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FORTIFICATION IN WAR.

A Lecture delivered at the S.M.E., Chatham, on Oct. 20th, 1927.
By MAJ.-GENERAL SIR EDMUND IRONSIDE, K.C.B., C.M.G., D.S.O., *p.s.c*

TO-NIGHT I propose to deal almost entirely with the strategical aspect of fortification in war, and I shall barely touch upon the technical side of the question.

If we trace back the history of fortification in military operations, we find its first uses in expressing the desire of peaceful people to protect their worldly goods against the lawless. Also, the lawless themselves made use of it to strengthen their homes, so that they might go out on their forays in the fullest strength. Thus arose the walled town and the strong castle. As the world became more civilized and nations arose, we find these two forms of fortification developing into the entrenched camp and the border fortress Campaigns at first were undertaken for the reduction of one or more strong places. Slow and leisurely campaigning became the rule, and the number of fortresses grew rapidly. With the advent of standing armies, the value of these strong places declined, for these armies were made ready for war much more quickly than the old levies, and campaigns were won and lost without much effect having been exercised upon them by the fortresses. It became evident that it was uneconomical to shut up large numbers of men in strong places and so weaken the forces actively engaged. Nations examined the situation of their fortresses and drastically reduced them in number.

If we take the French and Belgian fortresses as an example, we may draw some very definite conclusions from their geographical positions. They were constructed under a certain sense of inferiority. Neither France nor Belgium—at the time of the construction of these fortresses by Rivière and Brialmont—were aggressive from a military point of view. Both felt that they were inferior in readiness for war to their possible enemies, and so they resorted to fortification to gain the necessary time for preparation. You will see that the fortresses form a kind of barrier closing the communications leading from the enemy into the heart of the home country. That these fortresses have been constructed on or in extension of older works is explained by the fact that communications naturally run towards important towns, which were in the old days surrounded by walls.

In 1914, it cannot be said that any of the French and Belgian fortresses were up-to-date. Technically, their component forts were unable to resist the bombardment of modern artillery. In fact, generally speaking, it may be said that artillery science had definitely gained the upper hand of engineering science. But it was not only in this technical way that the fortresses were out of date. The range at which modern artillery fired had been so greatly increased that the fortresses no longer covered the points which they were designed to protect. If you take the map of Belgium and study our operations at Ypres you will see what I mean. Heavy traffic was confined to the paved roads, for to have used the unmade roads extensively would soon have involved you in a sea of mud. To have lost Ypres would have meant that we would have lost a most important junction of good roads. We should have had to use Poperinghe more extensively. To have lost Poperinghe would have been even a greater disaster, for we should then have had no good roads in the triangle between Rousbrugge—Cassel and Bergues. For the proper protection of Ypres we should have liked to have been further out than we actually were, and we were continually struggling for more elbow-room.

Military engineers realized fully the shortcomings of their fortresses and had many times demanded an overhaul of the barrier of fortification. Money is always at the bottom of all questions of military efficiency, and large sums of money must be expended in fortification works. These works take a long time to erect, and are often obsolete before completion. One therefore sees a continual process of tinkering going on—which leads in fact to a good deal of expense and little permanent betterment. This tinkering is plainly to be seen in the fortresses under discussion.

With all its inferiority, however, the French line of fortifications had a most important effect upon the course of the Great War. You will see how short is the common frontier of France and Germany