where his health can quickly be made good, and where he himself gains the hope of " making good " amongst his fellow-workers.

It is very depressing to see the numbers of officers " Home on Leave " who have no home, and to know that ill-health is the first cause of that leave, and the source of much financial worry, which is aggravated by the extortionate charges of sanatoriums, hotels, and " rooms " (whether in towns or in " health-resorts ").

Osborne saves an officer all such worry, and all the weariness which mere " Leave " cannot remove.

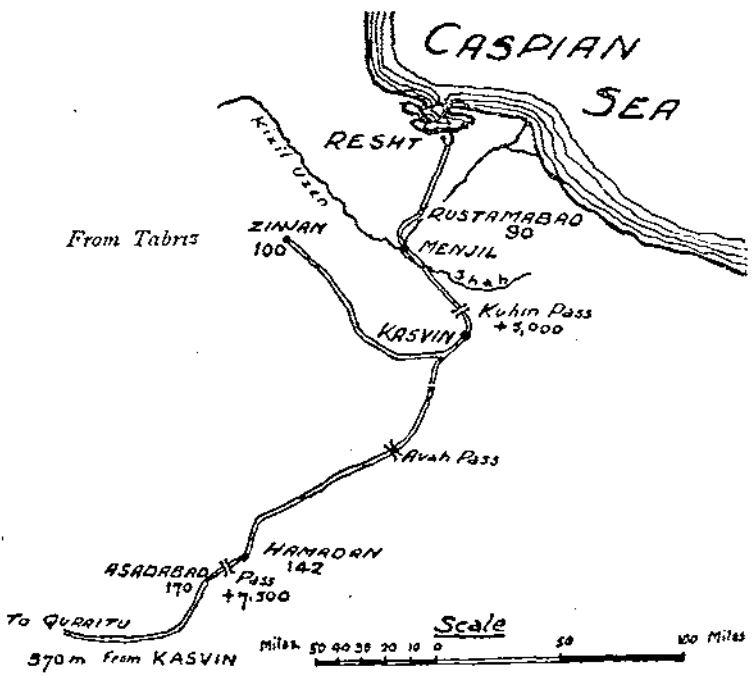
A proof of the excellence of (what may be called) the " Osborne Idea " is, that every officer who has once sojourned there invariably returns, if the later years have again deprived him of his health. So, in thinking of Osborne, one recalls the refrain of the old song, " *On y revient toujours.*"

" EXPERTO CREDE."

ENGINEER WORK WITH NORPERFORCE IN 1919–20.

By MAJOR C. F. STOEHR, R.E.

PROBABLY many officers have read Major-General Dunsterville's *The Adventures of Dunsterforce* or M. H. Donohue's *With the Persian Expedition*, and thus know something of the curious adventures of our forces in that corner of Persia. But these books end their narrative before the Armistice, and few people know what happened subsequently in that region. The only book on the subject, the Hon. J. M. Balfour's *Recent Happenings in Persia*, had, unfortunately, to be withdrawn from circulation owing to its containing a legal —and perhaps actual—libel on a former Persian prime minister. It is still obtainable, however, and gives a good insight into many of the diplomatic events upon which the action of our forces depended. In this article an attempt will be made to give a general account of the engineering work done, with an outline military narrative as a background to this account and a supplement to the book.



After the Armistice the Batoum–Baku line was occupied by British troops, the force there forming part of the Army of the

Black Sea. At about the same time General Dunsterville relinquished his command of Dunsterforce, which was re-named the North Persian, or, telegraphically, Norperforce. In April, 1919, the writer, with 19th Field Co. Sappers and Miners, joined the force and became its C.R.E. At this time Norperforce occupied Enzeli (on the Caspian), Resht, Kasvin, Hamadan, and Zinjan, but the last was evacuated immediately, and Resht during May; it consisted of a large mixed brigade, with headquarters at Kasvin. The country and neighbouring countries were quite quiet, except that round about Resht fighting between part of the Russian-officered Persian Cossack Brigade and local rebels under Kuchik Khan, in which we were neutral unless molested, was just fizzling out. The nearly-completed motor road from railhead at Quraitu on the Iraq-Persian frontier to Hamadan was held by "Percoms," a separate force with headquarters at Kermanshah.

The immediate problems confronting the C.R.E. were :—

(1) Barrack and road maintenance in the three occupied towns, with a personnel that was constantly melting owing to demobilization; (2) upkeep of the 290 miles of road between Hamadan and Enzeli; (3) the institution of some form of control over expenditure.

With regard to the first, the minimum requirements were six field engineers, and two of the existing six had to be released at once. Their places were filled by transferring one of the three (after August, two) officers from the Sapper company, and by making an R.E. Lance-Corporal, who was Acting-Serjeant, an Acting-C.S.M. and Field Engineer, Hamadan, where he was quite satisfactory during the four months for which he was needed there. The F.E. at Enzeli was a middle-aged civilian who had spent many years with a Baku firm and spoke Russian like a native. He was exceedingly good at getting work done quickly, though rather a trial over classifying and reporting expenditure. The other field engineers consisted of a young Territorial officer, whose pre-war engineering experience was confined to a year or two as an apprentice, and who had a curious habit of sleeping on his back with an electric light just above him, while in winter he kept a cat in bed, a large dog on the bed, and the door and window of his 11-ft. square room padlocked; a young Persian of about equal experience, who had been educated in England, fought in France with a British battalion and risen to be serjeant, and had been sent out to Persia when we became involved there; and a temporary R.E. officer who had done engineering work in Mexico, and had lurid tales of the revolutions there. Altogether it was a mixed team.

Subordinates were always a difficulty; there were no British personnel left, and only a few Assyrians of doubtful quality. Two or three excellent men were obtained from the 1/4th Hants (Territorial) Battalion, and by the time that this battalion was replaced by a regular one, which could not produce men with technical

knowledge, the local subordinates had improved in numbers and quality and two British N.C.O.'s had come to the Sapper Company. During the first summer, also, much of the minor repair work, which was the most troublesome and difficult to supervise, was done by the Sapper Company.

At Kasvin, where most of the work was, and at Hamadan, all new work was done by contract. After plans had been shown to contractors, a Dutch auction was held, the man who made the lowest bid getting the contract. Generally speaking, fighting troops were in newly-built barracks and departments billeted in *serais*. All barracks were of sun-dried brick, with mud roofs on *ballis* at a 1/6 slope, and burnt-brick floors. Doors and windows were made up in our workshops and supplied to contractors. This type of building was quite satisfactory provided that it was made sufficiently early in the autumn to let the roof dry thoroughly, otherwise it was apt to leak badly during its first winter. The cost, which had been about 6 krans* per square foot in 1918, was gradually forced down to $3\frac{1}{4}$ krans, which was under $\frac{1}{4}$ of the cost of very similar, though rather better constructed, buildings at Baghdad. Eventually, after contractors had been educated up to it, contracts were made on a plinth area rate basis, a more satisfactory arrangement, because, on a lump-sum contract, it was difficult to change the plan, even in minor details, once the contract was signed, and people nearly always did change their minds about what they wanted. We were much better off for contractors than were Percoms, in whose area contract, and even piece-work, was hardly known when we first went there, while the north-west corner of Persia had been educated by the Russians. At Enzeli, where the soil was mostly sand and the cold was never intense, the troops were in huts with boarded walls and floors, and boarded or sheet-iron roofs.

Except for a few articles, mostly iron, all stores required were obtainable at Kasvin or Enzeli, or in a few cases from Teheran. The Field Park, Baghdad, was supposed to bill us for all stores supplied from there, but never did; we had some reason to think that the bills might be going to Percoms, but naturally did not enquire.

Furniture supply and issue was a big item. In 1920 issue was gladly transferred to the Ordnance Dept., and only the supply in bulk to the Ordnance, which caused comparatively little trouble, remained under the C.R.E.

A noticeable point was the way in which those Assyrians who, after their expulsion from Urumiah in 1918, had stayed with Norper-

* 10 krans = 1 toman = 4/- at normal rate of exchange, but actually varied from 6/- to 10/- till the autumn of 1920, when it went down, reaching 4/- in the spring.

One rupee = from 2 to 3·2 krans (normally 3·6 krans).

force instead of going on to Mesopotamia, set to work to retrieve their fortunes. Nearly all the Works subordinates came from them, and, except for the Kasvin wood-contractor, an imperturbable little Persian, who took with a smile his innumerable fines for late delivery and whose monopoly we tried in vain to break, nearly all the contractors, and certainly all the best, were Assyrians. All those who were taken on as subordinates spoke English, generally with a strong American accent.

Various forms of heating were tried. For the winter 1919-20 stoves burning crude oil were made up and supplied, and, though not universally popular, were very efficient, provided that flues were occasionally cleaned and that the rate of fuel supply was watched. Water drips into the oil as it runs along an open channel into the stove, and turning to steam, helps to break up the oil. The Mesopotamian Force cooker, which works very efficiently on the same principle, was also introduced. For the winter 1920-21, when oil was not available, these stoves had to be turned into the Canadian pattern wood stove. An experiment very successfully tried in the R.E. Mess was an ordinary open hearth, with a 9-in. iron flue just clear of the wall, instead of a brick chimney. In this way nearly all the heat was given out in the room, the top of the flue being barely warm. In the winter of 1918-19 coal slack had been obtained from a mine near the Teheran road and briquetted in an improvised machine with the aid of a small proportion of clay. The Supply Dept. dropped the experiment, but a machine remained in the Field Park, and briquettes were always used in the R.E. Mess. The experiment would be well worth trying again in similar circumstances.

The road from Enzeli to Hamadan had been built by a Russian company, which recouped itself from tolls levied every 40 miles or so. Across the Elburz it ran for 70 miles through some very difficult country. It was well made and drained, but was not soled, and was only lightly metalled. An agreement had been made under which our troops were exempt from tolls but paid a monthly subsidy. Owing, however, to dissatisfaction at the way in which the road was being maintained we had ceased to pay the subsidy in October, 1918, had taken over the upkeep of the road in November, and during the winter had spent about £60,000 on it. For the financial year 1919-20 expenditure on it was to be limited to 120,000 tomans, which was a reasonable amount for normal upkeep.

We had no personnel, except one British officer and one Pole, formerly an engineer officer in the Russian Army, available for the work, but, luckily, the departing field engineer in charge, who had spent so much time in Russia that he spoke Russian better than English, had kept up friendly relations with the Company. An arrangement was therefore come to by which we took over and paid

all their supervising and subordinate personnel that we needed. The local manager of the company himself was made a field engineer, and nominally given charge of a 100-mile sector, though actually he provided another official to do the work and pocketed the difference. In return for this trifling amount we secured his experience and advice, which were particularly useful during the first few months, and the use of the company's plans and records, and guarded against obstruction by any of the company's officials.

The custom was to collect metal by contract during the summer and spread it by daily labour during the autumn, shortly before the snow was expected. In the plain sections it was generally rolled, and on the hill sections allowed to consolidate itself under the snow and traffic. As we had only one steam and one bullock roller that could be made to work, we had to rely almost entirely on the latter method, and it certainly was surprising how well the new metal was consolidated when the snow disappeared. By May there was no time to lose in starting metal collection, and with the manager's assistance contracts were quickly placed. During the summer only permanent subordinates and a few coolies, including gang leaders, were retained, extra coolies being taken on locally when required. The main duties of the one British officer were to act as inspector, and report to the C.R.E., to see that work ordered was being carried out and that coolies paid for were actually present, and to pay all labour himself.

The system worked excellently and without friction. Whenever the road was blocked or damaged, as, in some parts, it fairly often was by local storms of extraordinary severity, the nearest gangs were quickly on the spot and at work. Officially, the company refused to recognize the new arrangement, and sent in a monthly bill for the tolls due since the subsidy ceased, of which they professed to have an accurate record; we retorted with a bill for the amount spent on maintenance, and as nobody on the Russian side had power to settle the question it remained in suspense up to the time of the evacuation; this monthly formality, however, in no way hindered work.

In April, 1919, there was an efficient local audit of all expenditure, and an estimate had to be sanctioned by the local Force Commander before any new work could be started. But there was no sort of control or classification of expenditure; field engineers reported at the beginning of each month what amount they expected to spend during the following month, and that was all the information about the very considerable expenditure going on—something like £5,000 a month—which the C.R.E. received.

Obviously, the first thing to do was to classify expenditure under different headings, Permanent Establishment, Major and Minor Works, Maintenance, etc., and make field engineers show what

they were spending the money on; the next step was to tighten the control and have the expenditure on every job of work, whether new or maintenance, shown separately. Of course, this met with some opposition from F.E.'s, to whom it meant extra work, and probably seemed merely red tape; it must be remembered that from beginning to end there was no officer or subordinate in the force, except the C.R.E., who knew anything about Military Works routine. However, they soon realized that for outdoor work it was really not difficult, and in three or four months the system was working satisfactorily, except in the big workshops at Kasvin, which spent something like £2,000 a month on doors, windows, furniture, stoves, repairs to carts, etc. The classification and allotment of this expenditure really was a big and difficult job, which necessitated the pricing of every article made, and it was found necessary for one field engineer to devote his whole time to these workshops and other office work. At first there was a large discrepancy between the total monthly expenditure and the total output, calculated on the estimated cost of each article, but gradually this was diminished, and by December, when estimates for the next year were called for, every *kran* spent was allotted to some job and to its proper sub-head.

A constant difficulty was that, as there was no policy in London, or, at least, none that could be translated into definite statements of intention, no Works policy was possible. Recommendations or decisions about expenditure had to be made without the slightest idea how long the force was to stay in the country. For the same reason sanction to construct the barracks needed for the winter was always postponed till the last moment, or later, with the result that the roofs leaked badly during the winter after their construction. In 1919 there was no rain till December, and work was completed before it came. But in 1920 no orders were issued, despite urgent requests, till October 4th, and heavy rain fell in November, with snow and frost in December. Barracks and stables for an extra section of R.H.A. were actually ordered on November 9th; luckily, spare barracks were available, for the stable walls crumbled to dust under the frost and the roof was like a sieve.

A fact which added considerably to the interest of all the engineering work was that the force was so remote from Baghdad, and local conditions were so little known there and so different from those in Mesopotamia, that the Engineer-in-Chief left us entirely to our own devices.

The year 1919 passed peacefully. In August the Army of the Black Sea evacuated Trans-Caucasia, except Batoum; this made no difference at the time, as Denikin was in the full tide of success. In August, too, Percoms took over Hamadan and the road as far as Kasvin.

Early in January, 1920, it was thought that a brigade might be

wanted at Tabriz, and an estimate was called for of the cost of making the existing road, from near Kasvin to Tabriz, fit for motor traffic. This estimate had to be based on a very rapid journey, the first 140 miles, which were easy, being done by a Ford van in two days, and the remaining 120, which included two passes with gradients of 1 in 5, being done, partly by cart but mostly by pack, in four days. Except for tea and cocoa local provisions were relied on, in the shape of Persian bread, eggs, honey, and *mäst*, or milk curdled by some ferment which gives it a pleasant, somewhat acid, taste and is said to kill all disease germs. Fortunately, the flea does not appear to have invaded the ordinary Persian guest-house, for neither on this trip nor on others in the Elburz mountains was it met with. Fortunately, too, the winter hitherto had been exceptionally mild, and the maximum amount of snow met with was a few inches; a week after Kasvin was reached again there was a two-days' blizzard, and in a severe winter, such as the next one, communication even with Zinjan on the Tabriz road is broken for weeks at a time. Between Zinjan and Tabriz the country showed many signs of the famine of the preceding winter and of the depredations of the Shahsevans, a robber tribe who, in summer, haunt the district about 40 miles east of Tabriz, many villages being almost or quite deserted.

During the spring of 1920 Denikin's army collapsed, and on April 22nd the Red Army entered Baku. After the Armistice we had formed an armed merchant fleet on the Caspian, mostly Russian-manned, but with a stiffening of British officers and personnel, which forced the Red fleet to keep to the north end of the Caspian. When we evacuated Trans-Caucasia we made the fatal mistake, as it turned out, of handing this fleet over to Denikin. When his administration collapsed and the Bolsheviks seized the port of Petrovsk, the fleet went to Baku to offer its services to the Azerbaijan Republic, but could not accept the terms offered. The only course open to the fleet, therefore, was to come to Enzeli to be interned, which it did. The British Government, which, on the signing of the 1919 treaty with Persia had sent a financial, military and naval mission to Teheran, rushed out a naval party to take over the fleet, but Denikin's collapse was so unexpectedly rapid that on arrival at Baku the party found the town in Bolshevik hands and was made prisoner. At the same time, the melting of the ice at the north end of the Caspian released the Red fleet at Astrakhan, and their authorities lost no time in striking, for at daybreak on May 19th their fleet, escorting a number of transports, opened fire on our troops at Enzeli.

Here two low, sandy, jungle-covered spits of land, each some eight miles long and only a few hundred yards broad, enclose a very large shallow lagoon. The entrance, about 400 yards broad, between

the ends of these spits is kept dredged, and forms the port, with the Persian town of Enzeli on the west and the Russian port and business buildings, forming the suburb of Kaziān, on the east side of the harbour. It was Kaziān that was held by our troops, who had been reinforced up to a strength of two battalions and some pack guns, and had mounted two or three guns of four and five-inch calibre from the fleet. The nearest reinforcement was at Kasvin, where there were half a cavalry regiment, two sections R.H.A., and two battalions.

The enemy fired a few shells, which did no damage, and began to land troops a couple of miles to the east of Kaziān. Militarily, the situation was by no means desperate, for the Red troops were of very little military value, and the fleet, being only merchantmen, could not have remained within reach of our guns. And though their 6-in. guns could have shelled Kaziān from long range, even accurate fire, which the shots actually fired gave no reason to expect, would only have hurt the buildings and not the troops in trenches. It was generally believed, however, and probably correctly, that the G.O.C.'s hands were tied by vague instructions, which, without giving him definite political guidance, prevented him from treating the situation from a purely military standpoint. In any case, a motor-boat with a flag of truce was quickly sent out, the Gurkha company which was driving back the enemy who had landed was recalled, and an agreement made by which our force retired to Resht that night, taking only such baggage as there was transport for on the spot. A fortnight later the force retired to Menjil, and the Bolsheviks, who professed only to have come to Enzeli in order to secure the fleet interned there, occupied Resht and set up a local Red government under Kuchik Khan, while, in spite of many promises, they have not yet (January, 1924) evacuated Enzeli.

This incident resulted in a serious blow to our prestige and in the loss of a very large quantity of petrol (which henceforth had to come from Baghdad), and of a considerable amount of other stores and private baggage. It was an object lesson in the value of sea-power, for the obstacles to an invasion by land were so great that it is improbable that the Bolsheviks would have attempted it if the fleet had remained under its British officers and continued to dominate the southern part of the Caspian.

At Menjil the Safid Rūd, which is fordable in places from about July onwards, enters a rocky gorge several miles long, and is crossed by a bow-string girder-bridge, with one central span of 54 ft. and three others of about 100 ft. each. Here one battalion and the pack battery formed a defensive position, with another battalion ten miles in rear. Two sapper jobs were, first, to prepare the 54-ft. span for demolition, which was easy, and second, to prepare

a length of road in the gorge for demolition. This was much more difficult, for, though the road ran across the face of a rock cliff and at first sight looked easy to demolish, it was found necessary, on calculating the charge, to scarp the cliff below the road vertically to a depth of 30 ft. over a length of 50 yards in order to reduce the L.L.R. sufficiently. Even so, 600 lbs. of powder per mine were required, and five such mines at 30 ft. intervals were prepared, but eventually there was only sufficient explosive available to charge three of them. The result was good, 30 yards of road being blown away and a 45° rock slope left, but it took the enemy only three nights to make it passable for a lorry.

Towards the end of July the enemy approached and made a very half-hearted attack; he also brought up a howitzer which dropped shells into our camping area, and sent out some parties to harry our line of communication. These did no damage, though they succeeded in firing on the G.O.C. in his armoured car and shelled the other battalion's camp on one occasion. However, owing to fear for our L. of C. we suddenly withdrew from Menjil one night, after blowing down the 54-ft. bridge span. It turned out afterwards that the enemy, after a final bombastic summons to our force, had himself retired a day before we did.

Our troops now retired to Kasvin, leaving a tiny mixed force 20 miles out, where the road begins to dip down through the mountains, while a few miles behind this force the Persian Cossacks began to assemble. By now communication with Baghdad was cut by the Arab rising, and it was considered that any withdrawal from Kasvin was likely to bring in against us the Kurds, who live north of the Quraitu–Kermanshah road, so there was no alternative to fighting it out, if necessary, where we were. It had not yet been generally realized how contemptible as soldiers the enemy really were. Fortunately, the force had plenty of ammunition and obtained all essential supplies locally.

About August 20th our advanced force and the hostile force, which was camped some 14 miles beyond it, each decided to try to surprise the other by a night march on the same night. The enemy bumped into one of our camp pickets before dawn and ran away down the road; when a couple of miles from home, they came under a hot fire from our attacking party, which, at dawn, was a short distance above the road, having failed to reach the enemy's camp. The result of this shock was a hasty flight of the enemy, who covered the 100 miles to the Kazian peninsula in three days, hotly pursued by the Cossacks, who had been on the point of taking the offensive, and more sedately followed by us as far as Menjil. At the peninsula, however, the Bolsheviks were reinforced and rallied, the Cossacks came under artillery fire from the sea and probably from the lagoon as well, and a charge by a party of enemy

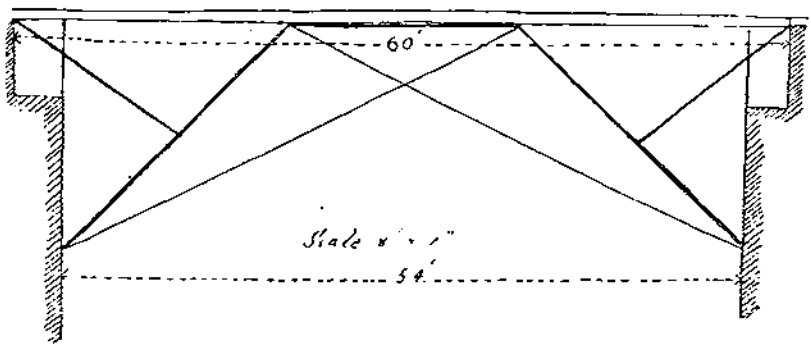
cavalry caused an utter panic, under the influence of which the Cossacks ran away to Menjil even more quickly than they had advanced. Here they were with difficulty rallied, while our force took up a better position 14 miles further forward.

The first job given to the sappers on arrival at Menjil was to build a trestle bridge about 100 yards long across the Safid Rūd, then 3½ ft. deep. The trestles were made from the roof of one of the barracks at Menjil, the road-bearers partly from the same source and partly from some 9-in. by 4-in. steel road-bearers from the big bridge, all the flooring of which had been burnt by the Bolsheviks as they retired, and the barrack floors furnished 6-ft. planks, which made a roadway just wide enough to take an armoured car.

As this bridge would be carried away by the first autumn floods, and, in fact, was carried away before it had been replaced, the depth of water increasing from 3½ ft. to 6 ft. in a single night, orders were given to replace the span destroyed in the big bridge, and to renew the roadway on the rest of the bridge. The materials available consisted of poplar poles up to about 28 ft. in length, poplar planks up to 9 ft., and plain and barbed iron-wire and nails as required; the only plant, besides that carried in the company equipment, was extra 3-in. rope and blocks, and perhaps a few jacks up to 3 tons. The new span was to carry light armoured cars and, if possible, loaded 3-ton Peerless lorries.

As the piers are about 30 ft. high and the bottom was obstructed by the fallen girder, anything in the nature of trestles was ruled out; wisely so, in the light of subsequent events. Calculations had already been worked out for plank girders, but in view of the tremendous gale which blows up the gorge daily except in winter, and the consequent difficulty of handling the girders, accentuated by the absence of flooring on the rest of the bridge, some other solution was desirable. Subsequent experience showed that the area exposed to the wind by the 60 ft. × 6 ft. plank girders would have made them completely unmanageable. At this juncture the head of the Road Company suggested the possibility of taking from one side of the bridge some of the 100 ft. long 9 in. × 4 in. R.S. joints which formed the road-bearers, putting them across the gap, and supporting them by diagonal struts from the piers. (See sketch, p. 262.) This solution was adopted. The existing bridge was about 17 ft. wide, and though two of the joists had already been used for the trestle bridge and lost when it was carried away, it was found possible to extract five more without reducing the width of the roadway below the 12 ft. over all which was wanted. They were taken across the gap by an overhead traveller, well tied to the existing road-bearers, and firmly held on the top of the piers by lime concrete. Each joist was then strutted as shown in the Figure, and the framework braced with barbed-wire Spanish windlasses.

The struts themselves were then strutted and tied in their centres as shown, and cross-braced to each other, and the joists well tied together, with distance pieces.



A single 9 in. × 4 in. joist will not safely take the rear wheel of a loaded 3-ton lorry, and it took some time to find a way of distributing the weight over two joists without making the distance between the two outer joists so small that the chesses would project too far for safety. A solution was eventually found in using extra-heavy chessing, spacing the joists at about 2 ft. 3 in. centre to centre, and placing the wheel guides so that Nos. 1 and 2 joists took one wheel and 3 and 4 the other.

The new span was quite stiff vertically, but it was found difficult to get lateral stiffness, for the barbed-wire ties were rather elastic, but by carrying ties from the ends of the piers under the roadway to its far side and windlassing up as tightly as possible, and using two spars on one side where the piers projected sufficiently, enough lateral stiffness was eventually obtained.

The winter was of abnormal severity, and a fairly sudden thaw in the spring was accompanied by heavy rains, with the natural result of record floods. At Menjil the water rose to the lower edge of the bowstring girders, and trees, etc., brought down either broke or dislodged the struts and ties to such an extent that at the time when our force retired, after being relieved by the Cossacks, no single joist appears to have had both its struts in position, so that the joists were really spanning a 54-ft. gap. Moreover, the central pier of the bridge, at one end of the improvised bay, was showing signs of scouring, and had tilted so that its top was 2 ft. up stream of the line of the other piers, and it was also leaning slightly towards the other pier of the new bay; the R.S. joists were therefore distinctly distorted, and it was fortunate that the ends had been securely fixed, and that no heavier load than a field-gun had to cross.

Meanwhile, the Cossacks had recovered from their panic and gradually pushed the Bolsheviks back to between Resht and Kazian.

Towards the end of October, however, another sudden retreat in disorder took place, due, probably, to maladministration and consequent lack of supplies. This led to the dismissal of the Russian officers and the withdrawal of the Cossacks from the scene till the following spring.

On October 4th General Ironside assumed command of the force with a much freer hand than his predecessor had had, and at once began to issue the very urgently needed orders for the winter dispositions. These included new barracks for a cavalry regiment and British infantry battalion at Kasvin, the re-occupation of Zinjan by a battalion and pack battery, which necessitated numerous minor works and the presence of a field engineer, and finally the conversion of three tumbledown Persian villages into billets for the Menjil column, which included a British and an Indian battalion, section R.H.A., section armoured cars, and half a sapper and miner company. The work at Kasvin and Zinjan gave little trouble, but that for "Menjcol" was much more difficult to arrange for. The work itself was simple, consisting of propping up and repairing roofs, and in some cases making new ones, fitting of doors, oiled linen windows, and stoves, which were all made up at Kasvin, and odds and ends such as a concrete floor for the hospital bathroom. But the autumn rains were already beginning, all the field engineers were fully employed elsewhere, all skilled labour had to be sent down from Kasvin, the area covered was considerable, and, of course, everything was being clamoured for at once. The work had to be put in charge of the sapper and miner subaltern, with such scratch assistance as could be raised, till the completion of one set of Kasvin barracks released one F.E. and our best contractor. Eventually the troops were, if not made comfortable, at least housed in comparatively weather-proof buildings. An "Operations" heading in the expenditure account did away with any loss of time in preparing estimates for the work for Menjcol. One or two sharp lessons made the Bolshevik patrols keep well away from our area, and the troops remained undisturbed by the enemy, who displayed no further activity until after we had handed over to the Cossacks and withdrawn in April.

Hardly had the work for Menjcol been completed when heavy snowfalls began to block the road, but an account of our efforts to keep it open, and of the work connected with the withdrawal in April, has already appeared in the *R.E. Journal* for October, 1922.

SUTLEJ RIVER HYDRO-ELECTRIC SCHEME.

An Appreciation.

By Maj.-Gen. A. C. de L. Joly de Lotbinière, C.B., C.S.I., C.I.E.

After certain preliminary surveys, river gaugings, etc., by P.W.D. Engineers, the Punjab Government in October, 1919, entrusted the preparations of this project in detail to Lieut.-Colonel B. C. Battye, D.S.O., R.E.

Battye's first step was to collect a staff of capable men, amongst whom were :—

Major R. N. Aylward, D.S.O., M.C., late R.E.
Major G. H. Hunt, M.C., late R.E.
Lieut. A. Guthrie, R.E.
Mr. R. K. Sibou.

The preparation of the project was then taken in hand in a thorough and systematic manner, each officer was allotted his section of the project, and the result has been a most exhaustive and comprehensive investigation of the project from every point of view.

The results of the above engineers' work have been embodied in five volumes which form most interesting and instructive reading, as every aspect of the generation, transmission and distribution of power over a large area of country has been fully discussed and investigated, and described in detail with illustrations.

As a rule people consider a hydro-electric power installation must be a most wonderful and complicated undertaking, as the electrical end of it consists of a mass of technical calculations and names which, to the uninitiated, convey little, but are really simple to an engineer.

The electrical end of the work is highly technical, but as long as the water-wheels turn round it is a matter of certainty as regards the electrical results.

What is a paramount and vital necessity to a hydro-electrical installation is to ensure the turbines turning day and night from year's end to year's end.

It is the solution of this problem which calls for engineering skill, resource, forethought and design. Having once solved this problem, and provided for every contingency, including extraordinary climatic conditions, the rest of the problem, *i.e.*, the generation, transmission

and distribution of the power, generated by the turbines, is more or less a question of calculation and absolute certainty.

Electrical energy, in infinitesimal or gigantic volume, can be handled with equal certainty of results. The hydraulic question, however, is a far more unknown and difficult problem.

The fascination of a hydro-electric project lies in the harnessing of nature's energy, *i.e.*, in the extraction of the power derived from falling water, and no two schemes are similar in every detail. Every scheme has its own problems to be solved and contingencies to be provided against, and it is the engineering ability and foresight displayed in securing a continuous supply of water to the turbine which means the success or failure of the whole undertaking.

No amount of skill, money, or forethought devoted to electrical generators, transformers, transmission lines, or distribution, can result in anything but failure if the motive power breaks down.

In order to secure this motive power as far as engineering skill can secure it, the following points must be thoroughly investigated and provided for.

1. What is the minimum flow in the river, or from the river and impounding reservoir combined, that can safely be counted upon ?

The solution of this question can only be based on a series of river gaugings carried over a number of years, in which both the flood discharge and minimum flow are accurately measured.

2. The siting of the Head Works is an important point, and future enlargements of the installation have to be borne in mind.
3. The safe leading of the water, by open channels, by flume, by tunnel, or by Penstock to the forebay above the power station, or direct to the turbines, is always a question calling for great deliberation and skill.
4. Then comes the question of head to be obtained, the siting of the power house, disposal of tail-race water, and security of building from floods.
5. Financial questions must largely enter into all the above decisions, but it is bad policy to take the slightest risk of failure by saving money on any of these works.

The amount spent on any of the hydraulic components of the scheme must not be allowed to interfere in any way with the security of these works.

Turbines may be replaced, if not suitable, and all plant in the power station may eventually be discarded or replaced when worn out, but the bedrock of the whole scheme, *i.e.*, the continuous supply of water to the power house, must not be imperilled in order to save money in the first case.

ENGINEER WORK WITH NORPERFORCE IN 1919-20.

Pass near Tabriz, on Tabriz-Kasvin Road.

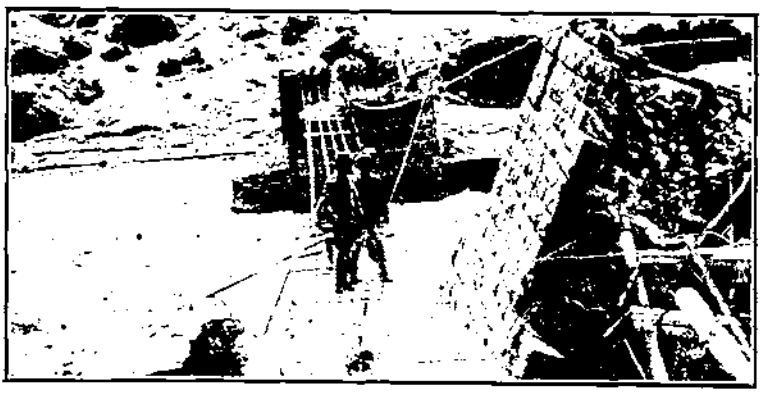
Tabriz Road, near Haji Agha.

Kasvin-Resht Road, below Yuzbashichai.

Kasvin-Resht Road, below Yuzbashichai.

Menjil Bridge.

Menjil Bridge, after the pier had gone. April 21.



Menjil Bridge, after the pier had gone. April 21.

Menjil, showing effect on the trees of wind always blowing up the gorge.

Having carefully gone over Lieut.-Colonel Battye's proposals and solutions of all the above points, I consider the scheme, as submitted by him, embodies a carefully, skilfully-planned and complete project, and one which, if carried out, will stand the test of time.

The details of the scheme, as submitted by Lieut.-Colonel Battye, together with the plans and estimates, fill five volumes. It is therefore impossible for me to do more than give a broad outline of the proposal in a short article. Officers wishing to study the subject of hydro-electrical generation and transmission of power will find it will well repay them to go carefully through the details of this great project, a complete copy of which will be found in the R.E. Library.

The proposal, broadly, is to take advantage of the fall in the Sutlej River, which occurs in a great loop of about 50 miles in length which the river forms in issuing from the hills. The river, in issuing from the hills, is met by a spur which forces it to change its course from south to north-east and back again south-west. The loop so formed is about 50 miles in length and the distance across the neck of the loop is about 5 miles.

The difference of level between the surface of the river across the neck is 443 ft. Owing to the gentle slope of the ground on the south side of the range 79·5 ft. cannot be developed to advantage, but by excavating an artificial tail-race 40 ft. deep a total net head of 328 ft. will be available after deducting loss of head in tunnel and penstocks.

It is proposed to drive a 20-ft. diameter tunnel through the neck; this tunnel will have a length of 2·16 miles; from the lower end of the tunnel five 10-ft. diameter steel pipes 1·8 miles in length will convey the water under a pressure of 328 ft. head to the turbines in the power house.

The discharge (minimum) of the river from a series of gaugings extending over a number of years has been taken as 3334 cusecs, and in the first case it is proposed to install plant to utilize this discharge only.

This flow of 3334 cusecs under a head of 328 ft. will generate 80,000 kw.

As demands arise for further power it is proposed to build a dam to impound flood water, to supplement the available winter flow. This dam would have a height of 140 ft. and would impound sufficient water to ensure a discharge of 6,600 cusecs all the year round.

The main transmission lines will have a length of 195½ and 185 miles with a pressure of about 140,000 volts. Branch lines pressure, 44,000. Three-phase alternating current at 50 cycles will be employed, as this will do for both power and lighting.

Detailed descriptions of all hydraulic and electrical plant in the

power house and transformer buildings, transmission lines, sub-stations, etc., are given in the estimate.

The question of financing the scheme and the probable returns to be anticipated are also carefully gone into, and from the figures given it is shown that eventually the scheme will pay well.

Personally I consider that the financial forecast of returns is conservative, and that the sale of power after the plant has been in operation for a couple of years will be considerably in excess of that anticipated.

Cheap power has a magnetic influence on industries and manufacturers, and draws them irresistibly within reach of the tentacles of a power station, when it is realized that the power can be depended upon, and that contracts for a long period of years can be made at rates for power which will not vary as does the price of coal. When once this truth is grasped the demand for power should quickly reach the capacity of the generating plant.

I was speaking to a Canadian manufacturer last week who has recently made a contract, extending over a long term of years, for the supply of 200,000 h.p. He is building his mills in the vicinity of the hydro-electric power station, in order to obtain power at a bedrock price. The plant to supply this power is not yet completed, but I venture to predict that, when it is ready to operate, the whole of its output will be sold.

India has not yet generally reached the stage of fully appreciating the blessings of cheap power, but when it does, then the many snow-fed rivers of the Himalayas will be used to their full power capacity.

I sincerely trust that this great undertaking in the North of India will be put in hand without delay.

THE KHYBER RAILWAY.

(Reprinted from *The Railway Gazette* of 17th September, 1923.)

THE CONSTRUCTION OF THE KHYBER RAILWAY, ONE OF THE MOST REMARKABLE LINES IN THE WORLD, IS PROGRESSING RAPIDLY. IT WILL CONNECT INDIA AND AFGHANISTAN.

The Government of India decided in 1920 to construct a railway over the Khyber Pass from Jamrud, the present terminus of the North Western Railway of India, to the Afghan Frontier as a single 5 ft. 6 in. gauge adhesion line. The total length is 26·84 miles, but only 26·13 miles will be laid up to Landi Khana, the remainder being formation up to, and just across, the Tora Tigga nulla in the direction of Dakka. The mileage is calculated to the centre of the four reversing stations, two on the ascent and two on the descent (including Landi Khana). The whole railway lies in independent territory in the Khyber Agency of the North-West Frontier Province, and it is contemplated to carry the formation up to the boundary with Afghanistan.

The reduced level at Jamrud is 1,496, at Landi Kotal (the summit) it is 3,495, and at Landi Khana it is 2,622.

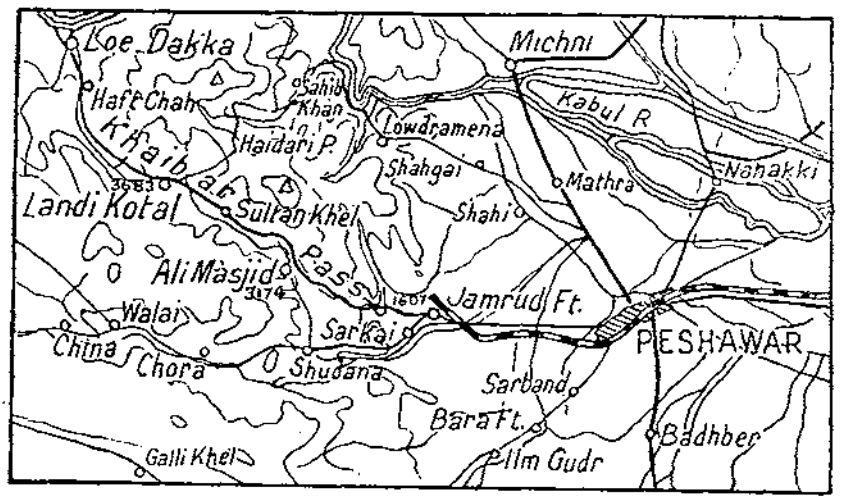
There are altogether 2·55 miles of tunnels, but none exceeds 1,400 ft. in length. There are only two high viaducts, one 55 ft., the other 80 ft. in height. There are seven crossings of the Khyber nulla, but bridging is, otherwise, not heavy. There are 10 crossing stations on this railway, but it is proposed to open eight only, and to leave two as "flag" stations to be laid and worked in case of a large increase of traffic.

In the location of the line political considerations had naturally to be given considerable weight, and for convenience of description it may be divided into sections between controlling points and described as follows :—

(*a*) From Jamrud to the jaws of the Pass the earthwork is comparatively light near Jamrud, but gets heavier and heavier with a deep cutting at the jaws in limestone.

(*b*) From the jaws of the Pass the line swings right-handed and crosses the Bagiari nulla and the Khyber motor road by a bridge of five spans of 40 ft. with piers 55 ft. high. Thence, swinging left-handed again through two tunnels, it crosses the Kafirtangi nulla on a bank 60 ft. high and reaches the lower reversing station, Medanak, at mile 5.

From there it follows the main Kafirtangi nulla until it passes through the spur by the long curved Kafirtangi tunnel (1,400 ft.) and, climbing up its south face, crosses the spur in cutting near its summit to reach the second reversing station, Changai, at mile $6\frac{3}{4}$. These two reversing stations, $1\frac{3}{4}$ mile apart by rail, are thus strikingly situated one above the other on the same hillside with a difference of level of 184 ft., though only some 350 ft. apart in plan at their nearest points. The staff for both will be accommodated in a defensible tower on the crest of the ridge, which commands a fine view of the eastern side of the pass and the vale of Peshawar beyond.



(*c*) From Changai reversing station towards the Shagai plateau the line first follows the Changai spur, crossing over the top of the Kafirtangi tunnel. It keeps on the south side of the spur, which is very steep and denuded of soil like most of the hillsides in the Khyber. Though the dip is favourable, the cleavage of the shale beds makes them none too stable and heavy work, including four tunnels and a 45-ft. retaining wall, is required. At the point of junction of the spur with the main mass the line curves to the south and passes in tunnel through Barley Ridge, which may be regarded as the edge of the plateau. It then follows a winding ravine, a tributary of the main Khyber Nala, to a comparatively good station site on the plateau, close to the two roads at this point.

(*d*) From the Shagai Plateau through the Ali Musjid gorge, the approach to the gorge is barred by two long spurs with two deeply indented ravines. It is necessary to tunnel through both spurs and to have heavy banks in the ravines. The line has been taken through the gorge at a high level, since both roads have been taken at a low level and the interference with them at a lower level would have been intolerable. The gorge consists of stratified limestone in thick layers. Although aggregating 3,360 ft., the tunnels can be pierced from many faces and adits and will probably require very little full lining. The

grade through the gorge is level so as to bring the line down to valley level at Katakushta, and also on account of the very strong winds which blow in certain seasons.

(*e*) From Katakushta to Landi Kotal. In this section the earthwork is heavy in a few places only, but the Khyber stream wanders from side to side and altogether seven crossings (major bridges) are necessary. The station side at Landi Kotal lies to the south of the curved Ghatzai Ridge, somewhat away from the camp, but it is necessary to tackle the descent to Landi Khana.

(*f*) From Landi Kotal to Landi Khana. Here the grade has become 4 per cent. At first the drop in the main water course is comparatively easy, though waterfalls make it impossible to keep close to the valley for long. The side ravines are deeply indented, making it necessary to tunnel through the spurs and introduce one viaduct. But at Michni Kandao the country falls right away. The spurs become more indented than ever on the north. On the south the slopes are very steep and are unstable for geological reasons. It was necessary to curve northwards, to tunnel through the long spurs and attain the Tora Tigga nulla, which flows into the main nulla below Landi Khana. A reversing station was sited as high up this nulla as possible and the 4 per cent. grade was then barely sufficient to keep down to the general rate of fall. The side ravines are deeply cut and the earthwork is very heavy. Between Landi Kotal and Landi Khana there are 15 tunnels aggregating 1¼ miles.

The terminus at Landi Khana is on ground which cannot be described as ideal by any means, but it is situated well within the frontier.

GRADES.

The ruling grade from Jamrud to Shagai is 3 per cent. (1 in 33·33), from Shagai to Landi Kotal (the summit) it is 2·5 per cent. (1 in 40), except for a length of 4,000 ft. on 3 per cent. This length can usually be operated by taking a run at the grade, but the high winds will probably restrict loads to the same as on the 3 per cent. grades. From Landi Kotal to Landi Khana the descent is on a 4 per cent. grade. All grades are compensated for curvature at the rate of 0·30 per cent. for a 7-degree curve or 0·043 per degree of curvature. The same compensation is given for the very few curves of easier radius. As a comparison it may be mentioned that the steepest grades on the motor road are about 1 in 9 and 1 in 13 respectively.

Vertical curves 200 ft. long have been introduced at changes of grade, approximating to a curve of 3,274 ft. radius on a 4 per cent. grade.

CURVATURE.

The sharpest curve is of 7 degrees (818·51 ft. radius). This is practically the same as the curve to a turnout with a 1 in 8½ crossing

for the 5 ft. 6 in. gauge; 51·8 per cent. of the line is on a curve. Transition curves will be 105 ft. long, equal to 15 ft. per degree of curvature. This gives a rate of increase of super-elevation of 1 in. in 30 ft., assuming super-elevation for 25 miles per hour.

GEOLOGY.

The rock generally consists of a hard deep-blue or black shale, sometimes splintered with soft pockets in it, and bands of limestone often of considerable thickness. The slopes are much denuded of soil, which has accumulated to a considerable thickness in the bed of the Khyber valley and in the fans of debris extending outside the Khyber range on both sides. This soil contains a high proportion of boulders small or large, and the lime abounding in the range causes a certain amount of cementation. None of the soil is comparable to the silt of the Peshawar vale, for instance, much less to that of the great plains of India. The larger ravine beds are deeply scoured and filled with debris to a considerable depth, so that rock founds to bridges are obtainable only on the slopes.

The slopes are extremely steep, even precipitous in places, such as in the Ali Musjid gorge, and there are several small waterfalls. Owing to the scanty and stunted vegetation the rain, which rarely falls on the area, has a high proportion of discharge. The larger waterways are dry for long periods, but come down as a wall of water after rain. Some of the water may be absorbed in those beds which have a long length of loose debris. There is a well defined strike in the rocks running east and west and a steep dip of 40 to 55 degrees to the north. Consequently the line has been located as far as possible on the southern slopes and where not so located has been kept in bank generally.

The water-bearing area is limited, although small springs can, in a good year, be found in several places. The last two years have been deficient in rainfall. There are, however, strong springs in the Ali Musjid gorge, and above Landi Khana. These are possibly snow-fed, but their persistence is mysterious, for the steep dip would bring their horizon to the surface in quite a short distance. The country is said to be liable to earthquake, but in the last three years no more than moderate shocks have been experienced.

Although a careful look-out has been kept for them, no fossil or useful minerals have so far been found, except a black substance described by the Director of the Geological Survey of India as "very inferior coal," which would not repay working.

CONSTRUCTIONAL DIFFICULTIES.

The line is unique in being situated entirely outside the administrative border of British India in the strip of the tribal territory which separates it from Afghanistan and over which only a limited

degree of political control is possible. For this reason all the "contractors" employed are influential tribesmen who have had no experience of such heavy work. All skilled labour has therefore to be imported and is in nearly all cases directed by the railway engineers themselves, the only important exception being that a European contractor with tunnelling experience has been actively associated with the tribesmen "contractors" in the case of 11 out of the 32 tunnels on the line. The unskilled labour employed consists almost entirely of local tribesmen. All the staff and the labour employed on the line have to be accommodated in camps with defensible perimeters formed by wire entanglements, for protection against tribal raids; and this principle has also to be applied to the permanent station buildings.

Good limestone for building is found in a few places, and when burnt it provides a pure "fat" lime. Bricks are being burnt at Islamia, near Jamrud, and at Landi Kotal, but are only used for tunnel lining. Brick-bats are ground at the kilns to a fine dust, called *surkhi*, which, when mixed with the fat lime, acts as an artificial *puzzolana* and forms a fair hydraulic mortar. But it is found in many cases that cement concrete is cheaper than either brick or stone construction, now that a large supply of first-class cement is obtainable in India at a fairly reasonable price from the Bundi Cement Co. Ltd.

The Permanent-Way.

The line is being laid with a heavy flat-footed rail of the British Standard section on deodar sleepers with bearing plates and dog-spikes. The standard points and crossings have 12-ft. switches and a crossing angle of 1 in $8\frac{1}{2}$ to suit the 7-degree curves. Each station will be protected by a slip siding at its lower end to prevent loose vehicles running away on to the main line, and by a catch siding at its upper end by which a train descending at a dangerous speed can be diverted on to a very steeply rising line with sanded rails, and brought to rest without damage.

It is proposed to work the line with the heavy 2-8-0 goods engine already in use on the North Western Railway. Each train will be fully vacuum-braked and will have two engines, one at each end; the maximum load of goods trains will consist of 22 four-wheeled vehicles (about 385 tons gross). Although this train would only require a length of about 700 ft., the sidings are actually 1,100 ft. long to allow for longer trains of lighter passenger vehicles or for the introduction of more powerful engines, which the new running dimensions make possible. This is the first 5 ft. 6 in. gauge line to be built to these dimensions, which were recommended for important lines by the Government of India in 1921 and allow for a maximum running width of 12 ft. and height of 16 ft. instead of

10 ft. and 13 ft. 6 in., respectively, as at present. All bridges are being built to the latest Indian standard loading, *i.e.*, an axle load of 24 tons.

PARTICULARS OF PLANT USED.

The increasing cost of labour in India has rendered economical the use of construction plant and methods usually found only in more civilized countries. A large fleet of "Sentinel" steam wagons and Fiat lorries is being employed for the transport of materials both up the main road and on the service roads up various side nullas constructed specially for railway purposes. Their cost is only about two-thirds of that of country bullock carts. In the tunnels, drilling is being done by Ingersoll-Rand jack-hammers, the compressed air for which is supplied by portable petrol-driven air compressors by the same makers. These have been hauled up the mountain sides to work in many places where no heavier type of plant could have been taken. The larger tunnels and labour camps are lit by electric light supplied from generating sets of Petter & Parsons engines coupled to dynamos made by the Lancashire Dynamo and Motor Company. Ransome concrete mixers are in use on some of the large bridges and retaining walls, while for the construction of buildings the Australia concrete block-making machine, fed by a small Tonkin mixer, has proved most successful. In a country where timber does not exist and has to be imported at great cost, the use of the self-climbing steel shuttering, made by the Climbing Steel Shuttering Company, has proved of great value, not merely in the construction of ordinary walls but even in mass concrete work for retaining walls and culverts. Many of the latter are being made of the curved "elephant shelters," familiar as the roofs of dug-outs to all who served in France, with a ring of cheap concrete above them.

The estimated cost of the line is approximately Rs. 1,97,00,000, and it is hoped to be able to open for traffic next year. The survey and earlier stages of construction were under the direct charge of Lieut.-Colonel G. R. Hearn, D.S.O., R.E., Engineer-in-Chief, acting directly under the orders of the Railway Board. Since his appointment as Chief Engineer of the Eastern Bengal (State) Railway the administration has been placed under the North Western (State) Railway, of which system it will form an extension. Major E. P. Anderson, D.S.O., R.E., is in direct charge as Superintendent of Works, with Mr. V. Bayley, C.I.E., and Captain J. R. Roberts, M.C., R.E., in charge of the two construction divisions, and Mr. A. Maitland in charge of a third division comprising the stores, workshop, and charge of running and repairs to plant throughout the line.

REINFORCED CONCRETE CHIMNEY SHAFT AT THE ELECTRICITY WORKS OF THE CITY COUNCIL, GIBRALTAR.

By MAJOR H. E. COAD, A.M.INST.C.E., S.R.E.S.

THE original steel chimney of the Electricity Works, 90 ft. high, 3 ft. 9 in. diameter, of $\frac{3}{8}$-in. metal, erected 20 years ago, having corroded to an unsafe condition, it was decided by the Gibraltar City Council to replace it. After consideration of brick, steel and reinforced concrete shafts, the latter construction was decided upon. The Crown Agents for the Colonies were accordingly communicated with, and eventually the Yorkshire Hennebique Contracting Company, acting as contractors executing the design of Messrs. L. G. Mouchel & Partners, Ltd., obtained the contract.

The contractor stipulated that the foundation subsoil should be guaranteed to bear 3 tons per square foot, and the Council accordingly prepared the necessary concrete foundations to ensure this.

A flue temperature at the top of the new shaft of 800° Fahrenheit was calculated for, although 400° Fahrenheit at the base of the old shaft had been the maximum recorded.

A reinforced concrete buttressed foundation, deep enough to contain the two flues, which are of arched section 3 ft. 9 in. wide and 7 ft. 6 in. high, was first prepared, and on this the reinforced concrete blocks of the shaft proper were laid. These blocks, as shown in the drawing, are of five different sections of equal depth of 10 in., varying as the shaft rises, from $38\frac{1}{2}$ in. to $25\frac{1}{4}$ in. long and 8 in. to 4 in. thick. One end of each block is hook-shaped, to take the vertical reinforcing bar in each of the 10 vertical joints, and these joints are further strengthened by $\frac{3}{16}$-in. stirrups.

At each horizontal joint is a circular reinforcing bar which is laid in cement mortar in a V-shaped groove in the top surface of the blocks.

The blocks themselves carry reinforcement of two horizontal bars spaced above each other, and these turn around the hook, giving strength to the weakest part of the block. These reinforcing bars are connected vertically with a $\frac{3}{16}$-in. wire. The blocks were cast in moulds and are of concrete made to the following specification:—

" Unless the proportion of voids in the aggregate is greater than 50%, the concrete shall be mixed in the following proportions:—

6 cwts. of cement,
$13\frac{1}{2}$ cubic feet of sand,
27 cubic feet of aggregate.

The proportion of voids in the aggregate shall be accurately determined by the contractor, from time to time, and if the proportion of voids exceeds 50%, the volume of sand and the weight of cement shall be proportionately increased, and the mortar shall never be poorer than the foregoing specified quantities."

The blocks took three to four days to set sufficiently to be moved from the moulds.

The height from ground line to summit of the new shaft is 101 ft. 10 in., the internal diameter at the base is 10 ft. 6 in., and at the top 7 ft. A 4½-in firebrick lining is carried to the top of the shaft, giving a minimum air space of 2½ in. between the lining and the concrete.

The time for erection was six months, and the whole work was carried out by a small gang, consisting of a foreman, a constructor, 2 bricklayers and from 4 to 6 labourers.

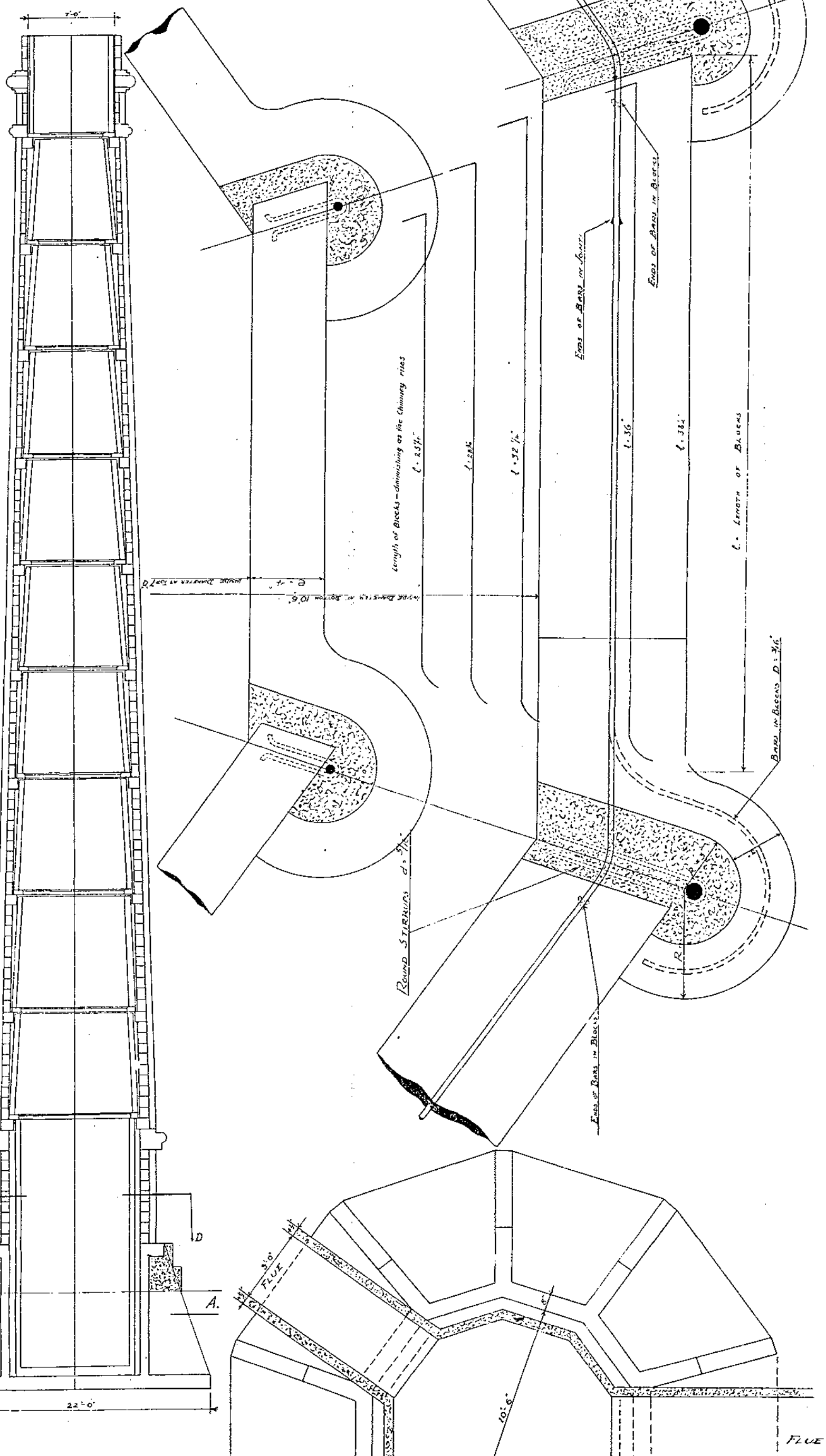
No external scaffolding was employed; an internal stage, supported on four of the firm's patented expanding putlogs, being gradually raised as the work proceeded. These putlogs consist each of two loose steel rods sliding inside and at each end of a steel pipe to which they are rigidly fixed by studs when in position. The outside ends of the rods are splayed, so as to fix easily in the horizontal joints of the chimney.

An electric power winch was used for lifting the blocks inside the shaft.

By these means, the constructional part of the work was of the simplest description and at the same time extremely efficient.

The cost of the shaft complete from foundation level, with outside steel ladder and lightning conductor, was £1,850.

CHIMNEY AT GIBRALTAR.



HISTORY OF THE 12th COMPANY ROYAL ENGINEERS.

By LIEUT. M. R. CALDWELL, R.E.

INTRODUCTION.

IT is a very difficult task to trace the work or continuity of any particular Company, during the early days of the Corps, as Royal Military Artificers and Royal Sappers and Miners, owing to three causes; first, to the fact that between 1778 and 1815 the Corps was being constantly increased and reorganized; second, because, subsequent to this, owing to reductions in the Army generally, many companies were disbanded; and third, because it was a very old-established custom for the Companies to be known by the names of their respective stations, so that when they are numbered for the first time, and again renumbered and moved, records become somewhat confused.

However, as far as the history of the 12th Company is concerned, there are four well-defined periods into which it falls. First, at the end of the eighteenth and beginning of the nineteenth centuries until 1817, the old Nova Scotia Company; second, from 1819 to 1834; third, when an extra "Service" Company was formed in 1846 and called the 12th, subsequently becoming a Fortress and afterwards a Depôt Company until 1885, and fourth, from 1885 onwards, since when the 12th has been a Field Company.

In spite of the fact, however, that these four periods represent four different units, each of which in turn bore the same number, and not four phases of the same unit, the three former periods will be sketched briefly from the point of view of general interest.

PART I.

Under a Warrant dated September 5th, 1806, by which the Corps of Royal Military Artificers was increased and reorganized, numbers were for the first time allotted to Companies.

The one given the number "12" was the old Nova Scotia Company which had already been in existence some years and was stationed at Halifax. It had been first formed under a warrant bearing the date 21st July, 1784, when it was laid down that at each of ten stations, among which was Nova Scotia, there should be one Company. The original officers with the Company were Captain John Cambel and Lieutenant William Booth, whilst on January 1st, 1801, Captain William Fenwick is mentioned as commanding, with Serjeant John Catto as his Serjeant-Major.

At the time when the number " 12 " was first given to the Company Captain William Bennett was the Commanding Officer.

The drill and discipline of the Companies stationed abroad at this time appear to have left much to be desired, owing perhaps to the small importance attached to soldierly appearance and achievements as compared with " the Works." Also a large number of the N.C.O.s and men were often much too old. However, about 1808, Lieutenant John Oldfield of the Royal Engineers, an officer who subsequently rose to distinction, and who had previously held the position of Adjutant at Portsmouth—the then model station for discipline—was removed to Halifax and appointed Adjutant there.

The materials upon which he had to work were mostly old in years, unused to very strict discipline and somewhat addicted to intemperance! In spite of this he managed, by means of regular drills, to mould them to an appearance which enabled them to march past creditably with the Line on Sunday Garrison parades! But, although not very tight and tidy soldiers, they were very valuable artificers and good workmen.

The practice of calling the Companies by numbers soon fell once more into disuse and although the Company still remained at Halifax, the number " 12 " had disappeared by the time the Corps was once more reorganized in May, 1812, in four Battalions of eight Companies each. The Company was then called the 5th Company of the 4th Battalion. Each Company consisted of 89 rank and file.

By a warrant of March 6th, 1813, the title of the Corps was changed from " Royal Military Artificers " to " Royal Sappers and Miners."

There seems to be but little record of the activities of the Nova Scotia Company, except that in 1809 one of their N.C.O.s was employed on a tour of inspection of the works on Cape Breton and Prince Edward Islands, while in August and September, 1814, a detachment of a Colour-Serjeant and 6 men under Captain Gustavus Nicolls was attached to Sir John Sherbrooke's expedition, and was present at the capture of Moose Island, Castine and Belfast (Maine). After this the Company was mainly employed on harbour defences and the works on Sherbrooke's Tower on Mangers Beach.

In February, 1817, the 4th Battalion was disbanded and with it of course the one-time 12th Company. It was replaced at Halifax by the 2nd Company, 3rd Battalion, from Woolwich, in 1818.

PART II.

In 1819 a further reorganization of the Corps took place, the three Battalions being abolished and the Companies once more numbered consecutively.

The 12th Company was formed at Portsmouth on March 1st under the command of Captain and Brevet-Major T. Blanshard, R.E.,

C. Upton being the Colour-Serjeant, there being in all 75 rank and file.

In March, 1822, the Company embarked on H.M.T. *Salisbury* at Plymouth and sailed for Bermuda. Here they remained until April 25th, 1829, when the Company, under the command of Captain R. Kelsall, embarked for Home on the *Flora*, disembarking early in May and proceeding to Woolwich.

After 21 months at this station the Company moved to Chatham in February, 1831, for two years, when they were once more ordered to Bermuda, embarking on the transport *Orestes* at Woolwich on 1st March, 1833, and arriving at Ireland Island, Bermuda, on the 31st.

While here, Lieut. A. C. Orlebar met with a fatal accident, being drowned by the upsetting of a boat while out sailing near St. Georges on 10th February, 1834.

The Corps was now down to a total of 12 Companies, three of which were Survey. The Companies were therefore re-arranged and renumbered, the old 12th Company becoming the 5th and the number " 12 " once more disappearing on February 28th, 1834.

PART III.

On April 1st, 1846, a new Company of Royal Sappers and Miners —the 12th—was formed at the Depôt at Woolwich under the command of Captain Theodosius Webb, R.E., with Michael Bradford as the Colour-Serjeant, and an establishment of 100 N.C.O.s and men.

In August, 1846, the Company proceeded to Chatham for a short time, returning to Woolwich in March the next year.

On September 26th, 1848, the Company, under the command of Captain G. C. Baillie, embarked at the Royal Arsenal on the *City of Manchester* for Gibraltar, where they relieved the 11th Company. They remained here eight years, during which time one of the officers—Lieut. Gilley—died of phthisis on the 18th June, 1856.

On August 30th, 1856, a cadre of the Company under Colour-Serjeant P. Leitch, embarked for Home on the *Crest of the Wave*, disembarking at Portsmouth on September 14th and proceeding to Chatham. Here the Company was once more made up to strength, none of the old officers and but few of the men, however, being still on its rolls.

Colour-Serjeant Leitch, who had won considerable honour in the Crimean Campaign, notably before Sevastopol, and had been awarded the Legion of Honour and been recommended for the Victoria Cross, had been transferred from the 2nd Company soon after they arrived at Gibraltar in 1856.

After the Crimean War the Army was considerably reorganized, and the unsatisfactory practice of having the officers and men in two separate Corps was at last abolished, the Royal Engineers and Royal Sappers and Miners being amalgamated, and the following appearing in the *London Gazette* of October 17th, 1856: "The Queen has been graciously pleased to direct that the Corps of Royal Sappers and Miners shall henceforward be denominated the Corps of Royal Engineers."

The Company was not to remain at Home long, however, for it embarked under the command of Captain M. S. Whitmore on the *City of Manchester* on May 18th, 1858, and, sailing for South Africa, disembarked at Algoa Bay on June 5th, whence they proceeded to King Williamstown in British Kaffraria.

On June 2nd the award of the Victoria Cross to Colour-Serjeant Leitch was gazetted.

The Company remained in all nine years in South Africa, spending 20 months at King Williamstown, 5¼ years at Cape Town and 26 months at Grahamstown. While at the latter place, one of the officers—Lieut. H. P. Cole—died of illness on 14th April, 1862. The Company was mainly employed on ordinary R.E. duties and repairs to a number of detached infantry barracks of a temporary nature.

During this period two infantry officers—Captain Henderson of the 10th Foot and Lieut. J. M. Grant of the 85th Regiment—were attached for some time as assistant engineers.

The whole time the Company was in South Africa it was considerably scattered, always having large numbers of detachments at various stations.

The Company quitted the Cape on 16th April, 1867, arriving at Chatham on the 10th June.

On 1st September, 1867, Colour-Serjeant Peter Leitch, V.C., left the Company. He had served in it continuously as Colour-Serjeant for eleven years, being with it at Gibraltar, Chatham, South Africa and Chatham again! One imagines very nearly a record!

In May, 1868, the Company moved out to Wouldham for training for four months, afterwards returning once more to Chatham.

On 8th April, 1869, the Company embarked and proceeded to Camden Fort, Cork, where they settled down for four and a half years, and were mainly employed on the construction of batteries of the then new Moncrief disappearing gun pattern. In December, 1873, they were sent to Aldershot. After two years here, the Company moved to Chatham for a short time, prior to embarking on 24th January, 1876, for Bermuda. Here they remained for nearly three years, moving once more in November, 1878, this time to Malta.

On the 11th May, 1881, the Company re-embarked for Home for

the last time, proceeding to Chatham, where it became a Depôt Company.

It remained there for four years until, in April, 1885, as a result of reorganization, the Depôt Companies gave up their numbers and were numbered "A" to "G," the 12th Company becoming "A," thus closing the third part of its history.

PART IV.

CHAPTER I.

12th and 23rd (Field) Companies formed.—In May, 1885, owing to the necessity for more Field Service Units, two new Field Companies were formed and numbered the 12th and 23rd, being stationed at Chatham and Aldershot respectively, their mounted sections coming from the R.E. Troops at Aldershot.

During the next two years the number of the Field Companies was raised to nine, one (the 24th) being in Egypt, and of the remaining eight, the 7th, 11th, 17th and 23rd, being on a war footing of 188 all ranks, known as the Higher Establishment, while the 12th, 26th, 37th and 38th, consisting of 103 all ranks, were on the Lower or Peace Establishment. These eight Companies were known as the 1st and 2nd Field Battalions, and formed part of the 1st and 2nd Army Corps respectively.

The first Commanding Officer was Captain K. MacKean, who did not remain long, however, being succeeded in January, 1886, by Captain J. C. Tyler, the inventor of the tool cart, who was faced by the task of having to organize and train a practically unformed Company. There was at this time no regulation drill for Field Companies, and a modification of the old A and B Troop Drill was usually carried out according to the ideas of the individual officers commanding. Neither had the equipment been standardized, the 12th Company being one of the few units in possession of the "Tyler" tool cart, then somewhat of an innovation.

Move to the Curragh.—On August, 19th 1886, the Company, which consisted of three officers (Capt. J. C. Tyler and Lieuts. F. M. Glubb and A. H. Cowie) and about 100 other ranks (30 mounted and 70 dismounted) with 26 troop horses, left Chatham, and, embarking on H.M.S. *Assistance*, arrived at the Curragh on the 22nd, where they settled down in the R.E. Lines on the South side of the Camp, near the racquet court and R.E. Office.

Here they spent a very satisfactory four years in company with the 17th (Field) Company. Both units had a great reputation for smartness, earning high praise from the G.O.C. (General Prince Edward of Saxe-Weimar) who told them that they were the smartest and best of any troops under his command—high praise indeed, as

the garrison included many crack units of Guards, Horse Artillery, etc.

There was at that period no "Training Grant," and consequently all fieldworks had to be carried out by arrangement with adjacent Irish landlords, useful work, such as bridging the Liffey, road-making, necessary demolitions, etc., being done as far as possible. Much combined training with Infantry and other arms was also carried out, a practice not universally adopted at other Home stations for some years.

In the early part of 1890 when various light railways were being laid in Ireland, several N.C.O.s from the Company were employed in their construction, an experience which was for them an exceedingly useful, and, from all accounts, an extremely enjoyable, one.

Move to Aldershot.—In October, 1890, the Company, under the command of Captain G. K. Scott-Moncrieff, moved to Aldershot, going by sea from Dublin to Portsmouth, whence the mounted section went by road and the dismounted by train. At first the Company found themselves quartered in huts in Stanhope Lines which had long since been condemned, and which were so bad that a formal complaint was made to the G.O.C. (Sir Evelyn Wood). As a result of this the Company was moved into Badajoz Barracks where they found ample and comfortable quarters, the barracks being shared by the Cameronians, with whom they became very good friends.

The lesson of combined training had not yet been learnt at Aldershot, and all fieldworks training was carried out by the Company at Pyestock.

Cycling Club.—It was at this time that a cycling club was formed in the Company. Bicycles were then very new toys, such things as pneumatic tyres being unknown, and it was considered *infra dig.* for an officer to ride them even in plain clothes! The club was, however, well supported and was financed by the Canteen Fund.

In addition also to their being used for pleasure, they were used greatly during training for such work as advanced guards, engineer reconnaissances, etc. This cycling club was the forerunner of the present equipment of bicycles in a Field Company and must have been one of the earliest instances of their being used for tactical or engineer work.

In July, 1891, the Company took part in a General Parade, when H.M. Queen Victoria reviewed the troops at Aldershot.

During this period the Company won the six-horse-team driving competition open to the Corps at the sports held in R.E. Week.

Move to Woking.—On May 24th, 1892 (the Queen's birthday) the Company moved to Woking where they were employed converting the Prison into barracks, married quarters, etc. Owing to lack of accommodation the Company was the whole time under canvas in the Prison Yard.

The same year the new Lee-Metford Rifle, of which but few people understood the handling, was issued. The Company were lucky, however, in having an officer (Lieut. C. O. C. Bowen) who thoroughly understood it, and consequently fired the best practices among the R.E. Troops that year.

At the R.E. Sports in May, 1893, they again won the Driving competition and tug-of-war.

The Company went to the 1893 manœuvres which were held on the Wiltshire Downs, and were a good deal broken up, the mounted section being used as general transport, and headquarters of the Company being in Uffington Park.

When the work at Woking was completed the Company returned to Aldershot for some fifteen months, being inspected by H.R.H. the Duke of Connaught on the Long Valley on the 30th April, 1894, and taking part in a Grand Review held by Queen Victoria on the 17th May, subsequently proceeding to Shorncliffe on 23rd October. Here they remained for three years, taking part in the 1895 manœuvres near Ashford, and those in 1896 and 1897 near Minster and Arundel, and returning once more to Aldershot, the dismounted on the 14th and the mounted on the 16th October, 1897.

On July 7th, 1898, there was a review by Queen Victoria on Laffan's Plain in which the Company took part. On July 30th the Company went off on manœuvres and established its headquarters at Stockton Park on Salisbury Plain, being chiefly employed on water supply for the various manœuvre camps and returning to Aldershot on September 24th.

CHAPTER II.

SOUTH AFRICAN WAR.

Personnel.—The outbreak of the South African War in 1899 found the Company still at Aldershot, where it was mobilized on 9th October. In addition to the officers and men already with it, Major A. Graham Thomson, Lieuts. Craven and MacDonald and 136 Reservists joined, and Lieut. Elsner, R.A.M.C., was attached, bringing the strength up to 6 officers, and 1 attached, and 207 other ranks, the officers being Major A. Graham Thomson commanding, Captain A. L. Schrieber and Lieuts. A. J. Craven, R. H. MacDonald, J. R. White and J. J. H. Nation, and Lieut. O. W. A. Elsner, R.A.M.C., attached.

The Company left Aldershot at 8 p.m. on November 7th and embarked at Liverpool the next day on S.S. *Bavarian* along with Lieut.-Colonel A. C. Foley (C.R.E., 3rd Division), his assistant, Captain P. G. Grant, and six foreign military attachés.

On November 10th the Dublin Fusiliers and Connaught Rangers came on board at Queenstown, the ships having an enthusiastic send off from the inhabitants and the other ships in the harbour.

Arrival in Africa.—The Company disembarked at East London on 3rd December and drew their saddlery and extra transport, consisting of 48 Scotch carts and one buck waggon, the same day, leaving in two trains for Putters Kraal, where they joined Major-General Sir W. Gatacre's (3rd) Division, the next day.

On 5th and 6th 127 mules and 18 horses arrived, but the drivers did not come until the 7th, when the transport at once started getting ready to take the field.

On the night of the 7th a conference of Officers Commanding units was called and the plan of operations for an attack on Stormberg was given out and maps issued. On the 8th, there being a change in the plan of operations, another conference was called and fresh orders issued.

Action at Stormberg.—On the morning of the 9th, Reveille being at 4 a.m., camp was struck and the transport loaded up. The latter, under the command of Lieut. White, moved by march route to Molteno; the dismounted, except Lieut. Nation and 13 sappers, left at Putters Kraal for defence works, entrained at 3.30 p.m. and proceeded to Molteno in open trucks, reaching that station at 6.40 p.m.

At 9.30 p.m. Major Graham Thomson and Lieut. Craven and No. 1 Section (53 rank and file) marched off as escort to the ammunition column with the artillery, the remainder of the Company staying at Molteno, under Captain Schrieber, to construct defences.

Staff arrangements for the march were very much lacking, and after about two hours some Mounted Infantry cut through the column, causing considerable confusion, as a result of which the Company, instead of being behind the second Battery, found themselves behind the Ammunition Column, where they remained until the close of the action. The column was also led wrong, and, after taking the wrong road, only arrived in the vicinity of Stormberg at 4 a.m., being off the map issued for the operation, and having had practically no halts all night.

There appeared to be no orders, and when firing commenced about 4.20 a.m. the R.E. and S.A.A. Column found themselves isolated with but a very vague idea as to where the infantry were actually engaged, and without any maps of the country. The infantry were, however, eventually located by the C.R.E. who had climbed a hill near by, and the S.A.A. was escorted up to the firing line, which at this point was composed of Northumberland Fusiliers and Irish Rifles. At about 8.30 a.m. the order to retire on Molteno was received. It was not then realized that 600 of the small force had been left behind, killed, wounded or prisoners, as well as two guns lost; such however was the case.

On the return march men of various regiments, without their officers, streamed past, the Boers giving evidence of their presence

by shelling the road. No damage was done, however, as none of the shrapnel burst in the air. One native policeman riding up to the O.C. 12th Field Company remarked " Boer shells no damn good, Sir ! " The few snipers who had come out from Molteno to enjoy the sport seemed equally unsuccessful ! The sole Company casualty was one mule slightly wounded.

Molteno was reached about 11.30 a.m. and about 6 p.m. the whole Company entrained for Cypherghat.

The absence of any preliminary reconnaissance, the bringing of men worn out with marching all night right into the enemy's position without apparently knowing where it was (the leading troops were in fours when fired on) and the complete absence of orders would appear to make success in such an undertaking almost an impossibility.

The party under Lieut. Nation had received a wire on the 10th warning them that a disaster had occurred and ordering an immediate retirement. This order was, however, countermanded just in time. Meanwhile the defences of the camp had been considerably strengthened and several wells sunk with diamond borers.

Sterkstroom.—On the 15th this detachment rejoined Headquarters, which had moved to Sterkstroom on December 11th.

Here the Headquarters of the 3rd Division and of the 12th Company remained till March 7th, 1900, during which time they were mainly engaged in constructing a large number of redoubts and other field defences, enlarging the school house in the village and turning it into a hospital, improving roads and carrying out water supply, including sinking three deep wells with diamond borers. Two dams were also constructed in a *dongha* near the camp to form a horses' drinking and men's washing place. These were, however, being continually washed away by sudden heavy rains.

Enteric was rife in Sterkstroom, chiefly owing to the somewhat primitive sanitary conditions, all latrines being open and flies abounding in all cookhouses and tents where food was eaten.

The climatic conditions at this time of the year were also particularly trying, as it was very cold and very often raining hard during the night, while it was always boiling hot during the day.

The usual working hours were about 5 to 7 a.m., 8 a.m. to 12.30 p.m. and 2 to 5.30 p.m.

In addition to the ordinary work there were many detachments, nearly half the Company being always out.

Detachments.—Lieut. MacDonald and 50 sappers carried out water supply and construction of field defences at Penhoek from 20th December to 1st January, 1900. On January 1st another detachment, under Lieut. White, proceeded to Bushman's Hoek to carry on work on defences there previously carried out by the 29th Company. On the 3rd an attack was made on them by the Boers, who, after

surrounding Molteno, advanced on and shelled Bushman's Hoek. Half a Battalion of the Royal Scots and a Battery of Artillery were sent up as reinforcements, and in spite of somewhat inaccurate practice made by our guns on their positions on Cypherghat hill, the enemy retired.

On the 8th a column under the command of Colonel Smith Dorrien, consisting of 1 Battery R.F.A., 25 sappers under Lieut. White, half a Battalion of the Derbyshire Regiment and about 100 M.I. carried out a reconnaissance in force towards Stormberg, but, although a few Boers were met and a little desultory firing took place, nothing of importance occurred.

On January 20th a party of 40 sappers under Captain Schrieber and Lieut. Craven, and again on the 24th, 25 sappers and 400 of the R.I.R., went out to the Looperberg and constructed defences, the former party remaining until February 5th.

On January 27th Lieut. MacDonald and about 20 men of No. 2 Section proceeded to Penhoek, where they remained constructing defences until Lieut. MacDonald with Serjt. (afterwards C.S.M.) Field and 11 N.C.O.s and men joined Brabant's Colonial Division on February 21st, Lieut. Nation then taking charge of the remainder of the detachment.

Lieut. MacDonald's detachment came in for a lot of hard work and several engagements while serving with the Colonials, Driver Wakefield being killed in action at Wepener on April 24th, 1900.

On February 7th another attack was carried out by the enemy, this time on Penhoek and Bird River. A party of 6 sappers under Lieut. Nation went out with half a Battalion of R.I.R. and some Irregulars, with guns, and, after advancing across country and shelling the enemy, the force occupied Bird River without much opposition, returning to camp in the evening.

On February 23rd Lieut. Craven with a detachment accompanied a reconnaissance made by General Gatacre towards Stormberg.

On the 24th Captain Schrieber and a detachment of 17 sappers proceeded to join General Brabant's force at Dordrecht, where there had been some sharp fighting during the previous week. They were joined on the 26th by Lieut. Nation and 18 more men, a redoubt on the heights west of the town and other defence works being subsequently constructed.

Action at Labuschaynes Nek.—Major Cedric Maxwell, R.E., finding himself in command (General Brabant being away temporarily) decided to carry out an attack on the Boer positions at Labuschaynes Nek. The force, consisting of about 1,000 M.I., two 15-pdrs., two 7-pdrs., 35 sappers with 2 officers and some Royal Scots, advanced at 12.30 a.m. on the morning of Sunday, March 4th, and, having captured Spitz Kop by surprise, arrived in position about 4 a.m., soon after which the shelling of the Boer position was begun. A good

deal of general fighting then took place on the forward slopes of the kopje, where there was very little cover, the Royal Scots who were in this position having a very hard time.

After constructing a few defences, the Sappers returned to camp about 4 p.m. They were, however, ordered out again at 6.30 p.m., arriving at the scene of action at 10.30. Here they did extremely useful work constructing gun pits, breastworks and *schantzes* under fire from about 5 a.m. onwards.

Captain Schrieber awarded D.S.O.—There was meanwhile a force of the enemy occupying a small bit of high ground, known as " the Fort," which completely commanded the ridge held by us and which enabled them to enfilade our position and give us no little trouble. A brilliant charge by 15 sappers under Captain Schrieber and an officer and 15 men of the Border Horse, however, carried the position and entirely relieved the situation, the Boers retreating precipitately, leaving their dead and wounded behind. In this action both officers were wounded. After this practically no serious opposition was encountered and the sappers returned to Dordrecht about 6.30 p.m. Captain Schrieber subsequently received the Distinguished Service Order.

Advance to Orange Free State.—On March 6th Stormberg was occupied, Lieut. Craven and No. 1 Section moving there and starting the repair of the railway line ; the Dordrecht detachment returning to Headquarters the same day.

On March 7th the general advance to the Orange Free State was begun, the Company marching that day to Cypherghat, about 18 miles, moving on the next day to Molteno where they entrained for Stormberg.

Repair of Railway started.—On the 9th the Company was fully employed repairing the line up to Bethulie, on the deviation at Lienfontein where the bridge was blown up, replacing about $\frac{1}{4}$ of a mile of rails turned over by the Boers, and repairing Wonderboom Bridge, enabling the first train to enter Burghersdorp at 6 p.m.

Between the 10th and the 13th two bridges were repaired and a deviation of considerable size at Olive Siding was completed and Bethulie reached. The Boers had been holding the North bank that morning when the Company arrived, but though five of the eight spans of the railway bridge were destroyed, the road bridge was still intact, enabling the transport to march in as soon as the enemy retired.

The next day (March 14th) the Company started work on the repair of the line from Albert Junction to Aliwal North. The first serious obstacle that was met was the bridge over Stormberg Spruit, consisting of 3 spans of 150 feet, each of which was badly damaged. The work which mainly consisted of building three crib piers, one of which was 36 feet high, was carried out by a detachment

under Lieut. Nation assisted by 50 kaffirs. This was finished on the 16th and the construction train ran on into Aliwal North, where a great reception was accorded them by the townspeople.

On the 18th the Company proceeded once more to Bethulie to construct a railway deviation to the road bridge. This work was of very considerable extent, requiring one-half to three-quarters of a mile of line on either bank of the river, and large working parties, mainly of the Royal Scots, were employed. The work on the deviations on both banks was completed by the 26th, when the Railway Pioneer Regiment arrived and took over the work, the Company proceeding to Springfontein, dismounted, by rail, the transport marching and arriving on the 29th, except the Company pontoons which had been left in the Orange River at Bethulie for the Railway Pioneers.

Bloemfontein.—On April 1st the Company—less Lieut. White and No. 3 Section, who rejoined on the 11th—left for Bloemfontein, the dismounted arriving on the 2nd and the transport moving by march route arriving on the 10th. The Company camped on a hill about three miles south east of the town.

While at Bloemfontein, the Company was employed on water supply, road making and defences. Detachments of 20 men each, under Lieuts. Nation and Craven respectively, also proceeded to Kaffir River and Riet River Bridges for the construction of defence works, from April the 11th until the 14th.

Company join 11th Division.—On the 21st the Company proceeded to join General Pole Carew's 11th Division at Springfield, where they found themselves with the 18th Brigade.

While at Bloemfontein, all the second line mules had been taken away, and when orders were received to march back to Springfield, sufficient mules were not forthcoming, and those that were drawn from Remounts were in such poor condition that many collapsed on the march, necessitating part of the equipment being left at Bloemfontein and some at Springfield.

At 5.45 a.m. on the morning of the 22nd the Company marched with the 18th Brigade, and later received orders to join the Headquarters of the Division at Karriefontein, which was reached after a 20-mile march at about 5.30 p.m.

A detachment had meanwhile been sent with the M.I. to cut drifts in the Modder River. Major Graham Thomson met the M.I. and their Commanding Officer asking him to tell his sappers to " gallop up after us ! " not realizing that they were on foot. The sappers consequently had a fast 15-mile march there and back, without result, however, as the Boers had retreated.

Until the 26th the Company was working with the 11th Division in the neighbourhood of Modder River, cutting drifts, etc., after

which date the whole division returned *via* Paardeskraal and Karriefontein to Bloemfontein, which they reached on the 29th.

April 30th was spent by the Company in refitting with clothing, equipment and transport. Although R.E. Companies no longer had any pack animals, the 12th retained their pack saddlery, which they found most useful with advance guards and working-parties in hilly country.

The next day, May 1st, the Company started on the first stage towards Pretoria, marching to Karee Siding, 22 miles, a very fine performance, as very few men fell out.

Volunteer Section joins.—On the 2nd Lieut. Pollard and 23 rank and file of the Newcastle Volunteers joined the Company. They were an exceptionally good lot of men and were paid the compliment of being, before very long, drafted into the sections of the Company, instead of, as in most other units, being kept as a separate "volunteer" section.

60 Basutos with 2 headmen and 2 gangers also joined the Company. These men were invaluable for work, especially when it occurred on the march. They remained with the Company until July 11th, when they were forced by their chief to return home with him.

On the evening of May 2nd the Company received orders to march with the Guards and make good two drifts over the Karee River. The Guards were, however, not informed of this and there was, moreover, no information as to the position of the drifts.

The Company moved off, with two battalions of the Coldstream Guards, and bivouacked right in the open where it was bitterly cold. The next morning Major Graham Thomson and Lieut. Craven rode out ahead to look for the drifts, imagining that the front had been cleared by the M.I. When they arrived within about 180 yards of the drift, which was over a thickly wooded dongha, they were suddenly shouted at to "Kom here," and discovered some 8 "Zarps" in the bushes. These at once started firing, but did no damage except wounding the Major's mare in the stifle, in spite of which, however, she managed to carry him back to the camp. The Company then proceeded to the drift from which the enemy had by this time retreated.

Practically no further opposition was encountered and Brandfort was occupied about 5 p.m. that evening.

Action at Vet River.—On the 5th, the Company having rested the previous day, the march was continued another 20 miles to the Vet River, where the enemy was met in some little strength, an artillery duel ensuing till dark, when the force encamped, with the Boers still holding the North bank.

The next day, the enemy having retreated once more, the force advanced to Smaldeel, a new drift being cut in the Vet River, and the old one, after much work, being repaired.

As the railway bridge was also completely destroyed, first Lieut. Craven and subsequently Lieut. White remained behind with a Battalion of infantry and about 1,000 Basutos to work on the deviation. There was also a considerable amount of repair necessary on the railway between Vet River and Smaldeel, which was carried out.

On the 9th the Company marched to Welgelegen Siding, where a drift was repaired. The next day the Zaand River was reached, where slight opposition was met, though after a little shelling the Division was able to cross and camp some 6 miles further on, the Company remaining at the river to improve the drift and to construct a new road from it, which work was completed late that night.

The men had by this time got thoroughly hardened and thought nothing of a 20-mile march with perhaps 3 or 4 hours' work, during, or at the end of it. One section usually marched with the Advance Guard, the remainder marching behind the leading battalion of the Main Body.

The next day another long march was made to Geneva Siding—some 26 miles, in which the men kept up very well.

Kroonstadt.—On May 12th the Division started once more at 6 a.m., expecting to meet determined resistance. None, however, was encountered, and Kroonstadt was entered about 2 p.m. Here the Division marched past the C.-in-C., Lord Roberts, the Company eliciting some very complimentary remarks on the fine style of its marching after a long and trying day.

The Company remained at Kroonstadt for 8 days, during which time some extremely heavy deviation work was carried out, reliefs of infantry working day and night. Owing to the amount of rock near the town, a very great deal of blasting had to be done, for some of which explosive which the Boers had left in Brandfort was used.

On the 22nd the march was continued to Hoening Siding, and the next day the Rhenoster River was crossed, drifts being repaired with the help of the 9th Company, who were also accompanying the Division.

On the 24th the Company remained at the Drift until all the transport was over, when they marched on and rejoined the Division about 8 p.m., after a 15-mile march.

The next day Grootvlei was reached and an abundance of excellent water found, and again on the 26th with the help of the 9th Company the drift at Taibosch Spruit was repaired.

On May 27th the Vaal River was crossed at Vieljoen's Drift by means of the drift and a pont worked by the 9th and 12th Field Companies. Lord Roberts and his staff rode across the drift that day.

On the 28th the march was continued to the Klip River, and the day after to Elandsfontein, where a great deal of delay was caused

in the morning by the 4·7 naval guns, which, starting before their proper time, went over an existing bridge over the Klip River, which they smashed, having to be dug out by the sappers. The bridge had then to be demolished and a drift cut by the 9th and 12th Companies while a new trestle bridge was erected by the 12th, over which the 7th and 11th Divisions crossed. Nor did this bridge escape scatheless, as the 7th Division left no staff officer to regulate the traffic and, owing to some reckless driving, one of the trestles was smashed up, a new one having to be erected.

Railway blown up.—The same day Lieut. Craven and 4 sappers went out with Henry's M.I. and very successfully blew up rails on the Natal line in four places, to prevent trains getting away, thereby enabling six to be captured at Elandsfontein junction.

Johannesburg.—On May 31st Johannesburg was entered, the 11th Division marching past Lord Roberts and camping at Orange Grove, about 4 miles north of the town, the 18th Brigade and 12th Company's camps being unfortunately situated in the vicinity of small-pox and leper hospitals!

The Column rested on June 1st and 2nd, and on the 3rd marched to Lanfontein, about 11 miles to the north.

The next day the march was continued and the Company were ordered to make a drift for the crossing of the 11th Division. They were, however, sent off along the wrong road, and, having made a drift by which the 7th Division crossed, they returned 2 miles east and made several drifts, over which the 11th Division and the baggage went.

Action before Pretoria.—When the Column arrived within six miles of Pretoria, the enemy, who were occupying the ridge round the town, put up a strong opposition. The naval guns thereupon shelled two of the forts, while the infantry advanced, after a sharp encounter and a considerable amount of firing, to within about three miles of the town, the 12th Company being just in rear of the 4·7 and 5-inch guns.

Pretoria entered.—On the 5th June Pretoria was entered, the column (7th and 11th Divisions) marching past Lord Roberts in the square, the 12th Company being once more complimented on the way they marched past.

On the 6th Lieut. Craven and 12 sappers went out in a train to Waterval prisoners' camp, and came under heavy shell fire, as a result of which the Dutch driver and fireman bolted, being replaced by Sappers Gilham and Pedley, the former driving and being slightly wounded. After proceeding under fire and picking up as many prisoners as possible, the train returned to Pretoria, going out once more to pick up stragglers—altogether a very plucky performance.

On the 7th the 11th Division moved to Silverton, remaining there till the 10th.

Action at Diamond Hill.—On the 11th the 12th Company moved out with the naval guns and took up a position from which the enemy on Diamond Hill were shelled in a somewhat desultory manner, though the Divisions on the right and left (Ian Hamilton and French) had a good deal of fighting.

The next day the Company marched off with the Guards Brigade in support of Ian Hamilton, and made good several drifts. A good deal of desultory firing took place, but little serious fighting, the Guards carrying the position in the evening, crossing a bridge constructed by the Company during the day.

On the 14th the Company constructed a bridge at Mark's Drift, and, with the rest of the Division, returned to Pretoria the next day.

On the 19th Lieuts. Craven and White, with a detachment of sappers and some 600 Scots Guards, proceeded to Waterval prisoners' camp to take down the shelters there. These were subsequently re-erected at Erstefabriken.

On the 21st the 11th Division moved to Mark's Drift near Erstefabriken, and on the 23rd the Guards Brigade, accompanied by Lieuts. Nation and Pollard with 40 men, moved to Donker's Kop, the Headquarters of the Company remaining at Erstefabriken.

The Company remained situated thus for a month, during which time a considerable amount of work was done on hutments, roads, water supply and defences. A few minor engagements also took place in the neighbourhood, in which, however, the Company took no part.

On July 23rd the Company rejoined Headquarters of the 11th Division and Guards Brigade at Donker's Kop, Lieut. Craven and one section being with the 18th Brigade, the march to Komatie Poort beginning the next day with a move of 15 miles to Bronkhurst Spruit.

On the 25th the Division marched to Hartebestefontein, the Company making good drifts over Wilge River and building a bridge to take the 5-in. guns, and marching the next day to Brugspruit where they remained until August 2nd, working on defences, water supply and the construction of some eight trucks for running to Middleburg to connect with General French's force.

On the 27th July Lieut. Craven's section continued with the 18th Brigade to Balmoral, where similar defences and water supply were carried out.

On the 30th Lieut. Nation and No. 2 Section proceeded to Olifants River with some battalions of Guards and some guns. Roadmaking, water supply and defences were again the main work.

On August 3rd the Company, with the Scots Guards, naval guns and ammunition column moved on to Olifants River, marching the day after to Middleburg, No. 2 Section remaining behind for work

on bridges, *schantzes* and other defences until the 20th, when they, too, moved on to Middleburg.

Here the Company's work was again on water supply and defences, a large amount of work being done in addition on the hutments and hospital.

On the 22nd the Company moved with the 18th Brigade to Pan, and on the 23rd to Wonderfontein, drifts being made good on the road and water supply improved.

Action at Belfast.—On the 24th a further advance was made to Belfast, where the enemy was met and exerted some opposition, the Column finally camping by the station. During the next two days trenches were dug and breastworks erected by the Company under heavy shell and musketry fire. The former was usually very accurate though not well burst. On the 25th a tracing tape was cut by a direct hit as it was being laid out, and on the 26th another shell hit the back of a trench in which the 12th Company and the Royal Scots were working, but luckily both burst in the ground. A considerable amount of unnecessary rifle fire was drawn on the working parties by officers riding up on horseback and standing in most conspicuous positions watching the work.

Serjt. Hughes awarded D.C.M.—During this period Serjt. J. Hughes was conspicuous for his coolness and devotion to duty while working under fire. He was subsequently awarded the Medal for Distinguished Conduct in the Field.

On the 27th a small advance was made, the Company moving with the Guards and 18th Brigades.

The next day the 18th Brigade, accompanied by the 12th Company, made a flank march to Swarz Kopjes to support General French, drifts being made by the Company, and the march being continued during the next two days to Helvetia, where the Column for the time being joined forces with General Buller, and then to Waterval Onder. The roads on this march were exceedingly bad and very steep, and even the small amount of sniping and desultory firing which went on gave a certain amount of trouble.

The force remained at Waterval Onder until the 9th Sept., the Company meanwhile improving the roads which were impassable for heavy traffic, building a suspension bridge across Elands River and carrying out water supply.

On the 10th the Column moved on to Nooitgedacht, where there had been a large prisoners' camp. The work on the march was very heavy, as the roads and drifts were extremely bad, similar work being also encountered the next day on the march to Godwan.

Very trying marches.—The next day's march to Kaapsche Hoop and Devil's Kantoor was exceedingly trying, as the road was as steep as 1 in 4 in many places, and two of the Company waggons had to be abandoned, "double banking" having to be resorted to

with the 2nd line teams, many of the waggons not arriving till early the next morning.

On the 15th, 16th and 17th the march was continued to North Kaap Station, on the Barberton Line. The descent was as steep as the ascent had been on the previous days and several waggons were upset. Very heavy work was again encountered on the roads, General Pole-Carew expressing his appreciation of the work done by the men, and presenting them with a case of beer!

On the march to Kaapmuiden, which was reached on the 20th, more bridges were found destroyed and a large amount of locomotives and rolling stock were captured, a party of engine drivers and fitters being sent on ahead to get them in running order.

Lieut. Nation and about 25 sappers were left behind under the C.R.E., when the march was continued, to repair Hector's Spruit Bridge at Malalene. A pumping station was also repaired here and the march continued to Komatie Poort which was reached on the 24th September.

The last three days of this march, when water was very scarce and roads bad, had been very arduous for a force accompanied by heavy guns and transport and, had the Boers made any stand, there is no doubt that the march would only have been accomplished with heavy loss.

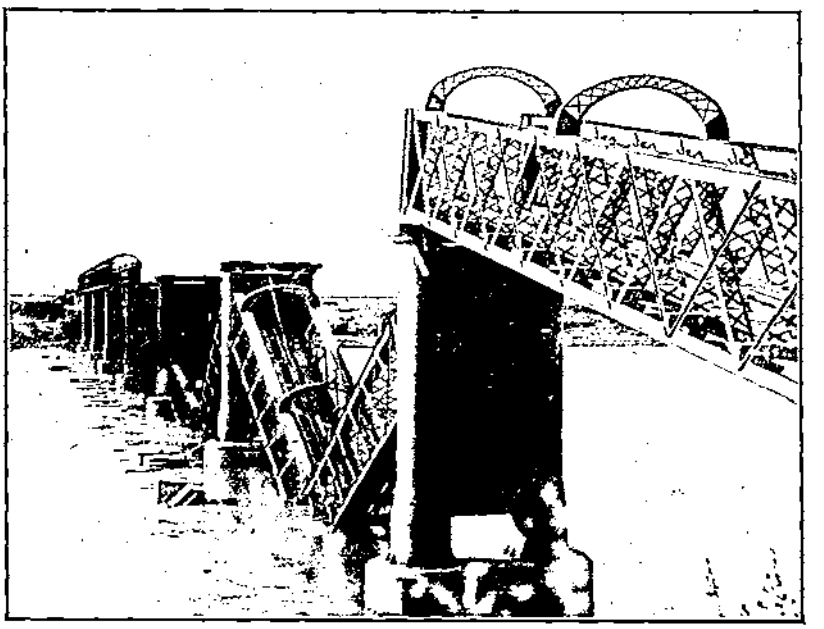
As some Australian M.I. had been sent on 48 hours ahead to demand the surrender of Komatie, the enemy had had plenty of time in which to effect demolitions, but had done very little, as they had been running a great number of trains to the Portuguese border and consequently a large amount of rolling stock was captured, most of it undamaged.

The railway bridge over the river at Komatie had been prepared for demolition, but no charges placed, as was discovered by C.S.M. Skinner and Serjt. Hughes, who swam out and opened up the cavities which had been cut in the piers to receive the explosives.

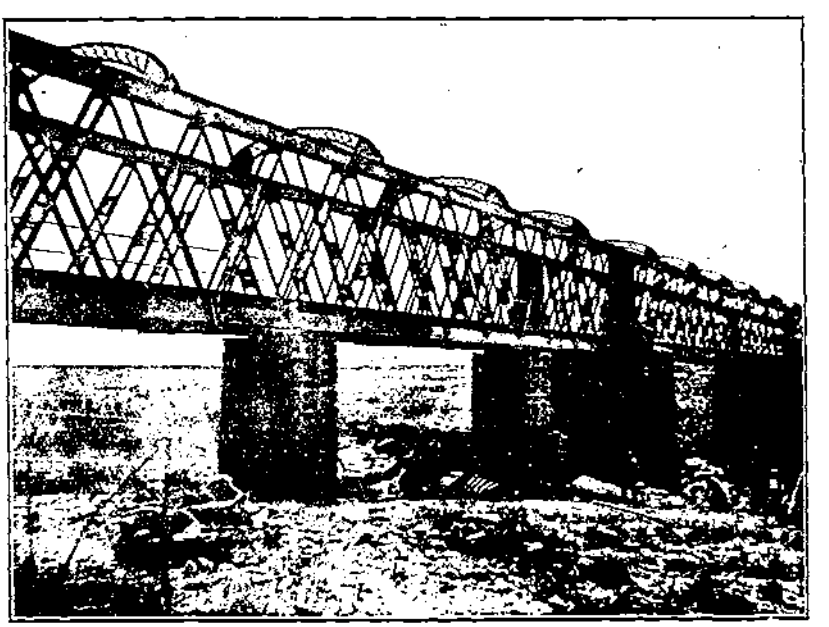
The section under Lieut. Nation remained at Hector's Spruit, repairing the bridge and carrying out water supply until October 2nd, when they rejoined the Company at Komatie Poort. On October 1st there was a bad railway accident at Hector's Spruit Station, in which Driver Pearce was killed and Sapper Phillips injured. Both belonged to the 12th Company.

(To be continued.)

HISTORY OF THE 12TH COMPANY, ROYAL ENGINEERS.



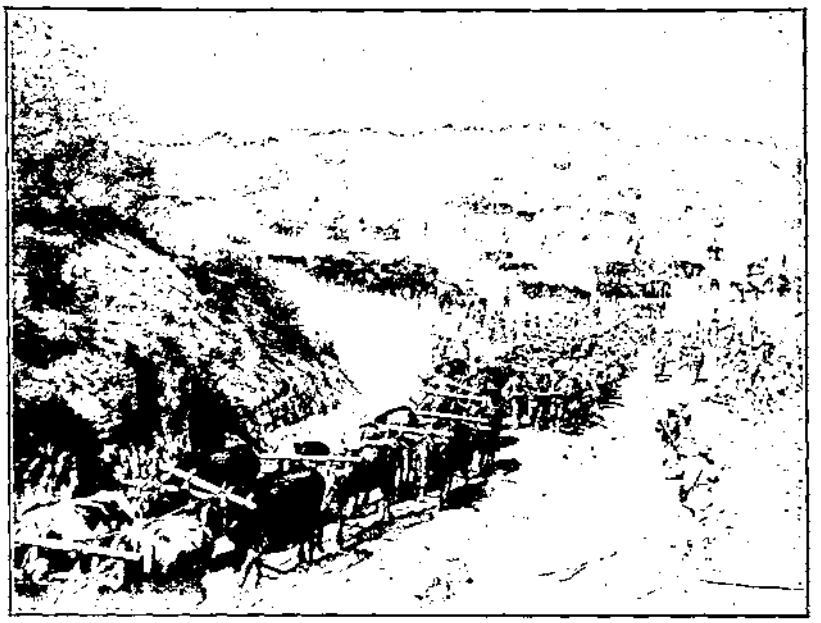
Bethulie Bridge destroyed by the Boers.



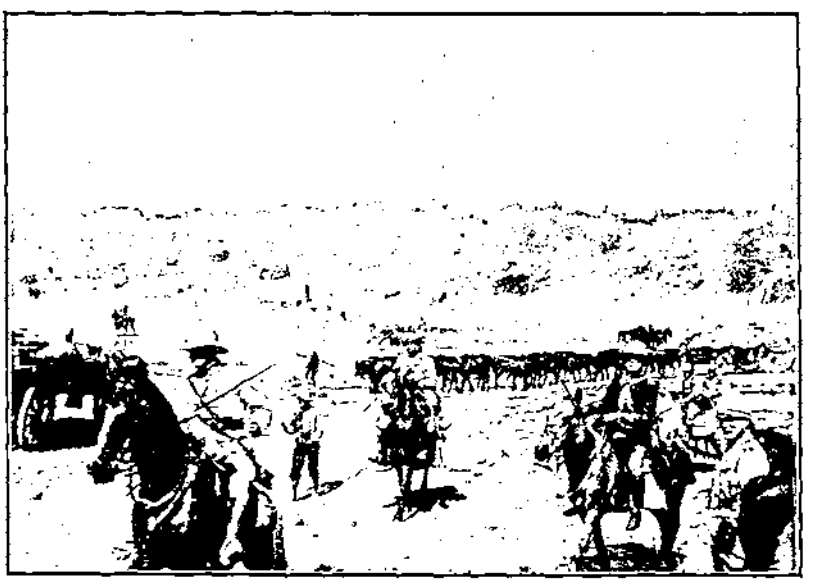
Bridge at Stormberg Spruit, repaired by 12th Co., R.E.

12th Co., R.E., on the March.

Company Pack Mules.



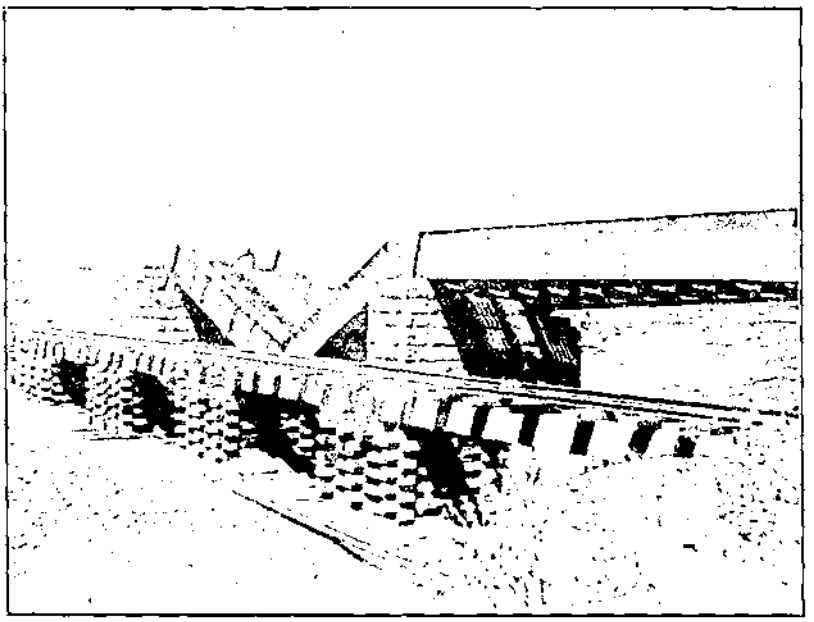
4·7″ Naval Guns crossing Zaand River, 10th May, 1900.



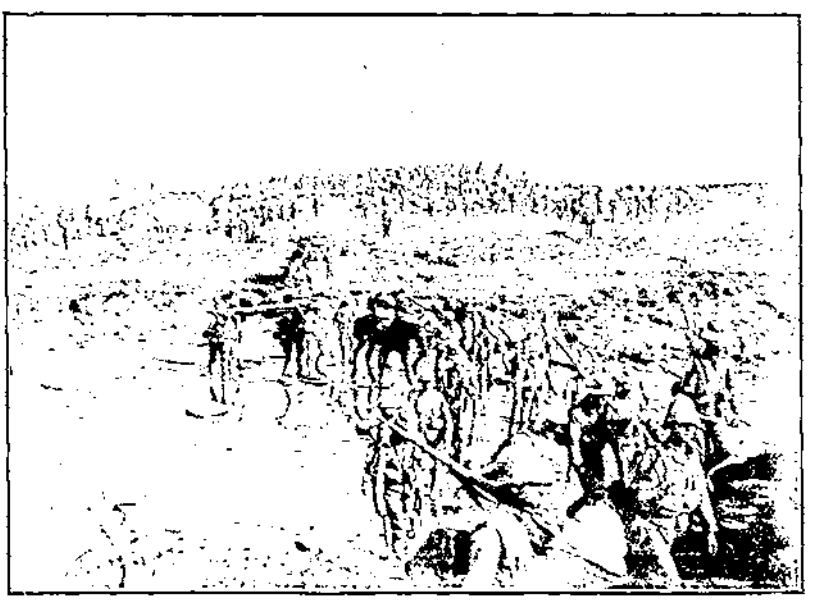
Lord Roberts.

Gen. Hills Jones, V.C.
Major A. G. Thomson, R.E.

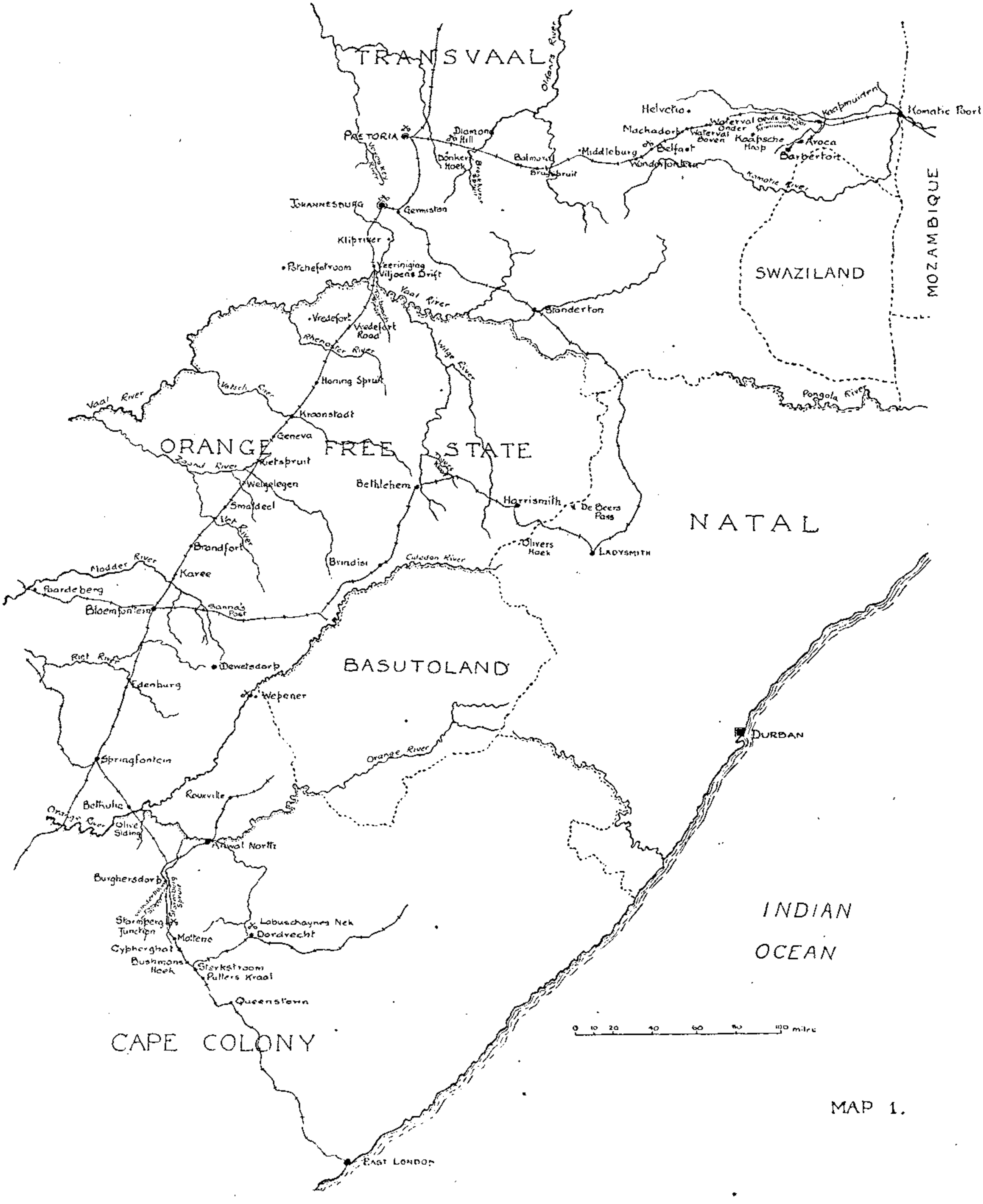
Naval ammunition wagons crossing Zaand River, 10th May, 1900.



Destroyed bridge and deviation at Olive Siding.



Guards Brigade (Gen. Inigo Jones) on the trek.


TRANSVAAL
ORANGE FREE STATE
BASUTOLAND
NATAL
SWAZILAND
MOZAMBIQUE
CAPE COLONY
INDIAN
OCEAN
PRETORIA
JOHANNESBURG
Germiston
Kliprivier
Potchefstroom
Vereiniging
Viljoens Drift
Vaal River
Vredefort
Vredefort Road
Rhenoster River
Honing Spruit
Kroonstadt
Geneva
Rietspruit
Welgelegen
Smaldeel
Vet River
Brandfort
Karee
Modder River
Paardeberg
Bloemfontein
Sanna's Post
Riet River
Edenburg
Dewetsdorp
Wepener
Springfontein
Bethulie
Orange River
Olive Siding
Rouxville
Aliwal North
Burghersdorp
Stormberg Junction
Molteno
Cyphergat
Bushmans Hoek
Sterkstroom
Pullers Kraal
Queenstown
Labuschagnes Nek
Dordrecht
East London
Bethlehem
Brindisi
Caledon River
Harrismith
De Beers Pass
Olivers Hoek
LADYSMITH
Wilge River
Standerton
Pongola River
DURBAN
Diamond Hill
Donker Hoek
Balmoral
Middleburg
Machadorp
Belfast
Helvetia
Waterval Onder
Waterval Boven
Kaapsche Hoop
Barberton
Avoca
Komati River
Komatie Poort
Kaapmuiden
Olifants River
0 10 20 40 60 80 100 miles

MAP 1.

PROFESSIONAL NOTES.

AN IMPROVISED FLOATING FOOTBRIDGE.

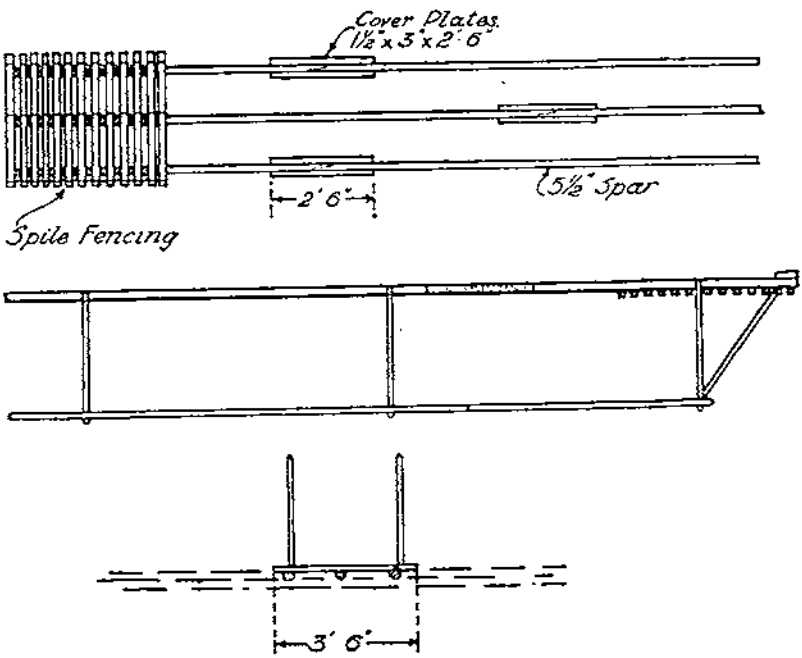
(Communicated by the R.E. Board.)

THE bridge described below was designed by the French Engineers at Montpelier, and has recently been tried at Chatham. A detailed description appears in the October number of the *Revue du Génie Militaire.*

Though subject to limitations, it possesses the advantage of being made of materials which can frequently be found locally. Its construction is simple and rapid. No rope is required.

It is, however, not an assault bridge, being too heavy and rigid. It is unsuitable for currents over three knots. Its buoyancy is only moderate.

Briefly, the bridge consists of a footway of light timber fencing supported on three rows of floating spars.



The fencing can be constructed of round spars, 1 in. in diameter, or of timber split from young trees, averaging some ¾ in. by 1½ in. in cross section, by 3 to 4 ft. in length. These are held together by three rows of double wiring, the wires (about 16 S.W.G.) being twisted together between each piece. The fencing can be rolled up, and is then very portable. Spile fencing of split chestnut, such as is now extensively made and used, is very applicable.

Construction of Bridge.—Three parallel rows of spars of 5½-in. mean diameter are first laid out at 1 ft. 3 in. centres, breaking joint. The joints are halved together and further strengthened by wooden cover plates, 3 in. by 1½ in. by 2 ft. 6 in. A light batten is nailed across the spars at each end as a shore transom. The fencing is then unrolled along the spars and nailed every 3 ft. Handrail posts are fitted into auger holes in the outer spars.

Time of Construction.—Two men can make 30 ft. of bridge in about 40 minutes, assuming that the material is available at site.

Method of Launching.—The bridge weighs about 26 lbs. per foot run. Two men every 6 ft. are sufficient to lift it bodily and launch. It can also be swung or paddled with shovels.

Buoyancy.—The bridge is capable of supporting armed men at 15-ft. intervals.

IMPORTANT WORKS EXECUTED BY THE BUILDINGS AND ROADS BRANCH OF THE MILITARY ENGINEERING SERVICES, INDIA, 1923–24.

THE more important works, executed by the Buildings and Roads Branch of the Military Engineering Services (till recently known as the Military Works Services) during the year 1923–24, have included the following :—

A.—FRONTIER ROADS.

The most important road work of the year has been the completion of the last link of the road through the heart of the Mahsud country in Waziristan, from the Tochi valley on the north to the plains of the Derajat on the south.

A hutted camp is now being constructed at Razmak, where a garrison of regular troops will always be within a few miles of Makin and Kaniguram, the two most important villages of the Mahsuds.

The garrison will thus be living in a comparatively temperate climate, at some 5,000 to 6,000 feet above the sea, instead of being situated as heretofore in the torrid plains and foot-hills of Bannu and Derajat Districts.

By means of the new "Circular Waziristan Road"—as it may be called—troops from this garrison can move rapidly, with their mechanical transport, to any of the various fortified points on the road, and thence act promptly against any hostile gatherings of tribesmen. It also affords the tribesmen and traders with a traffic route, and locally-owned motor-cars are to be seen on the road in increasing numbers.

The road is thus of a very great political and economic value and represents a change in the conditions of Waziristan, that is bound to have very far-reaching effects on the Frontier tribesmen.

In addition to the construction of the last link of the road itself—from Sararogha to Razmak—the other sections of the road, from Isha in the Tochi, on the north, to Khirgi, Tank and on to Dera Ismail Khan, on the south, have been improved to increase their capacity for mechanical transport, during the year. A large bridge of nine spans (total length 915 ft.) across the Tochi river at Tal is now rapidly nearing completion. Plans have been prepared for the rebuilding of another large bridge at Jandola across the Takki Zam, to improve the reliability of communications towards the southern end of the road.

Another road is being constructed from Jandola to Sarwakai, on the southern side of the Mahsud country, and this entails some heavy work where the route passes through a gorge known as the Shahur Tangi.

Intimately connected with the roads are the fortified posts on them which contain garrisons of irregular troops, recruited from frontier tribesmen, and forming a corps that is known as the "Waziristan Scouts." These "Scouts' Posts" are now nearly completed at most points on the main Circular Waziristan Road, but those on the Jandola-Sarwakai, and a new Post at Jandola, are only just begun.

Military labour—Sapper and Miner Companies and Indian Pioneer Battalions—has been very largely employed, and without their assistance the work could not have been completed as rapidly as it has been, as the work of the Indian or Pathan contractor in this inhospitable tract of country is very slow, uncertain and ineffective, especially where heavy cutting or tunnelling and building of walls or posts has to be undertaken, as well as being very expensive.

The following troops were employed, and it is interesting to note that this is the largest concentration of technical troops ever known in India hitherto :—

Sappers and Miners—

Nos. 3 and 5 Companies, K.G.O. Bengal.
Nos. 12 and 13 Companies, Q.V.O., Madras.
Nos. 19, 20, 21, 23 Companies, Royal Bombay.

Pioneer Battalions—

1/1 and 1/2 Madras Pioneers.
1st, 2nd and 3rd Sikh Pioneers.
4th and 10th Bombay Pioneers
and 4th Hazara Pioneers.

Altogether some 133 lacs (about £950,000) were expected to be spent during the financial year 1923–24 on the above frontier roads.

B.—TRAINING AND EDUCATIONAL INSTITUTIONS.

A Machine-gun School and the Indian centre for Armoured Car units are now located at Ahmednagar, and some Rs. 1·29 lacs have been spent in altering the old R.F.A. Lines there to make them suitable for the above establishments.

At Belgaum in South India, where the Senior Officers' School and the Indian Army School of Education have been situated for some three years, it is now proposed to locate the British Army School of Education also, which has hitherto been at Wellington.

In order to do this, the R.F.A. barracks at Belgaum are being altered for this new purpose at a cost of some Rs. 1·61 lacs, of which some Rs. ·75 lacs were spent during the year.

In order to complete the accommodation required for the Senior Officers' School, some Rs. 1·83 lacs were also spent during the year at Belgaum.

C.—I.A.S.C. WORKS.

An important Base Supply Depôt has been organized at Lahore and Rs. 24·69 lacs were spent during the year in building sheds and other accommodation there in connection with this project.

D.—ORDNANCE—ARSENALS AND DEPÔTS.

In consequence of the arrangements for the reorganization of the clothing supply for the Army in India a good deal of work has been carried out at the large Clothing Depôt at Shahjehanpur in the United Provinces, amounting to Rs. 5·31 lacs. For similar reasons clothing storage accommodation at the Kirkee Depôt has been sanctioned at a cost of Rs. 1·15 lacs, of which about half has been constructed during 1923–24.

A large scheme, amounting to Rs. 15·07 lacs for the improvement of Rawalpindi Arsenal, was sanctioned, and work has been done during the year to the value of Rs. 12·08 lacs.

Quetta Arsenal has also been enlarged and altered, some Rs. 1·80 lacs having been spent during the year, out of a total estimated amount of Rs. 2·60 lacs.

E.—DEFENCES.

As the result of the recent murders of officers and ladies in cantonments near the N.W. Frontier, schemes for providing barbed

wire perimeter fences, clearing areas of trees and undergrowth, and providing electric lights for these defences, have been carried out at Kohat and Bannu, and similar arrangements at Peshawar have been improved during the year at a total cost of Rs. 3·13 lacs.

Two fortified posts for large detached picquets have been constructed in the Khyber, one at Shahgai and one overlooking the Afghan frontier, where the Khyber Road crosses it, costing together about Rs. 1·24 lacs.

F.—Auxiliary Force (India).

Projects for the construction of Headquarter buildings for the Burma Railways Battalion at Rangoon and for the Calcutta Scottish Battalion at Calcutta were sanctioned, and Rs. ·30 and ·40 lacs, respectively, were to be spent during the year.

Eleven other estimates for providing quarters for Instructors, and also, in some cases, armouries, offices and ranges, in many distant stations such as Dibrugarh, Calicut, Cochin and Maymyo (in Burma) were sanctioned and funds amounting to Rs. 2·19 lacs were to be expended during the year on them.

G.—Accommodation for Officers.

The Government of India have accepted the policy of providing hostels for the accommodation of British Officers at stations where suitable accommodation is not available locally. In all, five such hostels have been completed, at Chaklala, Peshawar, Kohat, Quetta, Lahore Cantonments, or are under construction.

These hostels consist of a set of public rooms—dining-room, reading-room, card-room, billiard-room, etc.—with a varying number of "unit" quarters, from 23 to 32 units, according to the local requirements of the station.

Each "unit" quarter consists of a bed-sitting room, dressing-room and bathroom, with a 10-ft. verandah all round the block. The dimensions of the rooms vary according to location, that is, at a "very hot plains" station, "normal plains" station, "semi-hill" station, or "hill" station. So far, however, no hostel has been built at, or contemplated for, a hill station.

Each unmarried Captain or Subaltern is permitted to occupy one unit quarter, while an unmarried Field Officer may occupy two; a married Officer is given two or three unit quarters, according to the size of his family.

Each unit quarter is completed with water supply fittings and electric lights, fans also where necessary, and essential furniture.

At certain stations, where the provision of a hostel is not clearly justified, but where quarters are necessary, unit quarters are provided, for single officers only, adjacent to an existing Officers' Mess;

thus releasing bungalows in the station for the use of married officers.

The provision of bungalows for married officers is also provided at stations where these are clearly necessary.

H.—Accommodation for British Troops.

The evacuation by the Military, and the sale of the Fort and surrounding area to the Civil Authorities, necessitated the provision of accommodation for one Company of British Infantry on a new site at Lahore.

The work has been in hand for the past two years and was completed in 1923 at a cost of Rs. 9·34 lacs (£62,000 approx.). The project included the provision of quarters for two married and three single officers, officers' mess, barracks, dining-halls, quarters for married British other ranks, institute, hospital, and all other necessary buildings, as well as electric lights and fans.

The provision of accommodation at Quetta for a battery of R.F.A. was also completed in 1923 at a cost of Rs. 9·35 lacs (£62,000 approx.).

This accommodation was necessary owing to the sale of a portion of the Cantonment at Karachi, including the R.F.A. barracks, to the Civil Authorities, and also included quarters for officers, etc., as at Lahore, with the addition of stables, gun-shed, and a veterinary hospital.

The following projects also were in progress or sanctioned during the year under review :—

Accommodation for :—	Rs.
(i) A medium Artillery (tractor-drawn) Battery at Ferozepore	4·69 lacs
(ii) An Armoured Car Company at Kirkee	1·02 ,,
(iii) Mechanical Transport personnel attached to a Medium Artillery (tractor-drawn) Battery at Delhi	0·41 ,,

Apart from the above large projects, a great deal has been done to bring existing accommodation up to date, adding married quarters, improving institutes, and making up deficiencies generally.

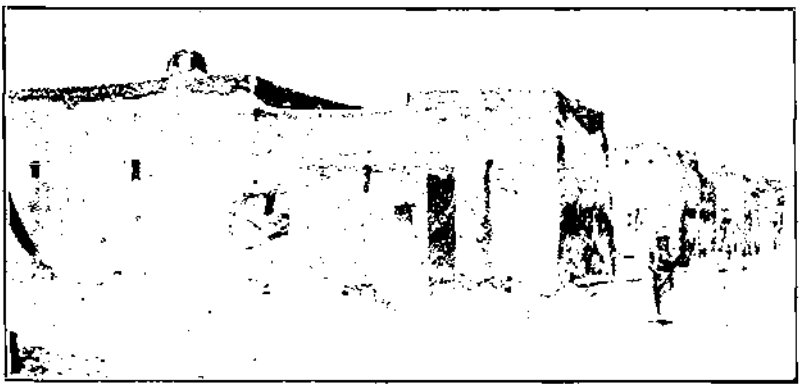
I.—Accommodation for Indian Troops.

In former years the provision of accommodation for Indian Troops was financed from what was known as the " Hutting Grant Fund " and the work was, in the great majority of cases, carried out by the troops themselves, without expert workmen or technically qualified supervisors, and the result, in most cases, was deplorable.

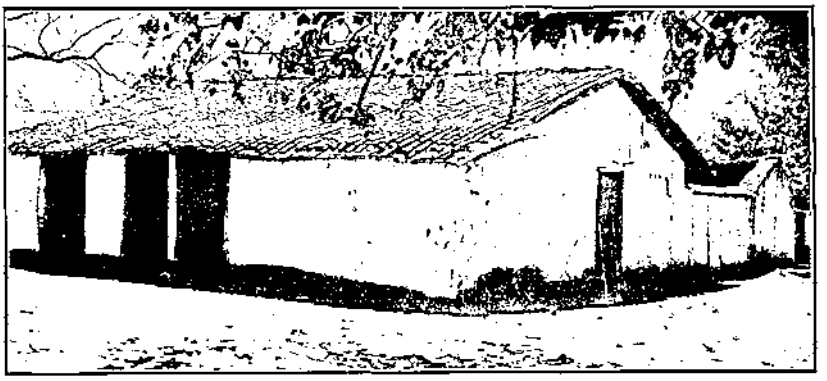
In 1910 it was decided by the Government of India that all future projects in connection with the construction or reconstruction of

ACCOMMODATION FOR INDIAN TROOPS.

OLD AND NEW TYPES.

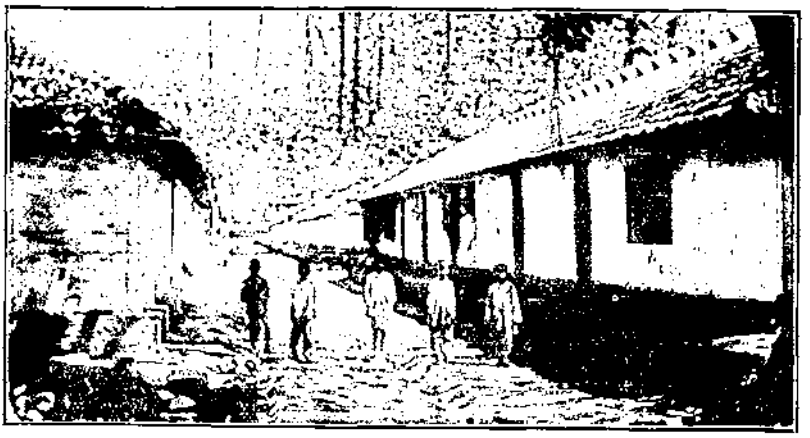


Indian Officers' Quarters. Old McQueen Lines, Kohat.



Indian Officers' Quarters. Old Mervara (I.I.) Lines, Ajmer.

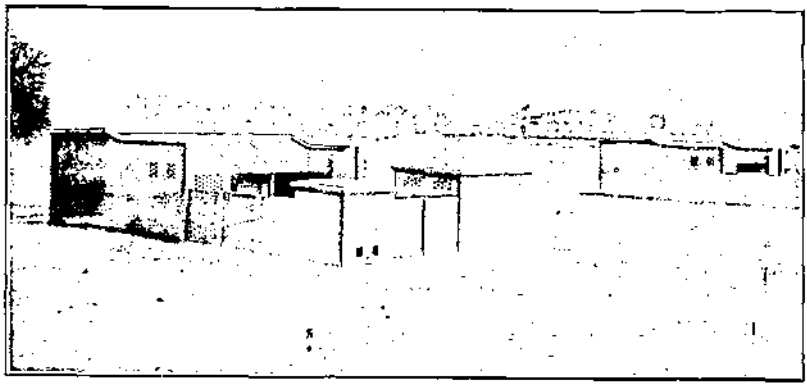
Married Men's Quarters. Old Carnegy (I.I.) Lines, Bombay.



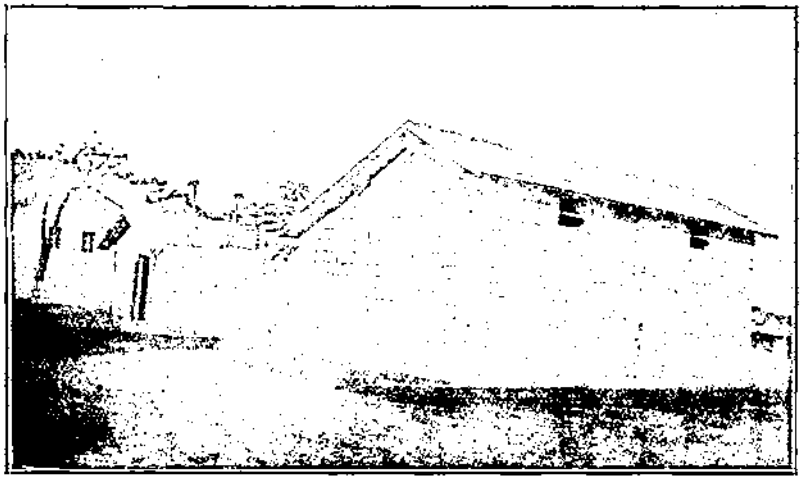
Single Men's Barracks. Old Carnegy (I.I.) Lines, Bombay.

Single Men's Barrack. Interior View. Old Madanpur (I.I.) Lines, Saugor.

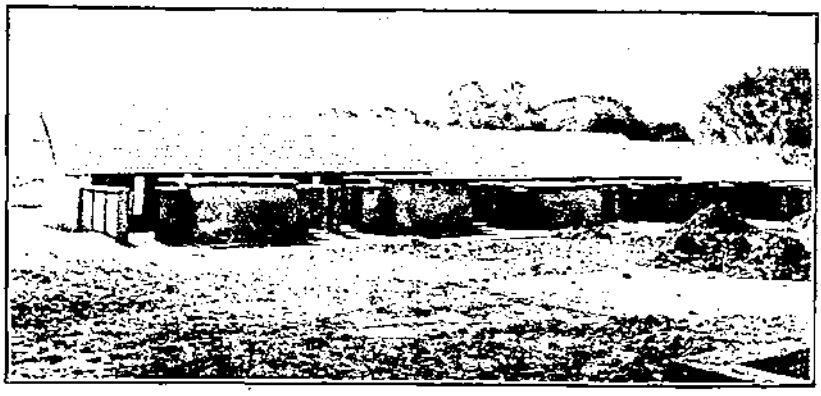
Followers' Quarters. Old (I.I.) Lines, Bangalore.



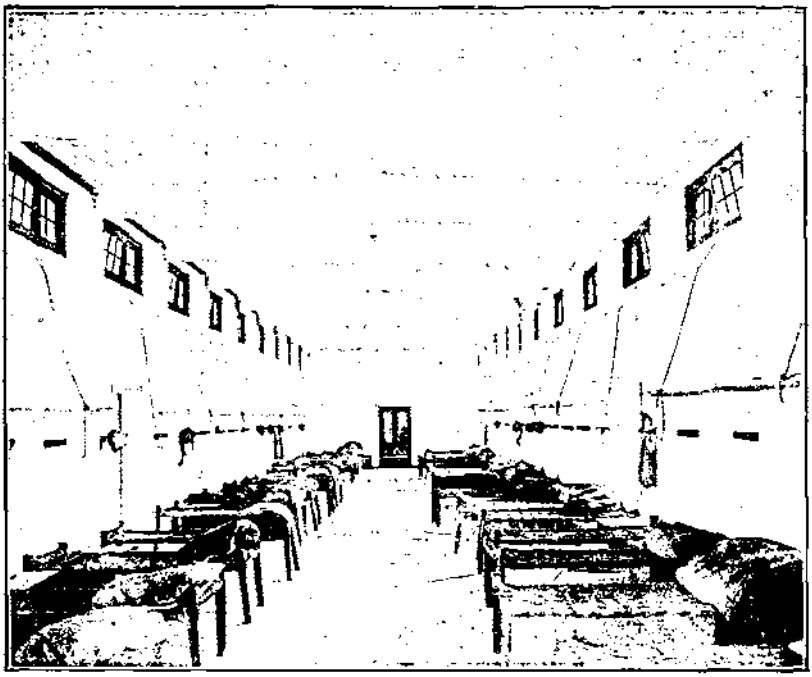
Indian Officers' Quarters. New Ferozeshah (I.I.) Lines, Ferozepore.



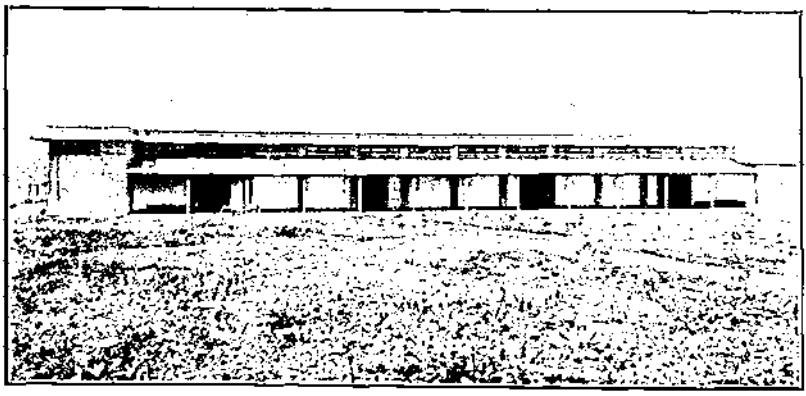
Indian Officers' Quarters. New Westmacott (I.I.) Lines, Kirkee.



Married Men's Quarters. New Shah (I.I.) Lines, Jubbulpore.



Single Men's Barrack. Interior View. New Police Barrack, Peshawar



Single Men's Barrack. New Police Barrack, Peshawar.

Indian Troops' lines should be carried out by the Military Works Services, now known as the Military Engineer Services.

During the past year work has been in progress or initiated on the construction or reconstruction of about 40 sets of lines for Indian Troops.

The average cost of a complete set of Indian Troops lines, excluding quarters for British officers, is about Rs. 6·00 lacs (£40,000 approx.).

Comparative photos are attached showing the old and new type of lines.

J.—Ordnance Factories.

Apart from the large number of comparatively small works in hand at the various Ordnance Factories in India, *e.g.*, new quarters for officers and subordinates, extensions to existing workshops, tramways, etc., the closing down of the ammunition factory at Dum Dum and the extension of the ammunition factory at Kirkee have been sanctioned, involving an expenditure of about Rs. 20 lacs (£126,000 approx.) in providing new buildings and machinery. Of this project the M.E. Services will be responsible for the expenditure of about Rs. 11·5 lacs.

K.—Hospitals.

A considerable amount of work has been done in improving and adding to existing hospitals to bring them up to date, both in accommodation and internal fittings and furniture. Among the major hospital projects in progress or initiated during the year the following may be mentioned :—

(i) *Bannu.*—New Indian station hospital of 120 beds, with administrative block, dining-halls, operating theatre and X-ray room, laundry, mortuary, infectious and isolation wards, quarters for nursing sisters and subordinates, ambulance shed, etc. Cost, Rs. 10·17 lacs.

(ii) *Murree.*—New British family hospital of 40 beds. Cost, Rs. 1·67 lacs.

L.—Medical Store Depôts.

(*a*) The Medical Store Depôt at Bombay, cost Rs. 14·09 lacs, is approaching completion. This Depôt consists of three double-storied blocks, each 150 ft. by 40 ft., and one three-storied block 320 ft. by 63 ft., all for manufacture of drugs and medical appliances ; also an office block ; all complete with shelving, machinery, electric lights and fans, etc. ; and water supply for manufacture and fire services.

The floors of the three-storied block are of reinforced concrete on the " mushroom " system of reinforcement, on internal reinforced

concrete columns spaced 20 ft. centre to centre each way; and each floor is calculated to take a super load of 2 cwt. per sq. ft.

(*b*) The Medical Store Depôt at Madras, cost Rs. 4·69 lacs, is also approaching completion. For this Depôt the existing buildings of the old Gun-Carriage Factory were utilized to a large extent.

M.—Sanitation and Drainage.

(*a*) The Government of India sanctioned, in 1922, at a cost of Rs. 3·80 lacs (£25,300 approx.), the improvement of the storm water drainage of Lahore. The cost of the M.E. Services' portion of the work amounted to Rs. 3·40 lacs, the balance being apportioned between the Lahore Municipality and the Punjab Drainage Board for work to be done in their respective areas of control.

This project was initiated in consequence of an outbreak of cholera in Lahore Cantonment, and consists mainly in the lining existing open drains to prevent stagnation, the widening of culverts and the reconstruction of a railway bridge.

The project is now nearing completion.

(*b*) In 1922 the Government of India sanctioned, at a cost of Rs. 100,810 (£6,700 approx.), the improvement of the drainage on the Ridge, Jubbulpore. This was in consequence of the very high incidence of malaria among the British troops on the Ridge, which at one time was so bad that the barracks had to be vacated.

The project consisted of lining existing open drains to prevent stagnation and breeding-places for mosquitoes, and clearing away dense jungle undergrowth.

The project is now practically completed, enabling the barracks to be re-occupied, and has brought down the percentage of malaria to a negligible amount.

N.—Accommodation for Mechanical Transport.

(*a*) Since 1918 work has been going on to provide workshops, stores, reserve parks for motor vehicles, living accommodation, etc., etc., for M.T. units at Chaklala, about five miles from Rawalpindi. The Government of India has, up to date, sanctioned the expenditure of about Rs. 80 lacs (£530,000 approx.) for this purpose, of which about Rs. 69 lacs has already been spent.

(*b*) Among recent sanctions accorded by Government for the provision of accommodation for M.T. units are the following:—

	Rs.
Bannu.—Accommodation for the Headquarters and two sections of a Light Indian M.T. Company (30 cwt. lorries) ... ... (About 80% completed.)	2·05 lacs
Sitapur.—M.T. Training School ... ... (About 90% completed.)	1·09 ,,

	Rs.
Calcutta.—M.T. Company, utilizing existing available buildings ... ... (About 80 % completed.)	0·40 lacs
Karachi.—M.T. Company ... ... (Work not yet commenced.)	1·22 ,,

(*c*) Estimates are at present under consideration for the provision of accommodation for M.T. at Poona, Bombay, Quetta, and for certain additional accommodation at Bannu.

O.—Remount Department Works.

Projects are in hand, or about to be initiated, for the provision of accommodation for the Remount Department at Multan, Montgomery, Saharanpur, Sargodha, Mona, and Hapur, at a cost of about Rs. 3·95 lacs.

P.—Farms Department Works.

Various quarters and offices for the Farms Department are in progress at Sialkot, Lahore, Jubbulpore, Kirkee, Quetta, and Dehra Dun, at a cost of Rs. 1·00 lac approx., and estimates are under consideration for railway sidings for the above Department at Quetta and Hafizabad (about 40 miles from Wazirabad).

Q.—New Cantonments.

(*a*) *Delhi*.—For a complete Brigade, in modern up-to-date buildings, including officers' quarters and messes, hospital, etc. Total cost about Rs. 120 lacs. The major portion of the work has been completed by the Public Works Department. The M.E. Services have now taken over the project for completion.

(*b*) *Razmak*.—For two Brigades, in semi-permanent huts and providing only for essential requirements. Total cost, Rs. 62 lacs approx. Work about to be commenced.

(*c*) *Khormaksar* (*Aden*).—For the major portion of the Aden garrison, owing to the modern unsuitability of the accommodation in Aden. Cost not yet known and consequently the project has not yet been sanctioned.

R.—Marine Works.

Quarters for the Deputy Director, Royal Indian Marine, Bombay. Cost, Rs. 1 lac approx. Recently completed.

New three-storied block of Stores, Bombay. Cost, Rs. 2·28 lacs. Approaching completion.

S.—Miscellaneous Works.	Rs.
(*a*) *Maymyo.*—Offices for Headquarters, Burma District ... ... (Approaching completion.)	1·11 lacs
(*b*) Removal of a complete set of Indian Infantry Lines and officers' quarters from Bhamo to Maymyo. These were dismantled at Bhamo and transported by steamer down the Irrawady to Mandalay and carried by rail to Maymyo. The whole work was done by the 3/2 Bombay Pioneers and Burmah Sappers and Miners. The buildings are two-storied and built of teak with shingle or tile roofs ...	1·25 ,,
(*c*) *Lahore.*—O'Dwyer Memorial Institute for British and Indian soldiers ... ... (About 80% completed.)	1·18 ,,
(*d*) *Lucknow.*—Additional cells for the Detention Barracks ... ... (Just starting.)	0·29 ,,

From the above it will be seen how many and varied are the works on which the Engineer officer in India may be employed in the Buildings and Roads Branch of the Military Engineer Services, and the numerous problems, both of design and execution, that may confront him during his service in India.

SURVEY OF INDIA.

Report for 1922–23.

Owing to financial retrenchment the field operations of the parties employed on geodetic work were considerably curtailed, and the Astronomical, Pendulum, Triangulation and Base Line Parties did not take the field at all.

The Tidal Party carried out tidal registrations at nine tidal observatories, and a new tide gauge, which is expected to be in working order before the end of 1923, will shortly be installed at Bassein. Data for the prediction of tides for 1924 were computed for 40 ports and the detailed compilation of tide tables for nine riverain ports was completed.

The tide-predicting machine which was received from the National Physical Laboratory, Teddington, in 1921, has been erected at Dehra Dun; it was used for the first time in 1922, and the tide-tables for 1924 were completed and issued by October, 1923. Before the installation of this machine, data for tide predictions had to be

sent to England every year, but in future this will no longer be necessary.

The increasing demands for accurate bench marks for irrigation projects have made heavy calls on the Levelling party, this party, working in five double and one special detachments, completed 205 miles of primary, 2,793 miles of secondary, and 13,889 miles of tertiary levelling, chiefly in connection with the Sukkur Barrage and Ghatprabha projects in Bombay, the Sutlej Valley Project in the Punjab and various projects in Burma.

The Magnetic Party recorded daily absolute magnetic observations for declination, horizontal force and vertical force at the Dehra Dun and Toungoo observatories, and observations for the comparison of instruments were made at these two observatories as well as at the Kodaikanal and Alibag observatories, which are controlled by the Meteorological Department. Magnetic observations were taken at six repeat stations to supplement the five-yearly observations made at all repeat stations, and to ensure the accurate determination of the annual changes in the magnetic elements.

Topographical surveys, which constitute the main work of the department, were carried out by 13 parties and the total output of 61,648 square miles constitutes a record for the area surveyed in any one year. Triangulation or traverse was also carried out to supply points for the surveys of 1924. Survey was mostly on the 1-in. and ½-in. scales, but the ¼-in. scale was employed for some 3,000 square miles in Rajputana, and many scattered forest areas were surveyed on the 2-in. scale. The publication of new topographical maps, which mostly represent the surveys of the previous year, amounted to 97 1-in. sheets, 74 ½-in. sheets and 63 ¼-in. sheets.

The scattered nature of the topographical operations is exemplified by the distribution of the parties, which was as follows:—

> Three parties worked in Burma, 2 in the United Provinces, 1 in the United Provinces and in Bihar, 1 in Bengal and Bihar, 1 in the Punjab, 1 in Central India, 1 in Hyderabad State, 1 in Madras, 1 in Bombay and 1 in Assam, and altogether work was carried out in 52 districts and in 49 Indian states.

To meet the increasing demands of local Governments for special surveys outside the normal topographical programme of the department, two parties are now employed on special work in the Punjab; one of these is employed in fixing permanent traverse points for the identification of boundaries in the extensive riverain areas of the Punjab, and the other is employed in laying down by traverse permanent marks representing the corners of rectangles which will be utilized by Settlement and Irrigation Officers as the basis of their surveys.

It is probable that in 1924 two more parties may be somewhat similarly employed in various parts of the country.

The three parties working in Burma have, in the past, been administered by the Superintendent, Eastern Circle, from Shillong, but they are now grouped into a new Burma Circle under the Superintendent, Burma Circle, with headquarters at Maymyo.

The Cantonment Party carried out large-scale cantonment and bazaar surveys in Bareilly, Agra, Muttra, Sitapur, Gorakhpur and Naini Tal.

A new party is under formation to deal with air-photo surveys and will be employed next year in connection with air-photo surveys of the Irrawady Delta.

A special survey party has been formed and placed on " foreign service " at the disposal of the Bhopal State to carry out traverse work in that state.

Two survey detachments were formed during the year and were employed on field service as the Razmak and Waziristan detachments; the latter of these is still at work.

A detachment was employed on survey work in Persia for the Anglo-Persian Oil Company; this detachment will be again employed in 1924.

The six drawing offices and publication offices at Calcutta and Dehra Dun have been fully employed in drawing geographical and general maps, small-scale topographical maps and special maps; over $1\frac{1}{4}$ million sheets, of a face value of over $6\frac{1}{2}$ lacs of rupees, were printed during the year, and the Map Record and Issue Office, Calcutta, issued over $1\frac{1}{8}$ million prints, of a total value of over $4\frac{1}{2}$ lacs.

The Mathematical Instrument Office at Calcutta, which supplies and repairs instruments for all Government Departments in India, did work valued at over $4\frac{3}{4}$ lacs in its workshops, and issued instruments to Government Departments of a total value of over $6\frac{1}{2}$ lacs.

During the year the death occurred of a very senior officer of the Department in Colonel Godwin Austin, who retired in 1877; the name of Godwin Austin has long been associated with the nameless peak in the Karakoram Range, which was first observed by Captain T. G. Montgomerie, R.E., when he was employed on the triangulation of the Great Trigonometrical Survey, and was then given the serial identification number of K2; subsequent computation fixed the height of this peak as 28,250 ft. and thus determined it to be the second highest known peak in the world. The name Godwin Austin seems to have been first suggested and accepted for this peak at a meeting of the Royal Geographical Society in 1888, in consideration of the fact that the first topographical survey of the southern portion of the Karakoram Range was carried out by Godwin Austin.

Major-General D. A. Scott, C.B., C.V.O., D.S.O.,
Colonel-Commandant R.E.

MEMOIR.

MAJOR-GENERAL DOUGLAS ALEXANDER SCOTT, C.B., C.V.O., D.S.O., COLONEL-COMMANDANT R.E.

"We regret to announce that Major-General Douglas Alexander Scott, C.B., C.V.O., D.S.O., late R.E., died on 5th February, after an operation in a nursing home at Oxford, in his 76th year.

"The death of General Scott deprives the commissioned ranks of the old Army of one of their most distinguished representatives, and one, moreover, who can hardly be said to have received reward commensurate with his services. Born on December 14th, 1848, the son of John Scott, M.D., he was gazetted to a lieutenancy in the Royal Engineers from the Royal Military Academy in January, 1870. Proceeding almost immediately to India, he was employed as a consulting railway engineer, and was in charge of the Royal train on the journeys which the late King Edward made all over the peninsula when he visited that country as Prince of Wales in 1876.

"As a subaltern young Scott saw service in the Afghan War, and had not long been a captain when Arabi Pasha's rebellion induced the British Government to send an expeditionary force to Egypt in 1882; Captain Scott accompanied it and was rewarded for his services with the brevet majority. He remained on in Egypt among that band of rising young officers who had the prescience to see that there was reward to be gathered for good service, became Director of Sudan Railways during the campaign of 1884–5, and served as D.A.A. and Q.M.G., being again "mentioned" and securing a D.S.O. and a brevet lieutenant-colonelcy. He now served for some time at home, was A.A.G of Royal Engineers at Army Headquarters from June, 1894, to June, 1899; C.R.E., Southern District, from June, 1899, to September, 1902; as a major-general he was C.R.E. of the Second Army Corps from September, 1902, to September, 1905, and during the ensuing four years he commanded the Coast Defences of the Eastern Command. He was given the C.B. in 1897, the C.V.O. in 1901, and was appointed Colonel-Commandant Royal Engineers in 1921.

"In 1894 General Scott married Mary, daughter of the late Captain Cardew, 74th Highlanders, and had one son and two

daughters. Mrs. Scott, who was a grand-daughter of Lord Chancellor Westbury, died in 1918."—(*Extract from "The Times" of Wednesday, 6th February*, 1924).

General Douglas Scott was a brother of Sir John Scott, Bart., who was instrumental in securing the Wallace Collection for the nation. Considerable details of his work in command of the 8th Railway R.E. in Egypt in 1884 will be found, given by himself, in the Memoir of Lieut.-Colonel Pelham von Donop, which was published in the *R.E. Journal* of February, 1922. In commenting upon these notes, Major-General Sir Richard Ruck, K.B.E., C.B., C.M.G., the writer of the Memoir, called attention to the fact that this was the first British campaign in which military railway companies formed an important feature in the supply of an army in the field. A correspondent states that General Douglas Scott claimed to have been the first officer to *receive* the D.S.O., and that he was very proud that an officer of the Royal Engineers should have been the first recipient of the Order.—(EDITOR, *R.E.J.*)

BOOKS.

LIFE AND ADVENTURE IN PEACE AND WAR.

By Major-General Sir ELLIOTT WOOD, K.C.B., D.L. Edward Arnold. Price 16s.

IT is sometimes advanced, as one of the advantages of a commission in the Royal Engineers, that the exceptional facilities for extra-regimental employment, in such services as Colonial Administration, Indian Survey or Public Works, or the like, give opportunities such as are not normally enjoyed in other branches of the Army for adventurous experiences, as well as for a wider sphere of useful work, in various parts of the British Empire. Whatever truth there may be, and doubtless is, in such a claim, it was certainly not due to any such collateral circumstances that Sir Elliott Wood was able to enjoy, and now to record for the benefit of others, a very remarkable life of adventure and useful service. He was during the whole of his service, practically, a regimental officer, for, although at one period he was an A.D.C., it was on the staff of the I.G.F. (Sir Lintorn Simmons), and though he was later on the H.Q. staff at the War Office, it was as A.A.G. of his Corps, and therefore during both those staff appointments, he was in close and constant touch with the regimental administration of the R.E. Nor can it be said that, in this long life of close association with the regimental work of the Corps, he was not also associated with its great task of construction, for he had the duty, in many places and under varied conditions, of designing and executing many important works. The supervision of the building of Knightsbridge Barracks in London, for instance, came under his charge when he was still a subaltern. The development of the fortress of Malta, from the medieval condition in which it was after the Crimean War to its present spacious and complete modern state, was largely due to his plans and superintendence, and especially this is the case in the utilization of the natural features of the island along the Victoria Lines which he planned and executed. These are some of the works which he carried out, wholly or in part, and it may be said that throughout his career he filled the not-too-easy *rôle* of soldier and engineer, thoroughly efficient in both.

His book, therefore, is an account of how, in the usual routine of an engineer officer's regimental life, opportunities can be used. He did not seek personal advantage, nor go out of his way to ask for comfortable billets. He took the rough with the smooth, and, like the good sportsman he is, rode straight, with his heart in the right place. The result is a really amazing record of good work done, and adventures of no ordinary character.

He takes us into his confidence, very pleasantly though briefly, in his account of his family life. Fortunate in having a home in a lovely part

of England to which at all times his thoughts would turn, and to which he has now retired "with years and honours crowned," still more fortunate in having in his home life parents of the godly, upright character that is of such unspeakable blessing to their offspring, he had the very best of preparation for a career of usefulness and legitimate enjoyment of life. Incidentally, it is possible to notice and admire the solidarity of the family ties, and to realize what must have been the lofty example of the parents who so united their sons in mutual esteem. One likes to think that such instances of personal family unity, in our country, are not rare, and that the influence of such homes is a strong national asset.

One of the results of early influence was the love and attraction which Sir Elliott has had for animals. His dogs are a delightful feature of his reminiscences, and their companionship must have been most real to him. There is a charming little account of how he swam the Mahmoudiyeh Canal in the first Egyptian War with a derelict kitten perched on his neck and purring with its paws on his head. And the adventures which he shared with his horses, and especially with his charger and hunter "Merriman," would themselves fill a volume, are they not written in the Chronicles of the Chase at Aldershot and the Curragh?

Then he had the advantage of being associated, if not intimate friends, with some very notable men. He was A.D.C. to Sir Lintorn Simmons, as above noted, and with this chief he went to the Berlin Conference in 1878, when he came in touch with many notable people—the Emperor William, the Crown Prince (afterwards Emperor Frederick), Bismarck, and many others. With Sir Lintorn also was associated Sir John Ardagh, and (earlier) Sir Charles Watson, both men who made their mark in the Army, and the Corps, and close personal friends of Sir Elliott Wood. An even more remarkable man than any of these was General Charles Gordon, with whom Sir Elliott was associated on many occasions, and it is especially interesting to learn that he and another officer (Captain Kelham, H.L.I.) were actually under orders to accompany Colonel Stewart to Khartoum and join Gordon there, and that on the very day that they were to start from Cairo those orders were cancelled. One cannot but wonder what would have been the result had another R.E. officer, of Sir Elliott Wood's calibre, been with Gordon at Khartoum. One is at least justified in assuming that in that case Khartoum might have held out for a few days longer and "in any case I should have been some comfort to my old friend, the lonely hero." History might have been very different if those orders had not been cancelled till a few hours later.

The whole story of the Nile Campaign is one of sad regrets for what might have been, and of discredit to the politicians of our country.

Sir Elliott was associated in Egypt with many men who played a most conspicuous part in the early days of our occupation, both in civil and military life, and of our campaigns in that country and the Red Sea littoral. It is a period in our military history of the deepest interest to the Corps, for both in military developments and in engineering R.E. officers were ever conspicuous. In the operations in and near Suakin none did better work than Sir Elliott Wood and his admirable Company,

the 17th. This Company, under the same officers, had done good work in the 1882 campaign, both at Alexandria and on the main line of attack, but it was on the Red Sea littoral in '84 and '85 that it did specially invaluable service, and it was there that its gallant commander's adventures were so thrilling. Sir Elliott was not only, in one capacity or another, in all the fights that took place—battles where there was comparatively little of modern military science, but a great deal of primitive hand-to-hand fighting—but he was in the thick of them, " a bonny fighter " of the good old-fashioned sort. The following is a sample worth quoting (though not more so than many others) :—

" I was retreating with the men, firing my revolver at close quarters over my horse's back, and so not looking where we were going, when the horse came to a standstill. Looking round I saw we were blocked by a mimosa bush, round the sides of which the men were pressing to whose difficulty it was impossible to add. My revolver was empty, so I thought ' That's the end of E.W.' Then I remembered I was on a big English hunter, who had no deterrent experience of the mimosa thorn, so roused him up vigorously and he got over and through it. We jostled a man on the other side, to whom I apologized and hoped he was not hurt. A poor fellow badly speared said ' Don't leave me,' so he was told to hang on to my boot, but after a few steps he said ' Oh, I can't,' so I leant down low and somehow or other—one hardly knows how—managed to lift him up, and bear him a short distance, etc."

One might quote page after page of this personal experience ; it is told in the simplest fashion, but is all the more convincing as to the cool head and active brain that was ever on the alert for useful co-operation with others. His experiences at Suakin were not only those of desultory and intensive fighting, but also those that fall to the R.E. under any circumstances, such as building huts and hospitals, arranging for water supply and landing stages, roads, etc., and he notes, what many of us have often found, that " the worse the climatic conditions, the more important it is to have plenty of interesting work to do, instead of lying in tents." There was sport also to be had, however ; bustard and sand grouse, and occasionally larger game, such as gazelles, fell to his gun.

The activities of the enemy began to mount again as the weather got cooler in 1884, and the season's campaign of 1884-85 was quite as full of incident as that of the previous year. The enemy were adepts at night attacks, and they seemed to have an extraordinary faculty for discovering land mines laid out for their benefit. The R.E. officer (Lieut. Askwith), who was placed under Sir Elliott for the purpose of working the mines, was himself blown up, and his detailed report of actual positions, which he had intended to submit, was destroyed with him ; so it fell to Sir Elliott's lot to find out where the mines were and remove them, a duty which he performed himself alone, and a very hazardous task it was. This was prior to the action known as " McNeill's zereba," in which he was, as usual, in the thick of the fighting.

The 17th Company was commanded by him in peace and war for nine years, during which time he had risen from being a junior captain to a brevet-colonel. It is no disparagement to the other admirable services rendered by Sir Elliott Wood when it is stated that possibly

the greatest service he rendered to the Corps of R.E. and the Army was the extraordinary efficiency of that Company, as it was when he brought it in the last year of his service with him from Aldershot to the Curragh. Up to that time field companies were not very favourably regarded by anybody. Senior officers of R.E. were inclined to regard them as not sufficiently good engineers, other branches of the service were doubtful of their value as soldiers. The 17th Company, under Sir Elliott Wood, was a model for any troops; officers, and N.C.O.s knew their work, each had his own allotted sphere of duty, and collectively they worked together admirably. The Commander of the Forces in Ireland, a Guardsman, said the field companies were the smartest and best troops under his command (which included many *corps d'élite*). Sir Elliott himself, owing to his high army rank, often commanded composite bodies on manœuvres, and it was freely said that his presence was equal to a battalion. At ceremonial reviews—more common then than now—where he commanded, everything went with smooth regularity. The prestige of the Corps was very high. (These facts are not, of course, mentioned in the book, but they are known to all R.E. officers who served in Ireland at that time.) As engineers, too, the 17th Company did admirable work, everywhere useful and in some cases solving difficult engineering problems—such as the Hare Park Well at the Curragh—in record time.

Sir Elliott's service in the South African War, where he was Engineer-in-Chief, was naturally on a different and higher level than the exciting experiences he had in the Sudan. He was at first sent to De Aar to command the Frontier Posts, as well as carrying on his duties as Engineer-in-Chief—a combination which seems strangely at variance with modern practice. This command he retained until the arrival of Lord Roberts as Commander-in-Chief in February, 1900, when he reverted to his original duty as Engineer-in-Chief, after several months of very responsible and difficult command.

The nature of the warfare in South Africa did not lend itself, as in the Great War, to the direct supervision and control of the Engineer-in-Chief. Sir Elliott was with Lord Roberts in the Paardeberg operations, where his advice was valuable and bore good fruit, and this was also the case in the subsequent advance to, and occupation of, Pretoria. In the later parts of the campaign he had much to say to the initiation and extension of the blockhouse system (there were 8,000 blockhouses constructed) and in many problems of water supply, railways and other communications. He found the difficulty of engineer stores and supply a serious one, as we all do in war, and also the not uncommon obsession in the minds of transport and supply officers that such stores are of secondary importance, irrespective of the nature of the military operations which may be absolutely dependent on them. He was less fortunate also in two respects than we were in the Great War, in that the Commander-in-Chief (unlike Lord Haig) did not appreciate and praise work done, and the Contract Branch at the War Office could not cast off (as it did of late) the costly and dilatory routine methods of peace. It is, however, possible that the troubles which Sir Elliott experienced made the way open for future and more reasonable procedure.

So much for the military adventures recorded in this book. We have, however, still to comment on the very remarkable experiences of Sir Elliott Wood as a builder and navigator of canoes. To one who is not in any way an expert in amphibious matters, the account of these voyages, and the skill with which the fragile craft was saved from destruction and the navigator from a violent end, reads nothing short of miraculous. It must surely mean more than ordinary nerve to discuss the possibilities of attempting a voyage in a small canoe round the stormy coast of South Africa, and actually to circumnavigate the group of islands at Malta, besides inland voyages down the Danube, Rhine, and many streams in the British Islands.

Where Sir Elliott first learnt to navigate boats is not told, but he evidently joined the Corps at Chatham with a good working knowledge of sailing and rowing, and seems to have been as much at home in the water as any aquatic animal. It was not until he was, as a subaltern, at Cape Town that he built, to his own design and with his own hands, the first of his three *Zephyrs*, canoes 13½ feet long and 2 feet 4 inches beam, weighing 66 lbs. "The whole frame is so elastic that in 35 years of canoeing, including the descent of many a rocky rapid, the framework of a *Zephyr* has never once been damaged by bumps or collisions." A pretty severe test of naval construction. So much for the canoe. A picture of this craft with its designer is given, and affords to the uninitiated a better idea of the hull, masts and sails than any lengthy specification.

Of the voyages, and hairbreadth escapes, that he had in these successive *Zephyrs*, it is only possible to give the very barest outline.

The first *Zephyr* was launched in stormy seas at Cape Town. In her the intrepid owner made some four long canoe trips, navigating rivers never before explored, and undergoing risks which all expert opinion regarded as foolhardy. The appetite for further adventure was stimulated on his return to Europe, and he navigated the Thames from Hammersmith to Shoeburyness, and across the Nore, returning by the Medway. Then followed service at Malta, where the Mediterranean is by no means always like a mill-pond, but where the *Zephyr* made light of the rough weather. In later years, with one of his brothers, in a second *Zephyr*, Sir Elliott had two varied trips in Scottish waters, with a good many hairbreadth escapes. A few years later, with the same brother, a most unique voyage was taken round Malta and Gozo, not entirely for pleasure, as the reconnaissance of possible landing places was an important object for the trip, which certainly was not one usually undertaken by two senior field officers!

In 1896, having built a third canoe of the same pattern, three brothers (whose united ages were 150 years) navigated the Danube from the Black Forest for 780 miles to Buda Pesth—a most interesting voyage, full of adventure.

In later years, after his retirement from the Army, when he was well past the usual age for such enterprises, he navigated the Rhine from Switzerland (the Reuss) to Cologne.

This takes no account of trips in England, among rivers and estuaries in the West country especially.

Even this brief outline, however, is sufficient to indicate how Sir Elliott Wood seems endowed with perpetual youth, if not in years, at least in activity and spirit. He comes of a long-lived race and, like his canoe, is possessed of a buoyancy which has borne him cheerfully in life's voyages, always making the best of the weather and steering straight for difficulties with a clear head ready for instant action.

His many friends, both in the Corps and in the wider circle beyond, congratulate him on this record of his adventures, and hope that he may long live to enjoy the retrospect.

G.K.S.-M.

GEOHYPSOGRAPHICAL PROBLEMS.

The problems in question are those which deal with the heights of the land surface, the depths of the sea, the areas of sea and land, their mean heights, their volumes, densities, and so on. The *Revue du Génie Militaire* has recently published some articles on the subject by Colonel A. Romieux, and these have been issued in book form.* The author has been studying the question for many years; indeed, his first paper was presented to the Academy of Sciences as far back as 1890. In 1895 H. Wagner wrote a critical study of the state of our knowledge of these matters up to that date, and included a discussion of Colonel Romieux's hypotheses; he published a second study, with amended figures, in his *Lehrbuch der Geographie*, in 1912. Amongst other writers who have contributed estimates of areas and volumes may be mentioned Lapparent, Penck, Supan, Heiderich and Murray; so that anyone who wishes to go more deeply into its history has a considerable literature at his disposal.

The interest of Colonel Romieux's work is chiefly that he finds certain relations to exist between the levels and the densities of the land and the sea masses. He first takes a "surface of equideformation," that is the surface of revolution which would exist if there were no sea water and if the land masses were levelled off to fill up the sea basins, leaving a uniform, smooth earth. He then finds that there is:—

(1) An equality of *level* between the sea water uniformly spread over the whole earth and the land *remblai* covering the terrestial areas.

(2) An equality between the weight of this *remblai* (or the equal, corresponding *déblai*) and the weight of the waters of the sea.

The author devotes a great part of the book to the exposition of a theory, which is to explain the reason for these two equations, by means of the play of an oceano-continental equilibrium in cycles of successive deformation. These ideas should be taken in conjunction with those of isostasy, with the conceptions of "sal" and "sima," and perhaps with the (at present quite unproved) theory of Wegener of floating continents. We do not, as a fact, yet know very much of the mechanism at work with regard to the equilibrium of the earth's crust. But studies like those of Colonel Romieux, by presenting special points of view, will assist us to arrive at correct conclusions.

* *Recherche Géhypsographique*. Colonel A. Romieux. Imprimerie Berger-Levrault. Paris, 1922.

The reviewer may, perhaps, be permitted to grumble at the plates which accompany the volume. The first plate, which shows the "geohypsographical curve," gives no indication of the ordinates used, and, to find these, it has been necessary to consult Wagner's article of 1895. The other figures are crowded together, away from the text which refers to them, and this greatly increases the labour of reading the book.

EMERGENCY WATER SUPPLIES.

By A. Beeby Thompson. Crosby, Lockwood & Son, London. Price 21s.

The true inwardness of this book, which is dedicated to the Engineer-in-Chief and the R.E. officers of the Salonika Army, is not revealed by the simple title upon the cover, and it is not until the title page is investigated that one begins to realize the importance of the book for military engineers.

Mr. Beeby Thompson may be said to have been the *deus ex machina* who solved the water problem for the Allied Armies in Macedonia. Yet his experience was not confined, during the war, to that inhospitable area. He also worked in Egypt and Gallipoli and his achievements in the latter theatre were conspicuous. To a ripe, scientific and commercial experience he brought a fertility of resource and an energy of execution for which the hospital patients and refugees at Salonika, quite apart from the inhabitants of the divisional areas in "the line," have every reason to be thankful.

Mr. Thompson pays some pretty compliments to the Corps of Royal Engineers and the Army in his book; they are less deserved than what we ought to say of him.

To turn now to the text of the book. It deals with Hydrology generally, the Hydrography of Macedonia, Development of Water Sources, Utilization of Norton Tube Wells, Deep-well Boring, Pumping Equipment and Water Analysis.

The earlier chapters are written in a language which, I fear, will be a little obscure to the average soldier engineer, but we shall refer to this later. When we use the word "language" it should perhaps be stated that it is the terms and nomenclature that are particularly alluded to.

What seems to us to instantly emerge from a perusal of the book is the enormous importance of geological knowledge to the military engineer. This functionary in our experience is looked upon by the Army in much the same way as Moses was viewed by the Hebrew tribes. He is supposed not only to know where water is, but to lead it, so that it will drip gently out of a tap, into every thirsty mouth. In the time when the present writer sat at the feet of Schoolmen, Geology was not one of the many things his mind was required to assimilate and it was only by private pursuit that any knowledge of the sort could be acquired. This seems to be an important fact on which to lay stress, for without geological knowledge no one can emulate Moses as a water finder.

From the point of view of the military engineer, who may be called upon to produce water in a rough and barren country with but few

appliances, the chapter on Development of Natural Sources and Springs and that on the use of Norton Tube Wells are especially interesting. The experience of the present writer in Macedonia was principally in respect of development and piping of springs. The area in which we operated was not ill-watered, in some places it was abundantly well watered, but a good deal of care was necessary in dealing with the natural sources.

In one case we had to pipe water two miles to a railhead to reinforce the supply from one of Mr. Thompson's bore wells, which was of rather a recalcitrant character. Our doctors discovered "Bacillus Coli" in the spring. There was a good deal of fuss and it was feared that if the engines did not die of cholera they would do so of thirst. However, the evil genius of the source seemed to yield to the treatment of vigorous gushing and disappeared. Some of the irreverent doubted whether the "Coli" had not been imported in a "sterilized" flask.

We had a noted mineral spring at Janes (the railhead mentioned above). This spring had been condemned by the *cognoscenti* as unfit for human consumption. After vigorous cleaning and protection it was, however, continually used by the 12th Corps Camp. The water was slightly aerated and made an engaging beverage when diluted with whisky: its slight aperient qualities also doubtless accounted for the general good health of camp population.

To turn now to the tube wells. Many R.E. officers doubtless have lurid recollections of the waywardness and apparent inefficiency of these instruments. In Macedonia they were an unqualified success, if they were *put in the right places* and used intelligently. Their usefulness and importance as a military store were completely vindicated.

It has been indicated above that the troops "in the line" in Macedonia lived in a fairly well watered country. It must be clearly understood, however, that the "line" was so thin that there was seldom a very large number of troops to be dealt with in any one place and the problem of water provision was therefore not a very difficult one to solve. At the Salonika base, however, matters were quite different. Here there was a vast accumulation of troops and animals, hospitals and refugee camps for which the town supplies, from Kotos Mountain and Eurenzik *via* the Roman aqueducts, was quite insufficient. Water for this great increase in the population had to be found and produced and that quickly, and it was here that Mr. Beeby Thompson's work was so invaluable. His work, however, was not confined to the base area, as, whenever and wherever his advice or assistance was required, it was instantly available.

It only remains to say that this record of achievement under most adverse circumstances should be carefully studied by all R.E. officers and that all R.E. officers should be made to study geology in its water supply aspect. This study is essential in order that R.E. officers may be able not only to study and understand contemporary scientific literature on the subject (it is for this reason that allusion was made above to the language and terms used in the volume under review) but also in order that they may be able to approach water supply problems, both in peace and in war, without an entirely "open" mind.

G.W.

MILITARY ENGINEERING, VOLUME V (ROADS).

H.M.S.O. Price 2s.

THE inclusion of the special section on Roads as Volume 5 of the Military Engineering Series issued by the Army Council is very welcome. This volume replaces a manual on Road construction, etc., written by an officer of the R.E., and published in 1908 by the Institution of Royal Engineers for the use of Engineer officers.

The general composition of the original compilation has been followed. The subject matter has been rewritten by competent Engineer officers who took part in the Great War, giving the result of experience gained in the various theatres of action, where roads and communications played such an important part.

The present volume worthily fulfils its aim and object as a hand-book for Military Engineers and Pioneers in all parts of the world, and will undoubtedly find a place in the library of many Civil engineers and Prospectors in new countries whose prosperity can only advance by opening up roads and communications suitably aligned and scientifically constructed to meet the ever-increasing demands of vehicular transport.

It is an axiom that Roads and Communications are the avenues along which civilization is introduced into every land. No campaign in history has been carried through without "Communications" of some kind—chiefly roads and railways. Many roads in Britain and in Europe owe their inception to an invading force., *e.g.*, the Roman Roads of Gaul, Britain, Macedonia and Asia in ancient times, and Wade's roads in Scotland in the eighteenth century. Without doubt History will record a like indebtedness to Allenby's conquest of Palestine, and the occupation of Macedonia and Iraq by the British and Allied troops.

The strategic value of good roads behind a battle front is immense, the tactical value in forward areas is very great. An Army depends for its subsistence on the regular, as well as expeditious, delivery of munitions, food supplies and stores of all kinds; so good roads are one essential to success.

The difficulty in War is to make roads which are immediately fit for heavy traffic, often within a few hours of an advance, and to maintain them for a considerable period without impeding a continuous flow of traffic. This particular difficulty was very apparent on the Western Front and in Palestine.

Where roads already exist, their surface may be good, but the foundation weak or even non-existent. To the Engineer Officer, and certainly to the inexperienced and non-technical Staff Officer, the value of an existing highway is an unknown quantity. To the experienced roadman, every road requires as critical an examination and treatment as the condition of an ordinary shoe; like a thin sole it may last, or suddenly develop holes and require complete renewal. The lesson therefore is that "*Appearances in roads go for nothing.*"

The Engineer Officer may have to face the building of roads in a diversity of countries with great extremes of conditions. For instance, in the Near East existing roads and communications for all practical purposes in War were nil. They had for the most part to be created or adapted for military transport. Roads and Communications that

the Mediterranean, Egyptian and Palestine Expeditionary Forces had to deal with occurred in such extremes as the sea shore and limestone strata of Gallipoli—Nile mud in the Delta of Egypt—the hard desert of Libya, the soft desert of Egypt on the west and east of the Suez Canal and the bare wastes of Sinai. Again too, in Palestine, the hills of Judea, the cotton soil of the Maritime Plain, the mountains, ravines and rocks in Samaria, and the slimy mud and almost knee-deep dust of the approaches in the Jordan valley, as well as the varied country in Mesopotamia, give ample evidence of what Engineer Officers had to contend with during the Great War.

The advent of the heavy motor transporters has rendered the problem of road construction very difficult. The problem can only be solved by a scientific examination of foundations and surfaces under moving loads, whose intensive and continuous blows and impacts demand a very high standard of resistance of materials scientifically assembled and laid. Whilst the original principles of road alignment and construction have been subject to but slight modification, their application and fulfilment by the use of new materials and methods of construction have undergone radical change. The military engineer must be prepared to regard the latter as still subject to change, as there is little doubt that the day is not far distant when roads and communications will have to be built to admit of and withstand the traffic of lorries and loads of at least fifty per cent. if not eighty per cent. higher weight than those of the present time. It is conceivable that an immense network of heavy solid reinforced concrete roads will alone suffice to meet the transport demands of the future.

Whilst Volume 5, "Roads," of itself, is very comprehensive, the Military Engineer is reminded that much information which is cognate to road construction is to be found in other volumes of the Military Engineering series—notably Volume 3, "Bridgework," where Load diagrams of the principal vehicles, guns, etc., forming part of every expeditionary force are given. Similarly, for the principles of construction of retaining walls, masonry arches, etc., attention is directed to Volume 1.

In the present volume a very useful series of Appendices is given upon materials, quarrying tools and plant which come into road-work. The illustrations and Tables have been carefully selected and compiled, and the Index is full, sensibly arranged and completely paged into essential references.

In Chapter I are enumerated the various considerations which affect the alignment of roads and communications from the standpoint of the Military Engineer, who may be called upon at any moment to reinstate and recondition communications destroyed by enemy action so as to render them fit for military transport of all kinds within a few *hours*. The necessity of careful reorganization in the field, of close and intelligent co-operation on the part of the General Staff is very rightly emphasized.

In special cases a separate Road Directorate may be needed. The absence of the above essentials reacted upon and retarded general operations on the Salonika Front in 1915–16.

Traffic control on roads under reconstruction or repair is a matter which should receive careful attention, as it is of primary importance.

The amount of damage done by long trails of *empty* lorries bumping back daily at excessive speeds to their base, and following identical tracks, is seldom appreciated by the Q. and A. Branches of the Staff. Lorry drivers in such circumstances should be compelled to follow deviations and side routes wherever possible.

Although reference is made on page 6 to types of military vehicles it would have been helpful if something had been written about caterpillar tractors, and their nature and effect on roads.

Chapter II is devoted to Reconnaissance Survey and the factors which determine correct grading, location and alignment.

The information and principles recorded are exhaustive and excellently compiled and grouped.

Chapter III which deals with the Principles of Road Construction is perhaps the most valuable in the book. The principles given should be indelibly recorded in the memory of all Engineer Officers.

Chapter IV refers mainly to permanent macadam roads and the various expedients employed in construction, so as to maintain a hard-wearing, waterproof and dustless surface. Skilled work put in the foundation of adequate thickness and stability cannot be too strongly impressed on the Road Engineer, as the whole future efficiency of the road primarily depends thereon. The greater part of the chapter is applicable to peace conditions as apart from military conditions in the field. The ever-increasing dead weight, loads and speed of motor traffic presents a problem of great complexity—requiring careful observation and study in order to maintain any macadam road in an efficient state for continuous traffic. The information given introduces the student to many avenues of practical value and observation towards solving the problem involved.

Some reference might have been made to the often observed corrugations of road surface and the probably contributing causes which have so far not been definitely determined.

The notes on page 4 about the correct weight of road rollers are very much to the point. In many cases the "disturbing" effect of road rollers of excessive weight to both foundation and surface has received but little attention.

Chapter V, which refers to roads during minor military operations, is an admirable compilation. It would have been of considerable assistance if some data could have been given in tabulated form showing the approximate cubic measurement, weight, and truck loads of metal and surfacing materials required per 1,000-metres', or yards', length of road as a guide for the Engineer Officer engaged in making a new macadam road during minor military operations.

Deserts of sand and stones and how to cross them are a new feature in road work, the outcome of the desert campaigns in Egypt, Sinai, Southern Palestine and Iraq, etc., during operations 1916–17–18. The credit for the application of wire netting for the purpose of making communication across desert wastes and sand fit for light motor traffic, lies with the officers of the Corps of R.E. Wire netting was employed for sundry purposes in Gallipoli and for crossing dry river beds in East Africa very early in the Great War. The first use of wire netting in

Egypt was for laying pathways between hospital tents at Mehemdiya —east of the Suez Canal—and at Divisional Headquarters near Rafa early in 1916. Subsequently the tarpaulin floors of hospital marquees were laid over wire netting to prevent them from sinking into the sand. The use of wire netting was extended to local communications between Brigade and Divisional Headquarters in desert camps, and finally for evacuating the sick in Ford ambulance cars along main routes following the advance of the Expeditionary Force across the Eastern Desert into Southern Palestine. These wire roads were employed later on in other theatres and so formed a distinct feature of novel communication in the Great War, but they have not received the full appreciation they deserved.

Plate XVIII shows an actual wire road in process of construction close upon Gaza on the second day following its capture in November, 1917. The sparse brushwood and scrub over the alignment was roughly hacked down and cleared of tussocks, the sandy surface being made fairly even as a preliminary to the unrolling of the wire netting, which was rapidly laid, pegged down and fixed as described on page 55.

It is important to remove any large isolated hummocks and stones which may occur on or under the surface, as these will rapidly wear holes through the netting; if not quickly removable they should be crushed with a sledge hammer. Wire roads require careful inspection and immediate patching where any such holes or breaks in the netting take place: but careful laying and pegging down in the first instance reduces the risk of such breaks to a minimum.

Earthen roads in places where stone is absent are unavoidable *faute de mieux*. On all such roads a reduced speed is obligatory when they are used by heavy mechanical or motor lorry traffic—otherwise their destruction is rapid and irremediable for months.

Chapter VI, which deals with Roads and Communications during Stationary Warfare, is of no less importance than Chapter III, and the two should be read in conjunction. The chapter is a very useful contribution from experience gained in France and Flanders, and constitutes a valuable asset and fund of information for future operations. *Plate* XX gives useful information on how to repair shell-holes, and *Plate* XXI an example of a forward road system, the governing principles of which should be carefully studied by officers of the General Staff, R.E., R.A., R.A.S.C., Transport and Supply units, as this matter considerably affects military operations.

The screening of roads to counter enemy observation of troops, etc., in movement is one which was extensively used in Palestine and on the Western Front. In providing screens, ordinary rabbit wire netting enters largely into the construction whereby variations of foliage and screens can be applied to suit the backgrounds at different seasons of the year. Various types are illustrated, *Plates* XXIII, XXIV and XXV.

Chapter VII is one of a special character and of considerable importance to all engineers, pioneers and others who have to lay out and construct roads on hilly and mountainous country. The principles given are the result of many years' experience and collated from records of mountain roads in diverse parts of the British Empire, notably India,

Tibet, Kashmir, N.W. Frontier, and also from observations made in the Caucasus (*Plates* XXIX and XXXV). Section 41 on Drainage is of great importance: neglect of efficient means for carrying off water has in the past led to great damage and disastrous hindrance to traffic. Other matters which concern mountain roads are collated in a very practical manner, *e.g.*, Causeways—Avalanches—Landslides, etc., and, not least by any means, namely the recruiting of road labour; organization, management of same.

Chapter VIII is devoted to masonry structures in road work, viz., Bridges, Culverts, Retaining Walls, Flood Openings, Scour in Rivers, and the like. Various formulæ are given, more or less reliable in character, for estimating discharge from catchment areas and requisite flood openings; but, it must be remembered that all formulæ have their limitations, being usually based on assumptions which may have particular application and cannot be relied on in general. All such formulæ should be qualified by the most recent records which can be obtained from publications of the Institution of Civil Engineers. (See Papers Nos. 4,452, 4,473 and 4,489). The practical rules and tables for masonry arches based on Trautwine's rules are quite reliable, given sound materials and workmanship.

Chapter IX—the last—is one which leads up to the type of permanent roadway which one may expect to see provided in future, namely the reinforced cement concrete highway.

The road question, affected as it is to-day by the ever-increasing loads in vehicular transport, is both vital and urgent. Hitherto engineers have only been able to meet the demands to a small extent. It must now be recognized that the increasing loads and traffic demand reconsideration of the problem and its answer on a vast scale. The reinforced concrete road is the nearest approach to the ideal highway and bids fair to solve the problem both as regards strength, surface, durability and ultimate lasting quality. Concrete roads have the merit of being free from deformation, corrugation and wave action; they are more stable, lasting and obviate "tracking," besides offering a good surface and small resistance to traction.

They have been in use in America for some twelve or more years, and at the present time their aggregate length approaches 60,000 miles. Meantime but little has been attempted in the U.K. (only since 1912), though during the last four years considerable development has taken place. Good concrete roads are to be found near Tilbury, Manchester, Sheffield and Middlesbrough. In the more recent and new routes all pipes for water and gas and electric cables are laid in culverts under the footpaths. A Report upon the proceedings of the recent Road Congress at Seville, May 1923, is worthy of reference in connection with concrete roads. (*R.E.J., September*, 1923.) Useful information may be obtained from the Concrete Utilities Bureau, 25, Gt. St. Helens, London, E.C.3. One of the most recent systems of reinforcement in use applicable to roads is ordinary "black sheet iron" stamped out to a special pattern, used by the Rogers Construction Co., 20, St. James Square, Pall Mall.

Where reinforced Concrete Roads are to be laid the use of "Ciment Fondu," an alumina cement, should produce much better results than

ordinary P.C., inasmuch as the material develops in 48 hours a greater strength than P.C. after 28 days, whilst its rate of initial setting is slower, thus enabling the concrete to be handled for a longer period than in the case of P.C. "Ciment Fondu" would be invaluable in forward areas for roads which could be used sooner after completion than where ordinary P.C. is employed. For further information on "Ciment Fondu" see the *R.E. Journal* for September, 1923, pages 419–29.

MANUAL OF MOVEMENT (WAR).

H.M.S.O. Price 1s.

(From *Modern Transport*, 16th February, 1924.)

BOOKS issued by the War Office appeal as a rule to few readers outside the Army, but this one which has recently appeared is likely to prove of interest to a much wider circle. In war time the Army must rely in the first instance on existing transport systems, and if it establishes systems of its own, whether ox transport as in South Africa, inland water transport as in Mesopotamia, or extensive railway systems as in Palestine and France, it can only obtain the personnel for working them by drawing on civilian sources. The Army view, therefore, of how the best use can be made of existing systems and how military systems extemporized in war time can best be organized should prove of interest to everyone whose everyday business is transport of any kind. The importance attached to the subject by the military authorities is shown by an order that every officer is to be in possession of a copy of the book.

The book begins by dividing the operation of supplying an army overseas into five stages—collection from depôts at home and movement to a port, sea carriage, removal to main depôts, dispatch from these depôts by trunk services, and delivery at the front by distribution services. Then it names the transport agencies, from native carriers to aeroplanes, which may be employed. These may be existing systems under civilian management or services organized by the Army itself.

Considerable space is devoted to "Control." The loose use of the expression "military control" is responsible for much apprehension. Except where a transport agency is organized by the Army itself, military control does not mean control over the agency itself nor interference in the way it does its work, but control over the military demands made on the agency. In war time urgent demands are made by forces in the field on the depôts from which they are supplied, and the depôts do their utmost to load up goods to meet the demands. But neither the unit making the demand nor the depôt meeting it think much about how the goods demanded are to reach their destination. Different military supply departments compete for the facilities offered by some transport system, so that the sum of the demands frequently exceeds the carrying capacity of the system. The carrier is not in a position to say which consignments should have preference; no one but the

C.-in-C. (or his mouthpieces, the staff) knows which is the more necessary in view of his plans. The object of a military controlling staff is not to interfere with the working of the system, but to collect and co-ordinate all the various military demands, to decide and to tell the management which are to have preference, and to issue orders to military consignors as to what they may, and what they may not, offer for dispatch. This has always been the real business of a Railway Transport Officer or of an Embarkation Staff Officer; but to make their functions perfectly clear and to strengthen their control over military consignors they all now form part of a new branch of the staff of the Army, the Movement Control Staff. As members of the headquarters staff of the Army, they speak in the name of the Commander-in-Chief, and the old-time R.T.O. is now invested with the authority of a representative of General Headquarters.

After an outline of the objects and duties of the control staff, the manual goes on to deal with the basic principles applicable to every form of transport. To obtain the maximum output from any transport system used for military purposes six conditions must be fulfilled. They are :—

1. Unity of control, *i.e.*, a single military authority to control demands and a single technical authority to control the working of a whole system.
2. Non-interference with either the technical appliances or the technical management.
3. Reasonable regularity in the demands made on each system.
4. Adequate running facilities with equipment to match.
5. Ample terminal and transhipment facilities.
6. Full use of the capacities of the system, viz. : (i) Full loads of the vehicle and of the motive power. (ii) Quick turn-round. (iii) Movements :—

(*a*) Continuous in time, *i.e.*, neither the vehicle nor the motive power ever idle, and in space, *i.e.*, across the gap between the two termini at points of transhipment.

(*b*) In one direction, *i.e.*, on single lines or on narrow roads or canals by the use, wherever possible, of alternative return routes. (In the case of a double line of railway or of an ordinary road the return route is parallel and alongside the outward route.)

(*c*) At uniform speed.

(*d*) Over the full distance.

(*e*) Balanced.

Considerable space is devoted to these principles and much more might be said about their application to all the various forms of transport which might be used. To some they will appear truisms, to others counsels of perfection, but it is to disregard of one or other of them that transport difficulties in past wars can invariably be ascribed.

Chapter IV deals with movements in a theatre of war, naming the various points to be watched by the control staff to ensure that the working of transport services is not hampered by any action on the part of the Army at variance with the principles of efficient movement.

laid down in Chapter III. The control staff can insist that military traffic of all kinds has priority over civil traffic (including civil passenger traffic), and, with a view to the control of civilian refugees or spies, may impose conditions as to their conveyance, but, with these two exceptions, the orders of the control staff are issued to military passengers and consignors alone, not to the technical management of the system. The next chapter deals with sea transport. It is noticeable for the stress laid on the importance, firstly, of using transit sheds for transit alone, and, secondly, on the discharge of cargo being placed under expert management and not left to the branch of the army to which the cargo is consigned. In small wars prior to 1914 we "muddled through"; in the late war the only sound system for the transfer of goods from sea to land emerged plainly, not only in the French and other ports such as Basra, but in landings on open beaches like those of Gallipoli as well.

Chapter VI deals generally with trunk systems—railways and inland waterways, Chapter VII with distribution systems—road transport and light railways. The subject of Chapter VIII is the organization and functions of various military transport directorates. It defines the position of a Director of Transportation in a small war or of a Director General when the extent of the operations warrants the appointment of one. A certain amount of semi-technical information is given, notably on the chronic shortage in war of railway wagons and the steps that may be taken to relieve it; also on the design of new lines and sidings for military purposes. Provision is made for a parcel agency for dealing with small consignments, the lack of which has been acutely felt at the beginning of every modern war, and the functions of the Docks Directorate are described. The remaining Chapters, IX to XII, deal with miscellaneous subjects, transportation in small wars and in position warfare, the transport of sick and wounded, artillery on railway mountings, etc.

Two or three main ideas crop up again and again under different aspects throughout the book. One is that the problem of transport in war has two different sides. On the one side fall questions of how transport systems can best be used to further military aims, on the other technical questions of how any particular transport system is actually to be worked. The former is the province of the staff, the latter is a problem for the technical management, be it civil or military, of each particular system. Though not always quite consistent, the book starts by labelling the two sides of the question with different names. Transport is carriage effected by a single agency, road, rail, inland water or other; transportation is defined as the use of agencies, either singly or in combination to effect transport. In other words, from the military point of view, transportation is not transport; transportation is the art of making use of transport systems; it includes the selection of the particular agency to be employed, the issue of orders to military consignors as to what they are to send and by what route, the ensuring of continuity at points where the form of transport changes as from sea to land or railway to road, and a variety of special arrangements for the health and comfort of passengers and for the safe transit of special classes of goods. These matters are duties of the staff;

transport is the business of technical services under either civilian or military management. A transport service provided and manned by the Army itself is under a military director; its business is to supply or construct and to work some transport system, or to give technical assistance in labour, equipment or materials to an overtaxed civilian system. But as regards what such a military system is to carry and when and where, an Army system is in exactly the same position as a civilian system—it receives demands for carriage not from the military consignors direct, but from the staff.

Another idea running through the book is that, while every transport system is a potential weapon in the hands of a Commander-in-Chief in the field, yet to obtain the greatest advantage each system must be used in combination with other systems. Before the Great War there were one or two military text books dealing with particular forms of transport, but each was regarded as an entirely separate subject to be taken up by quite different people. The Engineer officer who had studied the use of railways for military purposes had little or no knowledge of the working of the mechanical road transport of the Army Service Corps. The late war brought home to the Army very forcibly that transport is a continuous chain of connected operations, linking the forces in the field to the factories and depôts at home, and that, however efficient any particular service may be, firstly each must be linked up with the next one to make a continuous chain, and secondly that the chain will be no stronger than its weakest link. In the pre-war organization one link was practically non-existent, viz., that joining sea carriage to land carriage; another, the connection between troops at the front and the railhead or riverhead from which they drew their munitions and supplies, was apt to be weak. And wherever one link was weaker than the previous one, congestion arose with the possibility of failure at a critical moment.

No two wars are ever the same, and even in the same war the lessons learnt in different theatres sometimes appear contradictory. In the late war the military transport problems on the Western Front, in Palestine, in Mesopotamia, in East Africa and elsewhere were quite different; all of them differed from the problems, say, in Egypt in 1884, South Africa in 1900, or on the north-west frontier of India at the present time. Those in the next war will be different again. There is a natural tendency to base opinions on one's own experience, and often the narrower the experience the more pronounced the opinions. This book is based on the experience not of one theatre, or even of one war. There is hardly a paragraph in it which is not founded on some actual occurrence in war time. It is an attempt to sift out principles from an immense amount of detail and then to lay down only such principles as are true, not merely under the special circumstances of some particular campaign, but those which will be true in any future campaign in whatever part of the world it may take place.

A. M. HENNIKER, *Colonel.*

MAGAZINES.

THE FIGHTING FORCES.

Vol. I., No. 1., March, 1924. Edited by Lieut.-Colonel F. E. WHITTON, C.M.G. Gale & Polden, Ltd., Aldershot. Price 5s. net.

IT is believed that the orthodox comment upon a new periodical is that it "fills a long-felt want." It is not clear what want our contemporary *The Fighting Forces* is designed to fill. Its attractive cover tells us that it is "*A Quarterly Magazine for the Royal Navy, the Army and the Royal Air Force*"; but it contains articles on such a variety of subjects that one is inclined to doubt whether it will, as a whole, be of real interest to the special public for which it is intended. It may be taken as an axiom that, for a magazine to pay, every subscriber must find at least half the articles in each issue of direct interest to himself. If this condition is not fulfilled the number of subscribers will fall off. We fear that *The Fighting Forces* has spread its net so wide that many of the fishes will escape through the meshes.

The articles themselves are of a high standard, and many of the contributors are well-known authorities on the matters about which they write. There are serious articles on questions of general interest, such as *The European Outlook* by Professor Pollard, and *Security for France* by Général Fonville. These two articles give the two opposite aspects of the French policy since the Armistice and, taken together, give the reader much food for thought. There are articles which are mainly of Naval, Military or Air Force interest, such as *The Air Situation of the British Isles and Empire* by Admiral Mark Kerr, *Britain's Air Problem* by Brig.-General Groves, *The Indianization of the Indian Army* by "Silladar." There are articles on sport, such as *Services Rugby* by Lieut.-Commander Davies, *Coaching in the Services* by Major-General G. H. A. White, *Hunting for Infantry Subalterns* by Major Tomes. There are historical articles, a short story, a poem, hints to house-hunters, a guide to Plymouth, and other excellent reading matter which it is hard to classify. Even the auction bridge and chess enthusiasts are catered for. Reviews of about a dozen books, mostly of service interest, appear at the end. Many of the articles are well illustrated.

A pleasing feature of the publication is the brevity of the articles, few of which exceed 10 pages or 5,000 words—an attribute which is not common in service periodicals generally.

The magazine is well printed on good paper, Royal octavo size, and the first number contains, apart from advertisements, 168 pages of reading matter. It is to be published quarterly, in March, June, September and December.

G.E.H.S.

REVUE MILITAIRE GÉNÉRALE.

(*January*, 1924).—*To-day's Duty.* In this article Capt. Charles Delvert points out the needs of France in the matter of additional canals, railways, and deep-water ports, plans for which have been under consideration for years, and many are already worked out in detail. Also three-quarters of French maritime commerce is carried in foreign vessels. Taxation presses heavily on the people even if reparation payments are secured from Germany. The nation is falling behind all her neighbours in the struggle for existence. The only remedy for this disastrous state of affairs is more men, whereas at the present time the birth-rate barely exceeds the death-rate. The article ends with an appeal to the mothers of France to rescue their country by bearing larger families.

Was it a Mistake to Retire the Belgian Army on Antwerp in August, 1914? By Colonel P. Nuyten, of the Belgian General Staff.—An editorial note states that this article was first published in the *Bulletin Belge des Sciences Militaires*, and is a reply to the article by Capt. Kuntz published in the *R.M.G.* in May, 1923. It regrets that the Colonel chose a Belgian magazine in which to state his case, instead of relying on the impartiality of the *R.M.G.* The writer takes all the arguments of Capt. Kuntz, and refutes them categorically. He marshals his facts skilfully and seems to prove that, not only did the action of the King of the Belgians, against the entreaties of the French, conform to the maxims of Napoleon, and follow out the instructions actually given by Napoleon to Macdonald in similar circumstances during the campaign in Belgium just 100 years before, but was in the highest interests of the Allies so long as communication with the latter could be maintained. The serious menace of Antwerp on their flank was so clearly acknowledged by the Germans that their first care, after suffering defeat on the Marne, was to lay siege to it. Its importance was equally recognized by the British Admiralty as constituting the true and most advanced possible pivot of the Allied left flank. The occupation of Antwerp was not undertaken, as has been averred, to defend "the national refuge," but to make use of its strong positions to aid the field army in its resistance to the German attempt to envelop the Allied flank. (*To be continued.*)

Ludendorff's Strategy on the Russian Front. The conclusion of the article by General Camon.—Ludendorff in July, 1915, again advocated his plan of annihilating the Russians by cutting their communications through Kovno–Vilna–Minsk, but Falkenhayn directed him to take part in the less extensive frontal and flank attack. This attained a great measure of success, but Ludendorff argues in his "Memories" that his own scheme would have given more decisive results in a shorter time and at less cost. Falkenhayn claims that it was impossible to annihilate the Russians owing to their immense numerical superiority and excellent lines of communication, but at least they had lost 750,000 prisoners, masses of material, Galicia, Poland and Courland, and had been unable to threaten Austria at the opening of her war with Italy. It was not until August that Ludendorff obtained leave to execute his

plan, and by that time it was too late. The Russian retreat had progressed so far to the East that the attack intended to fall on their rear now only reached their front and flank, so that again they were able to escape the noose. Owing to this, and that Ludendorff could never obtain the number of troops he required, and partly to difficulties of supply, the attack failed to be decisive.

The German Infantry.—The article by Commandant Pujo is concluded, and this month deals with the second and third phases of the attack. The following points are noteworthy (1) the exceedingly methodical manner with which all possible changes in the situation are provided for, and the thorough training instituted to educate all ranks to meet them almost automatically, (2) the large numbers of firearms allotted to the company, from accompanying artillery and heavy machine-guns to light automatic weapons, rifles and repeating pistols, (3) the strength of the staffs, officers, N.C.O.'s and men, allotted to all units, from the regiment to the company, and means of communication including small wireless telegraph sets, telephones, optical apparatus, cyclists, runners and dogs. The principle acted upon is that, once the action is begun, commanders in rear can see and know little of what is going on, those on the spot must therefore be in a position to act at once with the most powerful means required to meet the local contingency. All the higher commanders can do is to send up reinforcements of men, machine-guns, minenwerfer and, in case of need, guns, which the junior commanders make use of, and this is particularly requisite in the second and third phases, *i.e.*, from 400 yards into the position. This conception of the action is particularly suited to the war of movement; in short, the Germans realize that for many years, certainly as long as France holds the Ruhr, they cannot hope for material superiority, and aim at making up for this by the action of infantry of the highest military efficiency, which in the next war may thus be able to capture its material from the enemy. The whole article is well worthy of study.

Position and Open Warfare By Lieut.-Colonel Lucas. This article is an argument in favour of differentiation in the military regulations between these two classes of warfare, for, although the end aimed at is the same, viz., the destruction of the armed forces of the enemy, the processes by which this end is attained are very different in each case. The writer would have the regulations begin with the principles generally applicable to all cases likely to arise, and then be divided into two perfectly distinct parts. This would not only emphasize the differences of method, but would facilitate training in both types of warfare, and the preparation of schemes for exercises and manœuvres.

(*February*, 1924.)—*The Germans as Painted by Themselves.* By Albert Pingaud.—After describing the effects of their history and geographical position on the character of the Germans, the writer states that owing to these many causes they are exceedingly sensitive to the opinions of others, and show much of the snobbishness of the *parvenu*; frankness deteriorates into rudeness, intimacy into lack of reserve, differences of opinion into aggressiveness. The old German virtue of kindliness has been dulled by the grimness of the struggle for existence, and the historian Lamprecht avers that the old imperturbability, of

which Bismarck afforded such a brilliant example, has given place to a nervous excitability. Many German writers who have had opportunities of comparing their compatriots with other nationalities, feel with keen regret the extent to which the former are disliked, but almost all attribute this to jealousy of German progress; only a few of them recognize any personal defects in the German character and in their manner of dealing with other nations.

Was it a Mistake to Withdraw the Belgian Army on Antwerp? The conclusion of the article by Col. Nuyten.—The two sorties of 25th to 26th August and 9th to 13th September, when the forces in contact at Antwerp were nearly equal, and active operations continued until 30th September, diverted from the German line on the Marne and Aisne the 9th Reserve Corps and several divisions of other Corps. Had the Belgian Army been at Mons or Tournai on 24th August, von Kluck could have masked the fortress troops at Antwerp with a few Landwehr units, and would have had the 3rd and 9th Reserve Corps to reinforce his right, which might then have been extended to Boulogne and Abbeville. From 15th September the German force at Antwerp was definitely superior, and the Belgian Army resumed its rôle of general advanced guard. On 29th September began the change of base from Antwerp to near Ostend, proof positive that the King never intended to identify the fate of his field army with that of the fortress. The arrival of Winston Churchill on 3rd October with a Naval Brigade stiffened the resistance of the Belgians, but they were slowly forced back, although reinforced by more British units, and by Allied troops sent to hold Ghent. If Ostend and Zeebrugge were lost it was due to the fault of the Allies in withholding adequate reinforcements, which were available in England, by means of which their front could have been extended behind the Dendre, Scheldt, or even the Lys, to join with the Belgians. But for the stubborn resistance of the Belgians at Antwerp it would have been impossible for the Allies to concentrate on the Yser and at Ypres by the 18th October enough troops to stop the progress of the Germans; and Dunkirk, even Calais and Boulogne, might have been lost. Col. Nuyten then vindicates the natural desire of the Belgian troops to defend their national soil as long as possible, and argues that any other nation would have done the same in like case.

The Russo-Rumanian Campaign of 1917. By Col. Bujac.—Commencing with a sketch of the situation caused by the evacuation of Wallachia by the Russians in December, 1916, and the successful efforts of the French General Berthelot during the winter of 1916–17 to restore order in the Rumanian Army, the events of the first half of 1917 are shortly described, including the effects of the Russian revolution. The battle of Marasti (Mamaia) in July, and the early stages of the battle of Marasesti in August are then described in greater detail. It is impossible to follow the account without a good map, which is not supplied. (*To be continued.*)

Grand Manœuvres, what they were, what they are, and what they ought to be. By Lieut.-Colonel Jèze. After considerable criticism of past and present methods of conducting manœuvres, the writer argues that the aim of grand manœuvres should be the continuation of instruction.

Manœuvre areas should be close to garrisons, or, if more than two marches away, troops must be conveyed to them by rail. A review to close the operations is to be deprecated. Two complete opposing bodies are inadvisable, one should be a skeleton force operating under orders from the Director. Too much care for reality should be avoided if it interferes with the main object—instruction. Each day's operations should be divided into phases carrying out a definite programme, each phase followed by a rest affording time for criticism or, in case of need, repetition of a phase badly executed. The best way to simulate casualties is to fall out a less or greater percentage of the unit penalized according to the gravity of the fault committed. It is essential that the umpire staff should be ample and expert, and should comprise officers to accompany the higher commanders and follow the operations, and able to communicate with the Director and umpires.

Books. La Campagne de Macédoine. By Col. Feyler. Editions d'Art Boissonnas, Genève.—The second volume of Col. Feyler's book, relating events from the abdication of King Constantine and the intervention of Greece on the side of the Allies to the end of the war, is quite as good as the first volume, and is illustrated by carefully-selected photographs.

(*March*, 1924.) *Our North African Races in the New Army.* By Lieut.-Colonel Clement Grandcourt.—After a short dissertation on the services rendered to France by her so-called black troops, and the increasing need for their employment, even in the Mother-country, the writer proceeds to investigate the dangers possibly inherent to training for military service any large proportion of the youth of subject races of prolific and warlike stock, and suggests means for minimizing these dangers. He treats only of the infantry and cavalry—tirailleurs and spahis—of Morocco, Tunis and Algiers. Recruiting is mainly by voluntary enlistment, but latterly increasing recourse, especially during the war, has been made to conscription. The latter is becoming more and more unpopular, and for many reasons should be abated except in principle, since it may be necessary to apply it in case of war. The conscript is beginning to ask why he should be made to fight in a cause which may not directly concern him, and seldom re-engages. The volunteer or professional soldier frequently re-engages, after completing his four years with the colours, for 12, 16 or even 25 years, and makes an excellent soldier. It takes a few years to develop the native physically and technically, and the conscript, who serves for three years for less pay than the professional, and for a bounty of 250 francs, is barely trained by the time his service is completed. The professional soldier costs more in pay, his bounty is 500 francs, and there is his pension to consider, but he makes a smaller demand on the youth of the nation owing to his habit of re-engaging—instead of having to be replaced every three years, he serves for an average of 10 years. This makes a great difference in the cost of transport when he serves overseas, which almost cancels financially his higher cost under other heads, besides his greater military value. (*To be continued.*)

The Attack of the 10th Colonial Division, 25th December, 1915. By Commandant Janet, from documents of the Historical Service, and

information supplied by combatants.—This action took place during the battle known to the French as the second battle of Champagne. After shortly describing the general situation and disposition of the French forces, the writer traces in more detail the fortunes of the 10th Colonial Division, part of the first line on the right of the 4th Army. The Division at first overwhelmed the German first position, and the intermediate position some 600 to 1,200 metres from it, but was checked in front of the second position, which, two to three kilometres from the first, was situated on a reverse slope and had been insufficiently bombarded during the artillery preparation. From 1030 to 1530 hours the attack seems to have been held up by reason of the French artillery fire on the German second position being aimed too short; at the latter hour it was decided that the offensive could no longer be continued owing to the physical and moral state of the troops, absence of reserves, to the right flank being uncovered, want of information on the general situation, and the renewal of activity on the part of the enemy. Two good sketches illustrate the article. (*To be continued.*)

The Russo-Rumanian Campaign of 1917.—The conclusion of the article by Col. Bujac, completing the account of the battle of Marasesti, a dearly bought victory for the Rumanians assisted by some Russian troops. As with last month's article, the operations cannot be intelligently followed owing to the absence of a map.

The Campaign of 1679. By Capt. H. Delschinger.—Describes how Louis XIV. compelled the Great Elector to confirm the Treaty of St. Germain. Accompanied by two good maps, the article is of historical interest. The moral the writer draws is that, to overcome a threatening and treacherous Brandenburger he must be held on the Rhine.

Books.—The following are favourably reviewed:—

L'Evolution des idées tactiques en France et en Allemagne pendant la Guerre. By Lieut.-Colonel Lucas (Berger-Levrault).—Readers of the *R.M.G.* will have already seen these pages under the title "*La refonte des réglements et notre doctrine de guerre*" ("The Revision of the Regulations," *R.E.J.*, July, 1921, *et seq.*).

Napoléon et l'Amérique. By A. Schalk de La Faverie (Payot).—This work fills a gap in history by tracing the influences of America on the destiny of Napoleon, and *vice versa*, and is particularly interesting at the present time when it is so necessary for the French to understand the aspirations and mentality of Americans.

L'Enigme du Rhin. By Major Victor Lefébure (Payot).—Chemistry played an important part in the last war, and will probably play a still larger one in wars of the future. The author demonstrates the powerlessness of the Treaty of Versailles to prevent chemical armament in the Reich, and consequently the facility with which Germany can equip herself in time of need. The remedy for a situation so full of danger, he considers, is to be found neither in limiting the number of factories, the production of which can always escape control, nor in any possible system of inspection, but in the development of their chemical industry by the Allies in proportion to that of Germany.

A. R. Reynolds.

REVUE DU GÉNIE MILITAIRE.

(*July*, 1923.) *A Discussion on Dug-Out Roofs.*—As a result of a difference of opinion between two officers, during the war, as to whether roof timbers or girders should be placed on edge or on the flat, the author, Lieut.-Colonel M. Tricaud, analyses the effect of concussion in such cases. He points out that, though the resistance varies as $\frac{1}{y}$ for static loads, it varies as $\frac{1}{y^2}$ in cases of shock.

He then shows (1) that for rectangular sections it makes very little difference which way the girders are placed; (2) that for I-girders there is considerable advantage in placing them on edge; (3) that for channels there is less advantage and still less in the case of rails.

Foreign Reviews:—

(1) "The Effects of Bombardment on Namur and Antwerp," from *L'Artillerie Suisse*.

(2) "Portable Assault Bridges Made of Kapok," from *The Military Engineer* of March–April, 1923.

(*August*, 1923.) *The Lessons of the War on the Organization of Ground*. By Général de division Cabaud.—The article is written to discover the principles underlying the organization of ground as evolved during the war. These principles can be sought in the various orders, instructions and rulings published by commanders as the result of events, and of their analysis of the causes leading to these events, which were made possible by the documents and reports rendered to them.

Unfortunately, many of these orders are contradictory, probably due to the necessity of taking action without delay, with the result that conclusions were arrived at too hastily, conclusions which might meet the particular case but which events proved not to be capable of general application.

In June, 1918, the parts of the front which had not shifted, owing to the events of March and May, consisted of many successive lines highly organized.

On the 24th June appeared an *Instruction* defining Army lines and fixing their rôle:—In the highly-organized sectors the army commander could choose the line on which to give battle and was to cover his front with outposts, *i.e.*, the limited withdrawal. The *Instruction* goes on to say that in newly stabilized sectors, as long as the enemy is not ready there for an attempt to break through, there could be no question of giving up more ground, and the dispositions must be different. The Instruction does not say what these dispositions must be.

The author goes on to say that it can be shown that the underlying principles remain always the same, modified by armament, stores, and circumstances. He then examines the regulations in force in 1914 under the following headings: (*a*) General, (*b*) Attack, (*c*) Defensive, and points out that these regulations could not have been as well known as they should have been. He draws a conclusion that the troops of all arms are capable of carrying out the works required under the regu-

lations, but that it is absolutely essential that they should be trained and exercised in carrying out these works—the spade is as important as the rifle. He points out deficiencies in the *Regulations* which were issued to all officers, *i.e.*, the design of a strong point was given only in *l'Ecole de fortification de campagne* of 14th Nov., 1894, and no mention is made of the rôle of artillery in defence or the effect of artillery on the choice of a defensive position. These could be found, however, in the *Instruction* of 30th July, 1909, on Siege Warfare; all the principles enunciated in this *Instruction* were gradually rediscovered, for moving warfare, in four years of war, and their value confirmed by events.—(*To be continued.*)

The Oilfields of Péchelbronn (Lower Rhine). By P.J.D.—Sand impregnated with oil is found in pockets 2 or 3 metres deep, 30 to 300 metres wide, from 300 to 1,000 metres long, and at a depth of from 30 to not exceeding 600 metres. When pumping ceases to produce oil, shafts have been sunk into, and galleries driven just above these oil sands. These galleries have drains dug into the oil-bearing sands along which the oil can be drawn off.

Some 30% of the total oil in the sands is left behind, which at present cannot be profitably recovered by any known process.

(*September, 1923.*) *The Lessons of the War on the Organization of Ground* (continued).—The author then discusses the application of the principles. The *Instruction* of 1906 lays down that the object of fortification is to protect the soldier without hindering him from using his weapons. This should be enlarged to read all weapons, artillery, rifles, tanks, etc.

He points out that, though all the pre-war regulations laid down the necessity of outposts, it was not till 1918 that this principle was generally observed.

The outpost position should be deep, to give the army time to get into the battle positions, which should be out of reach of immediate assault, and sheltered from rifle and trench mortar fire.

It should be shallow, to reduce the number of men required to hold it to a minimum, and so that it can be supported by artillery placed in the battle zone, the bulk of which artillery must be able to fire two kilometres at least beyond the foremost line held by the infantry.

The bulk of the available resources must be spent on the battle position until this is completed, so that, at first at any rate, the outpost position must be very sketchy.

For the above reasons an outpost position would normally be 1,500 to 2,000 m. deep.

The zone covering the guns two to three kilometres and the artillery zone 3 or 4 km.

The outpost troops should fulfil their double rôle of delaying the enemy to gain time and of arresting hostile patrols; their rôle fulfilled, they should be withdrawn. This doctrine is always sound, and the organization of the outpost zone should be made with a view to its application. The situation changes when an army passes from the defensive to the offensive. In the outpost zone must be accumulated munitions and stores, trench artillery, assembly trenches, etc. This

requires the front of the outpost zone to be strong enough to stop any raid, and the zone to be organized to meet the new requirements. To do this just before an attack would be to warn the enemy. The idea to aim at, therefore, is (1) to concentrate on the line of resistance till complete, and then (2) to organize the outpost zone with a view to an attack at some future date.

The writer discusses flanking fire and field of view, and then proceeds to deal with the question of continuous lines.

He points out that pre-war regulations specified fortified areas separated by intervals under observation and fire.

Continuity of obstacle, of communication and of observation is essential, but shoulder to shoulder defence should be avoided.

Next are discussed the necessity of defence in echelon, obstacles and the use of various parallels of defence. A second position, in 1914, could be 1 or 2 km. behind the first, now 7 or 8 km. is the minimum. More use must be made of natural obstacles such as streams, floods, marshes, and slopes which tanks cannot cross; these will have their effect on the siting of the line of resistance. Parallels of defence are indispensable for watching obstacles, for command, for communications, etc., but more is necessary to complete the organization of a defensive position, which must include complete disposition of fire, and the command of units, told off for obstinate resistance, by making a judicious use of accidents of ground in creating strong points, supporting points, centres of resistance, etc.

The trenches joining these points would form the parallels.

Mines.—The war shows that the results obtained from mining seldom justified the labour, materials, and explosives expended. Should the enemy be suspected of mining it is probably better to capture or destroy the works from which the mines start than to engage on counter-mining operations.

New Principles.—

(1) Protection from the air. This has become as important, if not more important, than protection from machine-gun and artillery fire.
(2) Gas protection.
(3) The equipment of back areas.

In conclusion the author points out that all the principles laid down in pre-war regulations have been confirmed, new weapons have introduced a few new principles without proving any of the old false. Details in the application of these principles change as weapons improve. It is impossible to lay down these details, and all officers must keep up with developments as published from time to time in technical papers.

U-Frames for trenches in Reinforced Concrete.—These are described in detail. They were used early in 1918, and proved excellent for reclaiming trenches or for use in really bad ground. Weight, 60 kilogrammes, or 53 (according to reinforcement); can be carried by two men.

(*October*, 1923.)—This number contains an account of the repair in 1915 of the bridge at Rethondes on the Aisne. This was an iron girder through bridge which had been cut into two parts, the larger

weighing 105 tons and the smaller 26 tons. These parts were used in the reconstruction, the bridge being rebuilt on to an intermediate piled support. Excellent photographs illustrate the article.

It further contains a description of a light floating footbridge constructed with 3 runners and carrying a deck of light planks or of 2-in. or 3-in. diameter brush-wood in metre lengths. (This bridge is fully described on pages 297 and 298 of this number of the *R.E.J.*)

Such a bridge weighs 2½ kg. per metre, can be carried by 2 men every 5 metres, will support one man every 2 metres, and only requires 1 N.C.O. and 10 men to build 50 yards' run in 15 minutes.

(*November*, 1923.)—An article by Captain R. Villate on *Geology in War* mentions the introduction of geological units into the Allied and German Armies during the war and shows in what way information acquired by such units can be of use to armies in the field.

Colonel Lobligeois contributes an article entitled "A Study of Some Constructional Details." In this he describes improvements to, or new patterns of, mauls, heavy door stops, ablution benches, washing benches and shower baths.

The maul head is slightly conical in shape, with two iron bands to prevent the wood splitting. The act of striking tends to tighten the bands so that mauls so made do not split at all easily. The striking end of the maul head is flat, and the other round, so as to compel the use of the proper end.

Foreign Reviews.—Extracts of an article on "Pioneers at River-Crossings in the World War" from *Technik und Wehrmacht*, 1922, are translated.

The author describes various crossings, *e.g.*,

The Vistula, July, 1915,
The Danube, 1915,
The Duna, 1917, and
The Marne, 1918,

and then proceeds to draw certain conclusions:—

(1) That pioneers should be Jacks-of-all-trades and not specialists.
(2) The importance of instruction and practice in pontooning and rowing.
(3) That pioneers would tend to be employed more and more on the construction of heavy bridges, leaving lighter bridges to other arms.
(4) That it is a mistake to divorce the pioneer from his pontoons.
(5) The necessity of the provision of a couple of vehicles per company to carry such things as ladders, planks, pickets, floats (metal and otherwise), ropes, etc., if rapid crossings of obstacles are to be feasible.

C.LAT.T.J.

REVUE MILITAIRE SUISSE.

(1924. *Nos.* 1 *to* 3 *inclusive.*)

THE first parts of a valuable article by Colonel Grouard entitled *Le haut commandement et l'état-major* appear in Nos. 2 and 3 of the *Revue* for the current year. The contribution is not only of interest to soldiers, but would also prove instructive to statesmen and politicians would they take the trouble to read it. In the opening lines of his article, Colonel Grouard emphasizes the immense importance of placing the command of an army in the field alone in the hands of a really competent general and of giving him a free hand in the conduct of the operations. The question as to the limits both of the authority and of the responsibility of a Commander-in-Chief has frequently come into considerable prominence during the progress of hostilities. Colonel Grouard points out that the general functions of a High Command have remained unaltered throughout the ages, in spite of the fact that progress in the mechanical arts has, from time to time, brought about almost revolutionary changes in the armament and equipment of armies. The Great Captains of preceding centuries provided in their own time a sound solution to the problem relating to the rights and duties of a Commander-in-Chief in the field and have clearly indicated the region wherein lies the boundary between the functions of the political and the military chiefs of a State; no sound reason exists for departing in our time from the practice introduced by them and acquiesced in by the statesmen with whom they had to deal. There are, Colonel Grouard freely admits, at periods of national crises certain questions relating to a prospective campaign which require to be considered at a round table conference attended by both the political and the military chiefs; as, for instance, whether a war shall be conducted generally on defensive or offensive lines, and other similar questions. At such conferences the true sphere of the statesman is to lay down certain main principles of policy; once these have been made known to the generalissimo and his acquiescence thereto obtained, the latter should be given full liberty of action as to the utilization of the means for waging war which it is proposed to place at his disposal and made absolutely responsible for all he does. A general in chief command should certainly never be hampered by political interference of any kind. The really great statesmen known to history have at no time attempted to meddle in a military situation during the progress of a war. In this connection Colonel Grouard cites the attitude taken up by Richelieu in 1640. In that year, the siege of Arras was entrusted to three Marshals who received intelligence reports indicating that a Spanish Army was marching to relieve the town. The Marshals could not agree as to the plan of operations to be adopted to meet the situation and referred their differences to Richelieu. The great statesman's reply was a simple one: "When the King," he said, "entrusted your commands to you, he believed you to be competent for your task. Please yourselves whether you advance or do not advance from your lines, but remember you will have to answer with the loss of your heads for your failure to take the town." A few days later, the Spaniards were decisively beaten and Arras carried by storm. Three decades later

another type of statesman and another type of soldier were responsible, each in his own sphere, for the destinies of France. During the Dutch War, Turenne was in command of the French Army in the field and Louvois now attempted to interfere in the military plans; the great soldier firmly refused to be dictated to by the politician and conducted the operations according to his own judgment and received the full support of Louis XIV. Turenne's attitude during the latter part of the campaign of 1672 is well deserving of study, being worthy of imitation by every Commander-in-Chief. Colonel Grouard recalls other historical incidents and shows how serious have been the consequences where statesmen have failed to follow the example of Richelieu and soldiers that of Turenne; he points out, for instance, that France's misfortunes in 1870 were largely due to the "interference" of de Freycinet. Happily when the Great War broke out the political destinies of France were in the hands of a wise statesman; it is recorded that Millerand steadfastly refused to force his views on the French generalissimo, who had a perfectly free hand to act according to his own judgment during the early phases of the War in 1914. Unfortunately, at a later stage the politicians did not act with the same wisdom as Millerand and to the interference of Ministers are due some of the difficulties which produced critical situations on the Western Front. Obviously, in order that due recognition may be given by the statesman to the authority of a general in the field, it is necessary that those who are placed in command of armies in the field shall possess the necessary qualifications and qualities to carry out the tasks entrusted to them with success. Hitherto, the making and unmaking of generals has been a matter largely in the hands of politicians; unfortunately, they have not always been guided, when making their choice, by completely disinterested motives. It is no secret that a certain type of politician—call him statesman if you will—is terribly afraid of a really efficient and strong soldier; he looks upon the latter as a sort of potential Cromwell. The attitude of this type of politician is exemplified by a remark made, in all seriousness, just after the South African War, to a young officer by one who later became a Secretary of State for War; he expressed the view that the Army was a profession, and the only one, in which it was not necessary for a man to possess real ability in order to rise to the highest position. The line of reasoning by which such a conclusion was arrived at was probably based on the assumption that the failings and defects of a general in chief command can always be counteracted by giving him capable staff officers and, therefore, it is not detrimental to the interests of the State to place a mediocrity at the head of an army, so long as he is sufficiently pliant. This doctrine is, needless to say, a most mischievous one. A safeguard is absolutely necessary to prevent any but really competent soldiers being selected for high commands. Colonel Grouard definitely advocates a change in the present method of selecting generals; he would like to see political influences entirely eliminated in this matter. His view is, and it is perfectly sound, that only those brought up in a particular profession can properly size up a man following their own calling and assess his professional qualifications at their true value. Therefore, it is to the principal officers of an Army, acting as a committee,

that he would entrust the selection of a Commander-in-Chief. Colonel Grouard seeks to indicate the signs by which the really capable soldier can be recognized; much that he has to say on this subject is of considerable practical value. He admits that there has at all times been a dearth of men possessing the qualities required in a Great Captain; and so far as France is concerned, in his opinion, it was alone during the periods of the Revolution and the Empire that it can be said there was a sufficiency of capable men from whom to choose the commanders of the important formations, but even in those epochs the majority of soldiers who rose to fame were only qualified to hold subordinate commands. In the period 1815 to 1870, only one soldier, Marshal Bugeaud, stood out conspicuously head and shoulders above his contemporaries; it is doubtful, however, whether he would have been competent to undertake the supreme command in an important war. Colonel Grouard considers that in 1870 all the chiefs of the French Army were mediocrities and states that during the first few months of the Great War more than 100 generals were deprived of their commands; some of them, in his opinion, unjustly, the most notable of these being Lanrezac, whose chief fault seems to have been that of possessing a clearer vision than the "pontifes du G.Q.G." No summary can do justice to Colonel Grouard's article; in order properly to appreciate its value, it is necessary to study the original and to learn the views of its author at first hand.

The article by M. Jean Fleurier entitled *Une Légende; La faillite de la fortification permanente pendant la grande guerre*, begun in the number of the *Revue* for October, 1923, is continued in No. 3 of the current year. The Defence of Liége is dealt with in some detail and the question examined as to whether anything which ought to have been done was left undone. M. Fleurier places on record his opinion on the defence; he unhesitatingly affirms that General Leman put up the best defence that was possible and he is satisfied that the forts at Liége, obsolete although undoubtedly they were, fulfilled a most useful purpose. Unquestionably, the Germans met with a serious check at Liége; they succeeded, it is true, in attaining three of their objectives, but partially only: (1) they forced the passage of the Meuse at Lixhé; this was due to the fact that the Belgian detachment at that point was not supported either by machine-guns or artillery and was out of reach of the support of the "forts de Pontisse"; (2) the passage of the Meuse at Lixhé permitted the XXIV. (Mecklenburg) Brigade to attack the Belgians along the left bank of the river on August 6th, and a German detachment thus managed to penetrate into Liége; it became, in consequence, necessary for General Leman to take refuge in the "fort de Loncin," a position from which he could not properly direct the defence; and (3) the XIV. Brigade under Ludendorff seized the "fort de la Chartreuse," which was not defended, and managed, in consequence, during the night of August 6th/7th to seize four of the bridges over the Meuse and the Ourthe within the town. A Table accompanies the original article; therein particulars are given of the part twelve of the detached forts played in the defence of Liége, the dates on which they fell, the casualties suffered, the damage done to the fabric, etc., being duly recorded. Under the heading "general conclusions," M. Fleurier points

out, *inter alia*, that the Germans did not repeat, in their subsequent operations, the method of attack adopted at Liége; no further assaults on forts were undertaken, but the German artillery was allowed to reduce the works by degrees with its fire. In many cases, the Germans did not completely invest the forts at Liége and, in consequence, the garrisons escaped therefrom and rejoined the main body of the Belgian Army. A detailed examination of the detached forts disclosed the fact that, in the case of six of them, the cupolas were not destroyed, but certain weaknesses developed in other parts of the structure, causing the cupolas in some cases to sink, whilst in others the turn-tables "seized"; all these defects were of a kind that could have been easily remedied. M. Fleurier recognizes that the essential question which requires an answer is: "Did the fortified position of Liége properly fulfil its rôle?" A quotation is given from an article entitled *Essai sur la fortification permanente moderne* contributed to the *Revue du génie militaire* (August to October, 1922) by Colonel Lévêque, who writes: "*Une place peut tenir un an sans utilité, et telle autre en résistant six jours assurera le salut de l'armée, ou imposera à une armée ennemie une manœuvre qui lui sera fatale.*" In order to find an answer to the foregoing question, M. Fleurier examines it in the light of the extract from Colonel Lévêque's article mentioned above and points out that the important functions of a fortress are (1) to delay an enemy; (2) to cause him heavy loss; and (3) to produce a moral effect. Short as was the siege of Liége, it delayed the Germans sufficiently long to give the French time to complete their concentration without disturbance; undoubtedly, the Germans suffered very heavy casualties at Liége—the losses are not known with any exactitude, but have been estimated, perhaps too liberally, by the Belgians, at over 42,000 killed and wounded; on the whole, the resistance of the Belgians at Liége had a good moral effect on the Belgian people and went far to inspire confidence in the Belgian Army. M. Fleurier thinks that Liége really played a more successful rôle than was anticipated by the military chiefs of Belgium. Among the important ends secured by the defence of the town were the following: (*a*) the Belgians were able to complete their concentration on the Gette; (*b*) von Einem's Army was prevented from crushing the Belgian Field Army out of existence; (*c*) the French, as already pointed out, obtained sufficient time in which to complete their mobilization; and finally, (*d*) the British Expeditionary Force was able to land safely in France, and succeeded in reaching Belgian territory, where by taking up a position at Mons it materially helped to delay the advance of the powerful German Right Wing into Northern France, and eventually assisted in bringing about the discomfiture of the German hosts in the Battle of the Marne, 1914.

W.A.J.O'M.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1924. *Nos.* 1 *to* 3 *inclusive.*)

THE account of the operations of the Belgian Army in connection with the Defence of Antwerp appearing in previous numbers is continued in those now under notice, the events taking place on October 5th in the

sub-sector of the defence assigned to the 5th Division being duly chronicled. At this date, the Germans had reached the line of the Nethe and were attempting to force its passage, having already driven back the Belgian advanced posts. The defenders of Antwerp were now finding it difficult to maintain their communication services within the sub-sector and much time was, in consequence, being lost in connection with the transmission of orders and in passing reports laterally as well as from front to rear. The headquarters of the 20th Mixed Brigade had been established at the railway station at Contich; the choice of so distinctive a position for this purpose proved an unfortunate one. The German artillery quite naturally early turned its guns on to the station, bringing an effective fire to bear upon it. The result was that at 9.30 a.m. the Brigade-Commander and his Staff had to abandon their battle-headquarters, and, in doing so, left their maps and horses behind. It was not until nearly two hours later that a report was received from this Brigade-Commander notifying the misfortune that had overtaken him. The advance of the Germans to the Nethe on October 5th was to some extent favoured by a mist and they were also able to take advantage of the cover existing on the south bank of the river; it is stated that their movements could not be clearly observed from the position occupied by the Belgians. The German sappers were also able to utilize the Schollebeek for the purpose of constructing barrel piers in positions hidden from view. When completed, the piers were floated down into the Nethe and a bridge was thrown across in a bend of the latter river at a point some 800 yards from the south-west corner of Lierre. The Belgians did not discover the position of this bridge, and an airman who was sent to reconnoitre along the river definitely reported that the Germans had not thrown one across the Nethe. In the circumstances, no attempt was made by the Belgian artillery to destroy the structure which it is now known was put in position by the German sappers. The Germans crossed the Nethe near and in Lierre and extended westward along the north bank of the river and by midday their left flank had been pushed west nearly to Lachenenhof. The German bombardment was now beginning to tell on the Belgians and was proving disastrous to their morale. The German gunners were kept well posted as to the progress being made by their own infantry and they were, in consequence, able to render the latter effective support. The Commanders of the Belgian troops in the firing line were calling with greater and greater insistence for reinforcements: some of them do not seem to have had a real grip on the situation. The staff work was to some extent also faulty; the orders issued were occasionally ambiguous and necessitated an enquiry on the part of the recipient as to what exactly was required of him. Further, reports sent from the front line were not always framed with precision and due regard for accuracy; a false impression as to the true situation was thus created at headquarters. Towards the evening, the Belgians began to give way; in order therefore to steady his troops, the Commander of the Belgian 5th Division placed additional troops at the disposal of the Commander of the 1st Mixed Brigade and ordered him to undertake a counter-attack in the direction of Ringenhof-Ander-Stad. The troops of the Royal Naval Division

under General Paris were at this time covering the left flank of the Belgians near Lierre.

An anonymous contributor deals in No. 1 of the *Bulletin* with land defence against aircraft attacks. In discussing the employment of anti-aircraft artillery he recommends that the first line A.A. batteries should be posted in groups at the angles of triangles. The bases of these triangles should be approximately parallel to the front to be defended. The actual position to be occupied by the batteries will naturally depend on the characteristics of the ground, the mission assigned to them, and the military situation of the moment. The interval between any two batteries on the base line, which should, it is recommended, be from 2 to 5 km. from the front line, is likely to vary from 2 to 5 km.; the rearward battery of a group should be placed from 3 to 5 km. behind the base line. The author of the original article gives therein his views as to the methods to be adopted in handling A.A. guns; in obtaining information concerning the movements of enemy aircraft; and in transmitting the same to the A.A. batteries. He tells us that, in Belgium, the anti-aircraft searchlight unit is the battery of four sections, each section consisting of four projectors and one set of listening apparatus. The searchlight batteries are divided into two categories, namely, the "batteries de projecteurs de l'armée" and the "batteries de projecteurs de l'intérieur." The author of the original article emphasizes the importance of employing searchlights used in connection with aerial defence "in mass" so as to illuminate as large an area of the sky as possible, in order that enemy aircraft may not be able easily to avoid the lighted area, which should have such a depth that it may be possible for the A.A. guns or the defence aircraft formations to pick out the enemy's machines during the period they are in the illuminated field. Used singly, a searchlight becomes merely a navigation beacon and is, for defence purposes, worse than useless; for this reason, the use of single projectors should be forbidden. The author of the original article predicts a considerable development in the near future of the use of "protective balloons" and also an extensive employment of camouflage in connection with aerial defence; he points to the use made in Italy and France of "protective balloons" during the Great War and the useful results obtained therefrom. Those who are seeking information concerning the Fourth Arm in attack and defence will find much matter of interest in the article under notice.

Attention is called in No. 1 of the *Bulletin* to the Royal Decree published recently in connection with the reorganization of the Italian Army. Under the new law, a Supreme Council of Defence has been set up in Italy and comprises a deliberative committee, a consultative group and a general secretariat. It appears to be the intention of the new Government that in future the Minister for War shall always be a soldier; he will in peace-time have under him (*a*) an Inspector-General of the Army, who will on the outbreak of war take command of the army in the field; and (*b*) a General Staff, which on the declaration of war will automatically pass directly under the orders of the Commander-in-Chief of the Field Army. The peace-time formations formerly known as "divisions" have ceased to exist. The term "divis-

ion " now designates a territorial area ; Italy has been divided into 30 such areas, which have been grouped into 10 Army Corps Commands. Particulars are given in the original article of the new organization adopted for the several arms ; the new organization of the Engineer Arm provides for :—A " superior directorate " for engineering services ; 10 Army Corps Engineer Staffs ; 10 Army Corps Engineer Groups, each consisting of a staff, a battalion of sappers and miners, a telegraph battalion and a depôt ; a radio-telegraph regiment, comprising a staff, 5 battalions and a depôt ; a pontoon and lagoon regiment, consisting of a staff, 3 pontoon battalions, a lagoon battalion and a depôt ; a railway regiment, comprising a staff, 2 battalions, a traffic group and a depôt ; 10 " Engineer Directions " ; a military institute of radio-telegraphy and electrotechnology ; and a workshop.

Captain-Commandant Menzel contributes to No. 3 of the *Bulletin* an article entitled " Quelques considérations sur les couverts " ; it should prove of particular interest to Sappers. Articles are also published in the numbers of the *Bulletin* under notice, *inter alia*, on the following subjects :—Aeronautics, a sketch map of the international aerial routes being given (Nos. 1, 2 and 3) ; the 1/40,000 relief maps of the Jurassic region of Luxemburg (No. 2) ; conversion of solid into liquid fuel (No. 2) ; the pacification of Morocco [a map illustrating the progress made by the French in the occupation of this territory accompanies the letter-press (No. 3)].

W.A.J.O'M.

LA GUERRA Y SU PREPARACION.

[The following abridged translation of an article in " War and Training "—the monthly publication of the Spanish General Staff—for July, 1923, by General Avilés, contains some constructive criticism and an interesting speculation as to how the trench warfare on the Western Front might have been avoided by either side who wished to do so.]

The Principles of Field Fortification in the light of the Great War.—The transformation of the whole of the Western Front into an immense entrenched camp disproved by practice the theories of those who hold that fortresses are useless. These theorists take no account of the fortresses of North-Eastern France, which, in conjunction with the short (but sufficient) defence of Liége, imposed on the Germans a long and ex-centric line of invasion, and made possible the allied counter-offensive on the Marne. They demand of fortification what only men can give, forgetting that it is not the inert material which avails, but the courage and skill which utilizes it.

Fortifications have never been so abundantly or so badly used as during the years 1914-18, and, above all, on the Western Front, and from here emanate so-called " lessons," which should rather be termed " negations." Careful discrimination is necessary to separate true lessons from the mass of injurious " examples."

Whoever has attentively followed the unfolding of the operations on the Franco-Belgian front will sum up his opinion in the one word " con-

fusion." Each and every one of the belligerents was seeking to achieve victory without exposing himself to defeat, without running the risks which are inseparable from military success. For years man was relegated to a minor rôle and victory was sought by the preponderance of material in an attempt to make war a simple mathematical problem from which the moral factor was, as far as possible, eliminated.

If we accept this conception as the last word in progress it is not worth while to study the military art, but fortunately history does not confine itself to this one period alone and teaches us that power is not measured solely by material but by the courage and training of the troops and by the ability of their leaders. The human factor has always occupied, and will continue to occupy, the first place.

The Western entrenched front was neither a good example of *Field Fortification*, which should be the servant of tactics, and tactics became impossible when the garrison of the uninterrupted front used up the whole of the available troops; nor of *Permanent Fortification* because it prevented the power of strategic movement, to facilitate which should have been its object.

Rather can we say that on these battlefields every branch of the military art lies buried with the flower of the youth of Europe. Our deductions must be rather as to what is to be avoided than as to what is to be imitated.

During the three months of the "race to the sea," the trenches were gradually prolonged from the Aisne to the Flanders coast, but still had not acquired the continuity which they achieved early in 1915. If either side had at that time abandoned the continuous line and grouped its forces suitably, leaving wide gaps between groups, the opposing side would have been compelled to conform, and a war of movement would again have resulted.

But, as stated above, each side was seeking only to avoid defeat.

It is surprising to note that on the Alsace-Lorraine front, where German inferiority was most marked, the French multiplied their works until continuous lines were attained. The Germans for many months remained faithful to the true principle of field fortification and maintained themselves concentrated in "localities" and not dispersed laterally.

The French forgot the true rôle of their Southern fortresses as "axes of manœuvre."

Such conditions of unturnable flanks, perfection of communications, unlimited material and reciprocal timidity are unlikely to occur in another war.

One important lesson of the war is to make it possible to define the differences between "*Rapid*" (or "battlefield") Fortification, "*Field*" Fortification, and "*Permanent*" Fortification.

Rapid Fortification develops during the shock of an engagement. Its end is purely tactical; it must be of quick execution and accommodate itself to the formations and incidents of the struggle.

Permanent Fortification strengthens points whose importance is strategical, making them into "axes" or "points" of support, or provides zones of security in which troops can be assembled for major

operations directly destined to cover frontiers, close lines of invasion, or guard points of strategic importance.

It must be constructed before the outbreak of war, or at least before operations take place in the zone to be fortified. Its rôle is strategic and it has only a secondary influence on tactics.

Field Fortification shares some of the characteristics of the other two, having both strategical and tactical aspects. It is employed to strengthen points whose importance increases during a campaign, and which have to be occupied to free the bulk of the field troops for manœuvre elsewhere without weakening the front; or to prolong resistance in places which the enemy is bound to attack; to cover lines of invasion; or to cover a retreat or a movement.

It is clear that "rapid" fortification is confined to the slight modification of the shape of the ground, while "permanent" fortification admits, and even requires, the construction of works of great solidity and resisting power. "Field" fortification is a mean between the two.

According to these definitions the double Allied-German Western Front was of the "rapid" type which gradually tended towards the "permanent." Only at some points, mostly in the back areas, are genuine examples of "field" fortification to be found.

The primary object of each of the three classes of fortification is to enable the enemy to be attacked in the most efficacious manner. The protection of the troops holding them from enemy action is secondary. It is imperative that they should never be allowed to be an embarrassment and still less an impediment, to tactics or strategy. The power to modify the use of, or to abandon, fortifications constitutes an important auxiliary weapon in the hands of commanders, but it is necessary for troops to be trained so as not to lose morale in such circumstances.

Considered either tactically or strategically, field fortifications must be limited in extent and confined to those points on which attack is obligatory. Failure to observe this principle bears bitter fruit. A new "Wall of China" affords nothing beyond a modicum of moral sense of security to the defender. Tactically it gives to the battle front a uniform density which is the straight road to defeat.

When considering fortified "localities" it must be borne in mind that any area of less than 300 metres radius will be a shell trap, in which the power and rapidity of fire of modern artillery will in a few hours render life impossible except in deep dug-outs or shelters which require materials and time only available in permanent works.

Two means exist of neutralizing the effect of such a concentration of fire. The first is by counter-battery action, but usually the enemy will have concentrated sufficient artillery to ensure preponderance at the point of attack.

The second is by spreading the defended zone laterally and in depth so as to offer to the enemy a target disproportionate to his available ammunition supply and time.

Thus, the single positions of yesterday will to-day be, in principle, linked positions; and the single firing lines will become multiple.

We reach the conclusion that the redoubts of the past are no longer of use, and detached positions can only be effective in very difficult

ground. In their place we require multiple organizations scattered and concealed, groups of positions which mutually support each other.

But, it may be argued, this multiplication of positions will lead to a multiplication of troops required to hold them, and thus annul the object of fortification; and this argument is worth due consideration. One positive lesson that the Great War has taught us is that a few machine-guns, or even a single one, can defeat the most resolute and well-prepared attack. Consequently numerical strength is not so necessary for the defenders as the judicious siting of a few machine-guns, served by cool-headed gunners, available at the right places at the right time.

Against distant attack—dissemination; against close attack—machine-guns. These are the two chief principles of modern fortification. In order that dissemination should not be a mere word it is imperative that the enemy artillery should be kept ignorant as to which of the various lines and localities presented to his fire are the ones vital to the defence; and that the nucleus garrisons in these should be kept sheltered from his fire; and that the machine-guns should be able to take up their fighting positions at the critical moment.

The technical troops enable this plan to be put into effect in accordance with the tactical and technical considerations.

Tactics lay down and define the principles of the defence; technique, following tactics, brings them into being.

It is not so important as formerly to have the ground traversed by the attack under direct fire from the parapet, and considerations of concealment would frequently render this impossible.

Consequently, in laying out a position, the siting of the machine-guns must receive first consideration, grouping them always in twos or threes to increase the probability of at least one being available when required. The most forward machine-guns should be sited first, and then others to their flanks and rear to protect them and enable the ground to be completely swept.

These machine-gun posts form the pivots of the defence. Then by means of entanglements and other accessory defences the attack is broken up and directed into channels, augmenting the efficiency of the machine-guns.

Thirdly, fire trenches and communication trenches are dug in such a way as to permit of a "step by step" defence, so that the loss of a portion of the position does not involve the whole.

The first object of the infantry trenches is to protect the machine-guns. They should mutually support each other and sweep the whole route of the attack.

The last step is to shelter the defenders from the enemy's fire. Sometimes this can be done by adapting natural features, at others, mined dug-outs, "elephant shelters," or such-like are necessary.

To conform with these ideas, a fieldwork of the future will not bear the least resemblance to the classic "redoubt." Its active portion consists in nests of machine-guns which completely sweep the interior as well as the whole of the front and flanks. The passive portion consists in dug-outs and shelters for the machine-guns and for the garrison;

and, as a complement, a network of trenches developed on a scale much larger than is necessary for the effective rifles of the garrison. Communication trenches must be abundant, laterally and longitudinally, and there should be many "accessory" defences independent of the main trench system and well flanked. The whole must be well concealed.

The intervals between "localities" are usually left undefended, but are swept by the artillery of the defence and enfiladed and flanked from the localities. At times it is necessary to construct accessory defences to command them or to "shepherd" the enemy into the field of fire of the positions.

Translated by R. E. M. RUSSELL,
Bt. Lieut.-Colonel.

MILITÄR WOCHENBLATT.

10th July, 1923.—The leading article of this number deals with the strategic use of the German cavalry in the Great War. Half the first column is devoted to explaining that, though Germany lost the war, the blame is solely attributable to the politicians. General Freiherr von Gebsattel then introduces the subject of the article by defining the following as mistakes, the avoidance of which would in all probability have given a more favourable issue to the war for Germany. The watering down of Schlieffen's plan and consequently the attack against the French fortress line of the Western front, the withdrawal of the reinforcements considered necessary for the East from the German right instead of the left wing, the loss of control of the first German advance by the German G.H.Q., resulting in the completely unnecessary retreat from the Marne, further the attack on Verdun not being conducted on both banks of the Meuse, and finally the false strategic employment of the German cavalry.

The author asserts that the German cavalry of 1914 was absolutely on a par with its sister arm the infantry, "unsurpassable in training and morale." After further eulogies he comes to the interesting statement, 'Hence the fact, which I had already prophesied some 20 years ago: nowhere have our enemies dared to oppose their cavalry mounted against the German." This statement has even drawn a footnote from the Editor, who points out that the same conviction that the German cavalry refused combat with the *arme blanche* to the French cavalry has already grown into a "legend" in French military literature. The author then goes on to assert that the leadership of the great cavalry bodies was as a rule quite skilful, instancing von der Marwitz's Corps in Flanders and Schmettow in Rumania. Everything in fact was at hand for exceptional performances by the cavalry except one thing, the lack of a chief completely saturated with the spirit of cavalry employment, who had soared above the views usual at G.S. and cavalry staff exercises, and who had produced new ideas. He then gives three situations in which the employment of cavalry by German G.H.Q. did not come up to expectations; in the first and third he says their correct use would have decisively influenced the war, while in the second quite different results could have been achieved to what happened.

The first case came about through the forward movement on the Western front. The great German cavalry bodies were spread over the whole front, only kept stronger on the right wing, everywhere allotted to the several armies. "What could cavalry Corps do which were wedged in between two close infantry fronts and, even if the enemy were beaten, must find an end to their activity at the latter's permanent fortifications?" All the reconnaissance could have been done by divisional cavalry and aeroplanes. The entire German Army cavalry, except what was necessary in the Eastern theatre, should have been concentrated on the right wing of the whole Army and have formed an independent cavalry force. At first a limited number of divisional cavalry could have been allotted to the 1st, 2nd and 3rd Armies as necessary till the main bodies of all arms had encountered each other, but then these bodies of cavalry also should have been withdrawn to the right and joined to the cavalry force. The latter would then have consisted of about six Cavalry Corps with the necessary Jäger battalions, cyclist and machine-gun units and one or two *Abteilungen* of heavy artillery.

Against the argument that there was no cavalry leader even trained theoretically in peace for such a command, the author says he can name at once three men fully up to the task. The achievements that this force would have won he gives as follows: to stop the withdrawal of the garrison of Antwerp, to locate definitely the enemy's left flank, to attack and destroy the retreating enemy: "never would the opponent have been able to attempt to press back our right wing, the separation of the 1st Army from the 2nd would have been avoided, the retreat from the Marne also would not have resulted through nervous leadership. Besides this Dunkirk would doubtless have been occupied, perhaps even Calais." And so the campaign would have been finished off.

The second case is drawn from the break-through at Gorlice on the Russian front, where he considers that a strong cavalry force of one to two Corps should have been held ready to exploit the break-through and complete the enemy's defeat. "As the decision of the war lay in the Western theatre, the final victory could not have been wrested by this," so he passes after but a short flight of fancy over the probable results to his third case, the spring of 1918 in the West.

"Had it been possible to get a strong force of cavalry into position at the advance on Amiens, then after the infantry and artillery had gained their victory the enemy's defeat must have been completed and Amiens would have fallen into our hands." End of the campaign and of the war. "The conditions were similar at the attack on Kemmel."

He then admits that there were gigantic difficulties to be overcome, drawing such great cavalry masses from the front, replacing them, concentrating them at the right place, pushing them up to the distance at which they could be used, and maintaining them there. In addition a large part of the cavalry, even if it had still the old spirit, was no longer at the pitch of excellence of 1914 by reason of its long employment in the trenches, so many horses had been given up, lost or replaced by inferior material.

The author then states that he yet has such firm confidence in the genius of their first *Generalquartiermeister*, that he would have succeeded

in overcoming these difficulties if—" ah—if only he had at that time shared my conviction."

25th August, 1923.—The most interesting article of this issue is a review of the 3rd volume of Count v. Waldersee's Memoirs. The first part of the volume deals with the China expedition of 1900, while in the second part German conditions up till the time of the author's death in March, 1904, are illuminated as with a prophet's vision.

As regards the Boxer rebellion, it notes that the Germans took no part in the looting of Pekin; while the German Field-Marshal claims that in the course of the fruitless diplomatic intrigues between the Allies he can claim to have earned some merit that open conflict between them was avoided.

The second part revolves round William II., and the "melancholy prophecy" of a general German collapse repeatedly occurs. "But nobody dared tell the Kaiser the truth; everyone agreed with him; nobody warned him that his policy was inconstant and double-tongued and must destroy all confidence." Though the War Minister v. Gossler told him that he was the only man who could speak out to the Kaiser, the Field-Marshal could not bring himself to do it. The reviewer, Lieut.-General von Altrock, deplores that, though the Field-Marshal foresaw the collapse even in the early years of this century and was a trusted friend of the Kaiser, yet he could not find the strength to bring the full weight of his convictions to the knowledge of his War Lord. For decades the old Army, from its foremost leaders to its youngest soldiers, had been brought up on the principle that sins of omission and neglect were far graver than those of failure in selection of method, and the reviewer condemns the Field-Marshal on these grounds. The last thing he wrote was: "I pray God that I shall not live to experience what I can see coming," and v. Altrock calls this a serious charge against its writer, the very man who should have stood up to the opposition and helped the truth to its rightful position.

E.G.W.

MILITÄRWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

January–February, 1924.

THIS number opens with an article on the supreme command of the allied armies of 1813. The question as to whether the supreme command of Prince Schwarzenberg was really unquestioned is one of academic interest only, and the author of the article, Dr. Phil. Egar Lauppert, does not throw much light on the subject—but he gives some interesting details of the intrigues of Metternich, Stackelberg, Nesselrode, Stadion, etc., and quotes a long list of authorities.

Colonel Fleischer describes his adventures as a regimental officer in the 1914 retreat to Przemysl.

Major Rendulic studies the infantry attack as described in English, French, Austrian and German manuals. Austrian manuals consider the infantry attack under the headings: Approach Marches, Gradual and Progressive Deployment into Attack Formation, Working Up to the Position of Assault, Organization of Assault, Assault, Penetration,

Break Through, and Pursuit. German manuals follow the same course, but French and English (particularly French) stress the *prise de contact* in which German and Austrian training is deficient, and by considering the defence lacking in elasticity and depth, make no provision for gradually feeling the way against opposition to the final position of defence. English methods are criticised as keeping too definite a control of deployment in the hands of the battalion commander. The organization, strength and armament of platoons and smaller units are compared.

Cyclist Battalion tactics are discussed by Major Raus—the Battalion includes 9 mechanists and 7 motor-cyclists; cycles can be connected in fours, each four pushed by one man, or coupled, each couple being ridden forward by one man—three-ton lorries of the battalion can take 25 cycles without special arrangement, and 50 or 100 if special attachments of different kinds are added for the purpose.

In normal march formation (single file) the battalion takes 5,000 yards of road. Advance Guard is, say, 1 mile in advance, but flank guards are almost always impossible from lack of parallel roads. A flank attack on a battalion is not, however, to be feared, because of the possibility of encircling counter-attack by the Cyclists.

In the attack attention is to be directed mainly to flanking movements in order to get full benefit of mobility.

In considering employment with other arms such duties as the watching of an exposed frontier or of a river with mixed detachments, *point d'appui* for reconnoitring cavalry, escort to artillery, and to engineers engaged in demolitions, are mentioned. In all cases cycles are taken as far forward as possible.

An article on the infantry gun describes a model produced by the Skoda A.G. works in Pilsen in 1918 (after trials in the field). Calibre 3·2 in., projectile 14 lb. The total weight is between 7 and 8 cwt., and is divided into 4 pack or 11 man loads. Designed principally for ranges under 2,000 yards, the max. range is 3,000, and high-angle fire is possible at very short ranges.

Direct fire is, of course, possible at all ranges, but the general design is that of a howitzer and its suitability for anti-tank work would seem to be questionable.

An article by Krüger on German tanks gives details of the A.7-V and L.K. I and II tanks which were actually used, as well as a few facts about the U and K models which never reached a practical stage. Tactical matters are discussed in the next number.

H.St.J.L.W.

HEERESTECHNIK.

(January, February and March, 1924.)

A SERIAL article on the development of the German 16 field gun and light howitzer models is continued and finished in the January and February numbers. The technical difficulties and their partial solutions are described in the January number.

In summing up, the author refers to the tactical lessons which led to the demand for greater range, even combined with greater weight.

Scientific " location " makes it necessary to keep guns further back for safety, and, on the other hand, presents well-fixed targets at greater ranges. Modern artillery leading, by concentrating fire from widely distributed batteries, also increases range. F.K. 16 and L.F.H. 16 were designed to give this greater range, whilst the gun did not exceed 27 cwt. and the howitzer 29 cwt. Although considerable criticism has been focussed on the design, it remains the best in actual practice, superior to the French 75 and to the recent Austrian model. But, good as the designs are, there remain many points for improvement, and even so the pre-war task of the artillery cannot be carried out by guns and howitzers of such weight. Close support of infantry demands the infantry gun, and the field gun becomes intermediate between the " infantry " and the " heavy " types.

Major Klingbeil's articles on " Peace and War Experience " in concrete construction of permanent and semi-permanent fortifications are devoted to foundations and to the characteristics of various surfaces and subsoils. The one point of interest is his statement that reinforced concrete platforms are always used as foundations for German permanent fortification.

Dr. Ing. Becker has an interesting series (February, March, *et seq.*) on the daylight photography of projectiles. After a short historical summary (dealing mainly with electrically-controlled instantaneous photography of the path of a bullet, by Cranz) he describes the cinematograph work of Major Duda, in Austria, and the " Ballistograph " which he has perfected. The ballistograph has four rigidly-connected objectives which are placed in a line parallel to the path of the projectile.

The plate is made to fall at a rate which gives successive exposures (1/10,000 of a second) (in strip form) opposite each objective. Exposure is made through a cylinder (placed behind the objectives). The cylinder has holes in it of a shape, and so successively placed, as to allow exposure through each objective in turn. As it rotates this cylinder makes per revolution a contact which actuates a photographic timing device. The probable error of measurement of velocity from the resulting photographs of the projectile is estimated as less than 0·2 mm. The description is very clearly given and well illustrated.

Dep. Ing. Stumpf begins an article on open girder iron bridges. The necessity for some standard pattern of railway bridge for spans up to 100 metres was first apparent in bridging the Save near Belgrad in 1915. Pre-war military types were for spans not exceeding 60 metres, and not up to modern weights. The " K " type, simple in theory and convenient in construction, was then evolved and is here described and illustrated by diagrams.

General Giessler retired from the active list early in the year. He was head of the inspection department which dealt with guns, small arms, engineering stores, mechanical transport, signal stores, balloons, etc., and some interesting details as to the working of this new department are given in a farewell notice of his activities, in the January number.

In the May, 1923, number of the *Revue d'Infanterie* Capt. Desaivre discussed the question of the calibre of rifles and machine-guns. He

came to the conclusion that the tasks to be faced could not be solved by one universal calibre and advocates no less than three—0·24, 0·36 and 0·5 of an inch—covering zones from point blank to 6,000 metres—and engaging tanks and aircraft. This article is given a lengthy review. The German standpoint is then discussed and it is claimed that two calibres will, probably, serve the purpose by a judicious use of heavy and light bullets ("S" type).

Capt. Meyer Becherer writes of the lessons learnt by entente countries in mechanicalized artillery. Germany, not being allowed to experiment for herself, has to keep an eye on the foreign progress. The Americans have, he considers, gone further than European conditions and roads warrant. The most interesting and important development is the combination of wheel and caterpillar, to which final aim all seem to be tending. Artillery "portée," confined, for the most part, to the roads, and dependent upon borrowed teams for movement across country, nevertheless possesses a considerable strategical value. Weights and calibres will probably increase in proportion as mechanical transport is introduced.

An article by Th. Vahlen (in the February number) on the theory and practical experience of disturbing factors (meteorological) to the trajectory of shells and bullets may be of interest to the expert.

Two books of possible interest are reviewed:—

(*a*) *Die Fernrohre and Entfernungsmesser* (Telescopes and Range-finders), by Doctor A. König.

(*b*) *Explosivstoffe*, by Prof. Dr. Brunswig.

H.St.J.L.W.

THE MILITARY ENGINEER.

March–April.

Camouflage in the Russian Army.—Colonel Kolossovsky, of the Russian General Staff, describes the principles and means of camouflage adopted in the Russian Army.

The subject is evidently receiving considerable attention. A special camouflage school has been established in Moscow and every division includes a camouflage unit.

Chemical Warfare and the Engineers.—Brig.-General Frier, Chief of Chemical War Service, surveys the work of his Service.

In peace, in addition to its military experimental and development work, it undertakes chemical research in connection with problems of civil and general engineering. The action of marine pests on timber piles is occupying its attention at the moment.

In war, the Service can best help the Engineers by covering bridging operations with smoke. A recent development is the method of sprinkling smoke from an aeroplane. The liquid, carbon tetra-chloride, is loaded in tanks and released under pressure at the speed of the aeroplane but in the opposite direction. It thus falls practically vertically and is said to produce very accurate and satisfactory results.

R.I.M.

VOINA I MIR.

(No. 9 continued.)

Captain Ritter contributes an article on the German advance in France in March, 1918, in which he traces the failure of the German attack to the changes made in the original plan of operations. Quoting a phrase from Ludendorff's *Reminiscences*, "Tactical considerations had to take precedence of pure strategy," he states that the exploitation of unexpected tactical success, involving change in the original plan, is allowable in the case of divisions or even Corps, but during operations on a large scale such as those in March, 1918, the original plan of operations must be steadily adhered to. In the attack called by the German Staff, "Michael," the original plan, which was briefly to drive the English into the sea by an advance of the 17th and 2nd Armies, with the 18th protecting the left flank of the 2nd, was, as a result of unexpected successes, considerably expanded. The tasks of the 2nd and 18th Armies were much increased. The latter Army was reinforced at the expense of the 17th, and the attack devolved into a simultaneous advance against the French as well as the English, an operation calling for much larger forces than the German Staff had at its disposition.

Lieut.-General Borisov, in an article entitled, "The Versailles Treaty and the Strategical Situation arising from it," enumerates the conditions which affect the strategical situation of a country, such as the outline of the frontiers, geographical position with regard to other countries, material resources. He then quotes from the Italian paper, *La Preparazione*, the military and naval resources of the great powers before 1914, and briefly describes what the general strategic situation in central Europe was at that time (to facilitate an understanding of post-war strategical conditions). He records the errors made by the German Staff in their appreciation of the strategical situation. He then discusses the various articles of the Versailles treaty, dividing them into "effective" and "moral," the former being Articles 5, 6 and 7 (dealing with the creation of new states, surrender of German colonies and surrender of arms). He considers the abolition of Austria-Hungary, containing 38 million inhabitants, and the formation of four smaller states, as the most important factor in the present changed strategical situation and refers apprehensively to the position of any one of the seven smaller nations, Austria, Hungary, Czecho-Slovakia, Poland, Serbia, Rumania and Bulgaria, in face of an "awakened" Germany. He considers Articles 7 and 9, dealing with the limitation of armaments, whereby 70 million people are deprived of the means of self-defence, as an insult to national feeling, and as unlikely to be effectual in face of provocation. Comparing the populations of probable groups of nations to-day, there are on one side, France, Poland, Rumania and Belgium, with 91 millions, and on the other Russia, Turkey, Bulgaria, with 150 millions, to which must probably be added Germany, Austria and Hungary, with 75 millions. The position of Czecho-Slovakia and Serbia in a future conflict is doubtful. Of modern frontiers in Central Europe 70 per cent. are between hostile and doubtful countries.

Such is the "firm" political situation created by Versailles.

In "The Tactical Use of Gas" Colonel Kolossovski states that the fundamental principles of chemical warfare are the same as those for warfare by other methods, viz.:—

(1) The necessity for superior strength at the decisive point and moment,
(2) Decisive success can never be attained without active effort.

There are three types of gases, namely those producing (*a*) prolonged action, (*b*) short action, (*c*) penetrative action.

Shells filled with gas of the above types were called by the Germans "yellow-cross," "green-cross" and "blue-cross" respectively. The effect of blue-cross shells was increased by the fact that they burst into splinters, producing the modified effect of common shell.

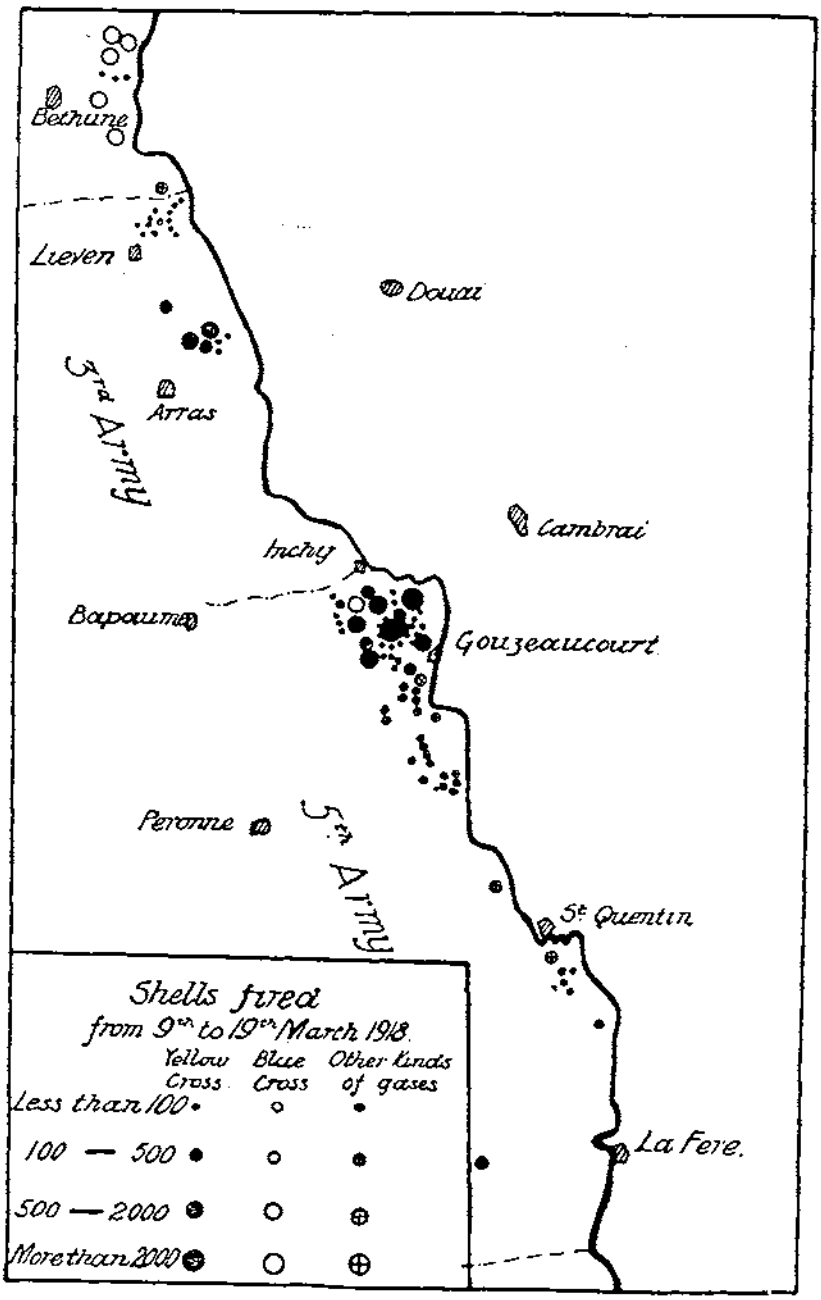
Principles for the use of gas under different circumstances can be deduced from the experience of the late war.

In the preparation of an attack yellow-cross shells (mustard gas) must be used on distant points of enemy concentration, lines of communication, villages, headquarters, etc., but can only be used on nearer areas over which no immediate advance is contemplated. In warm weather the shelling should begin the day before, but in cold weather 5 to 7 days before the attack. When the objective consists of woods or copses, times must be increased by 1 or 2 days, as these retain the gas longer than open country. Owing to the perfecting of anti-gas apparatus in future wars the intervals will probably have to be increased. It was observed that mustard gas affects the soil over an area of radius 2 to 3 feet from the crater. The foregoing remarks refer to position warfare; there is no experience to show how such gas should be used in open warfare, but it will probably be to form screens on areas over which no advance is to be made.

The use of shells filled with "short action" gas will be confined to points where bodies of the enemy are likely to concentrate, such as forests, villages, cross roads, battery positions, etc. The Germans used a mixture of green and blue-cross with considerable success against battery positions. Shelling should be begun shortly before the attack —to start long before entails a large expenditure of shells and discloses the intentions to the enemy. In the late war the practice was at first to start shelling 1 to 2 days before the attack, but towards the end of the war this time was reduced to a few hours. When once begun, the shelling should be repeated every three or four hours.

An example of a correct and successful gas preparation is afforded by the action of the Germans from March 9th to 19th, 1918, on the eve of their great advance on the line Arras–La Fère against the 3rd and 5th British Armies. A sketch is given showing the distribution and intensity of gas shells on this front. Yellow-cross shells (prolonged-action) were used on those areas where immediate advance was not contemplated, namely, Liéven–Arras and Inchy–Gouzeaucourt, especially the latter, which formed a pronounced salient, from which flanking fire could be brought or counter-attacks made. The effect was striking, as the British Corps occupying this area (left flank Corps of the 5th Army) lost 5,000 men before the attack, and its confusion and demoralization

led to the defeat of the whole 5th Army. At the same time green-cross shells (short-action) were freely used in the chief area of attack, Gouzeaucourt–St. Quentin, thanks to which the British front was broken without much difficulty. Gas shelling on other portions of the front was in the nature of a demonstration. On the line Arras–Inchy, where there was no



gas preparation, the 3rd British Army met the Germans with much greater success.

Another example of the successful use of gas was in the battle of September 26th, 1918, in the east of the Argonne forest, when the first American Army used mustard gas to protect its flanks. Fire began at night, six hours before the attack, and the results were highly successful.

During the period of an attack " short-action " gas shells can be used with advantage against places of concentration, batteries, reserves, observation posts, etc., timing being arranged so that the effect of the gas will have worn off before the approach of the attacking troops. " Prolonged-action " gas should be employed against objects on the flanks of the attack and on enemy flanking batteries, afterwards against distant points of concentration, railway stations, ammunition dumps, etc. During the attack, objects of immediate danger must be kept under continuous fire as far as possible and if much destruction is not effected the enemy will in any case be embarrassed by having to use gas masks.

In intervals between attacks, whilst localities are being fortified, " prolonged-action " gas is the most useful to protect the construction of positions and the organization of a new advance. It is particularly useful against counter-attacks and to stop concentrations of enemy troops in the rear. Important rear points such as stations, crossings, dumps, must be kept under a constant fire.

In defence and retreat " prolonged-action " gas must be used to an unlimited extent for the making of screens, blocking of lines of communication and bombardment of masses of troops. On retiring from a position the explosion of shells and grenades of mustard and other prolonged action gases inside deserted trenches, hollows, defiles, forests, etc., has great effect.

There is a wide future for the use of gas in war and the " detailed and persistent elaboration of methods for the tactical use of gas constitutes one of the most important problems for the consideration of every country desiring to omit nothing which might secure victory in future conflicts."

This number contains a review of the *R.E. Journal* of March, 1923.

(No. 10)

The tenth number opens with an article on " Strategical Defence " by Capt. Ritter. He states that a defensive attitude can be adopted by a country for several reasons, the commonest being to delay the enemy with a part of its forces whilst the greater part is concentrating and preparing for action. One aspect is shown by the withdrawal of the defending forces into the depth of their country, making use of its natural disadvantages to weaken the strength of the invaders. Another form consists of quiet observation of the initial movements of the attack by the defenders who, watching for mistakes and weak points, are ready to take advantage of them with concentrated forces.

The guiding principle of any strategic defence is the endeavour to compensate for inequality in strength by economical distribution and slow expenditure at a time when the enemy has to expend rapidly. This aim is favoured by the fact that in defence the element of movement plays a smaller part than in the attack.

Factors in favour of the defence are time, the advantages gained

by the occupation of prepared positions, the use of home railways, the assistance of existing fortresses and fortifications, finally, the attacker will be operating in a hostile country and will not have the advantage of local assistance and institutions.

The defender, possessing greater freedom, for the above reasons is in a position to confront the enemy with an unsuspected situation by suddenly changing his line of defence, provided the theatre of operations is sufficiently large compared to the opposing armies. Such action on the part of the defence compels a change of plan on the part of the attack entailing many complications, such as a rapid revisal ofhis transport system.

A force advancing into a country with badly developed communications will be obliged to move on a wider front, exposing itself to the risk of being beaten in detail by an unexpected advance of the enemy. Napoleon, in February, 1814, gave a brilliant example of such action, and Frederick William, in the Seven Years' War, carried out his successful defence in a similar manner on a large scale.

Any attempt on the part of the invading force to pass by an important position occupied by the defence can always be paralysed by flank attacks; so acted the allied armies at Lützen in 1813, and General von Werder when opposed to General Buorbaki in 1871 at Villersexel.

Readiness for action superior to the opponent's is one of the most important conditions for strategical advance; it depends on quickness of mobilization, on the possession of sufficient armament and means of transport and on the suitability of the country's geographical position. The country which adopts an attitude of strategic defence can afford to spend more time on initial preparations. From the political standpoint the sympathies of other nations are more generally given to the attacked than to the attacker, a fact which may affect the situation in a considerable degree.

The defensive attitude, however, has serious disadvantages, for inherent in it is a confession of weakness. By defence alone a decision can never be gained, and the most that can be hoped for is a more or less honourable peace—such as Frederick the Great obtained. In the Russo-Turkish War defence led to defeat.

The defence can never be secure from danger to its communications and may have to evacuate favourable positions in order to safeguard its rear, as happened in the case of the 1st and 7th German Armies after their long and successful defence of the Hunding-Brunhild position.

Finally, the long sojourn of an army in one place favours the spread of infectious diseases.

A.H.B.

CORRESPONDENCE.

TIDES.

MAJOR-GENERAL A. C. JOLY DE LOTBINIÈRE, C.B., C.S.I., C.I.E., in forwarding the following letter for publication, explains that to him it proposes a new theory and one difficult to refute. He would be glad to receive criticisms upon it from any of those of our readers who are interested in the subject.—(ED. *R.E.J.*)

DEAR GENERAL LOTBINIÈRE,

You once asked me, how did I account for the tides. I now intend to reply. My theory of the constitution of things has, as you are, no doubt, aware, rendered a gravitational field of force as a plenum of energy; hence I cannot look to attraction as an explanation of the tides. Indeed, it is worth while to point out to you that, even if physicists may be permitted to assume that mass generates a gravitational field of force, no explanation is forthcoming as to how such a developed field of force intersecting another field of force produces movement of the one mass towards the other. We can leave out the act of repulsion of two intersecting electrical fields of the same kind.

As long as force cannot be conceived as occupying space, a field of force has no meaning. A field is space: Hence arises the question—What contents of any space determine whether such is a field of force or not?

The term, "a field of force," really takes the place of the now disused term "action-at-a-distance," which only latterly became repugnant to men of science; though we still read that such men as Lodge and Rutherford continue speaking of attraction and repulsion.

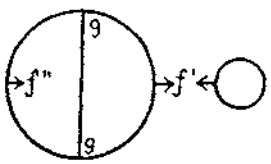
Be not, therefore, misled in believing that a field of force really gets rid of action-at-a-distance.

Now, since energy can be conceived as occupying space—for note how all its forms are fast becoming inertial; except that treacherous "heat"—it becomes easier to believe that these so-called fields of force are plena of energy. And this means that in a gravitational field the units of energy, as it were, push towards the centre of the mass.

It is easily understandable that under such conditions the motion of two masses towards each other can only be attributed to a diminution in intensity of the passages of the units of energy (gravity) between the two masses as against the intensity at the antipodes of that system—the earth and moon.

But that will not raise the water on both sides of the earth to produce those well-known antipodal tides: the theoretical explanation of which is confusing.

For imagine the earth covered with water to a uniform depth. It stands to reason that, on introducing the moon, the force of attraction in a line joining the centres of the earth and moon must be always greater than the force of attraction of the earth at right angles to that line; that is, both f' and f'' individually must be always greater than g.



This means that the water at f'' must be lower than that at g, and the water at f' must be higher than that at g.

Where do the antipodal tides come in in this construction?

Then, considering there is no pendulum that can record side displacement by the moon, it is futile to argue that the water at g is made lower than at f'' by side-attraction or slipping towards the moon.

The revolution of the earth will not help matters at all in respect of antipodal tides.

I have often wondered why no compensation is made in pendulum-swinging in respect of the positions of the moon and sun.

The conclusion I have come to is that the main cause of the generation of tides is distortion of the earth. That is, a wave of strain is constantly perambulating the earth. For it seems highly probable that a mass of this sort rotating on an axis cannot be perfectly rigid. Thus, as it were, the diameter of the earth, measured through the equator of revolution, is not constant: which inconstancy constitutes a wave.

In this way tides are a mechanical effect and not developed astronomically.

You will do me a favour in replying.

Yours sincerely,

Coromandal P.O. Mysore State. LOUIS STROMEYR.
7th April, 1924.

TIDAL ELECTRIC POWER SCHEMES.

To the Editor, *R.E. Journal.*

SIR,

At the end of his interesting article in the December *R.E. Journal*, on the construction of dams in the tidal creeks near Shoeburyness, Major Kirke puts forward a suggestion made to him by a visitor for the utilization of the tides to generate electricity. Countless schemes for doing this have been proposed in the past, and abandoned, usually because the promoters have overlooked certain fundamental facts which govern the economics of all hydro-electric schemes, tidal or otherwise.

In any such scheme the output of power varies roughly as the product of the volume of water passing through the turbines multiplied by the head. But the cost of installation varies roughly as the volume of water dealt with. It therefore follows that the cost of installation *per horse-power* varies more or less inversely as the head utilized. Owing to the relatively large sum required as interest on the capital expended on a low-head installation, such installations are rarely a financial success, particularly if other competitive sources of power exist to limit the price charged per unit. On this ground alone a scheme such as the one proposed to Major Kirke would almost certainly prove a failure from the financial point of view.

In this case, however, a further practical difficulty lies in the large amount of sand and silt carried in suspension by the water. The reservoirs would, as already experienced at one of Major Kirke's dams, gradually silt up, thereby reducing the available volume of water and head. Unless special steps were taken to prevent it, such water would also soon play havoc with many types of turbine, for if the water carries *any* sand in suspension it soon wears out the working parts of the turbines, and causes excessive charges for maintenance and renewals.

The second of these difficulties can be to a large extent overcome, but an economically satisfactory solution of the old and fascinating problem of the utilization of tidal power has yet to be found.

Yours faithfully,

LAHORE, INDIA.
24th March, 1924. E. P. ANDERSON, *Major, R.E.*

LADY GROVER'S HOSPITAL FUND FOR OFFICERS' FAMILIES.

This Fund, originally instituted in 1911 as the Officers' Family Hospital Fund —its title being changed in 1912—assists the wives, widows and children of all Commissioned Officers wherever serving, on the active or retired list, belonging to the Royal Navy, Royal Marines, Regular Army, Royal Air Force, and Royal Indian Marine, by means of grants amounting to the cost of actual expenses incurred up to £4 4s. weekly, in addition to the cost of medicines, for not more than six weeks in any one year. These grants are made towards the cost of residence in, or attendance at, any recognised Nursing Home or Hospital in Great Britain and Ireland, and, on a slightly lower scale, in cases where a hospital nurse is required in the home of a member. The Fund gives the same assistance to mothers and unmarried sisters dependent on bachelor Officers.

An important change was made in the scope of the scheme in June, 1923, as the result of a General Meeting held in that month, for, whereas up to that time eligibility for membership had been restricted to Officers on the active list and to those serving in India only, it was decided to extend membership to Officers of all Services wherever serving, both on the active and retired lists, as already described; the grant or benefits remaining, as heretofore, towards expenses incurred in Great Britain and Ireland only.

The records of the Fund were examined this year by an eminent Actuary and by a firm of Accountants, who regard the Fund as being on a sound footing and soundly administered.

The annual subscription is £1 1s., payable on January 1st to Lloyd's Bank, Limited, Cox's & Kings' Branch, 6, Pall Mall, S.W.1. Further particulars with copies of the Rules are obtainable from the Secretary, Miss Burbury, 2, Earl's Terrace, Kensington, W.8.
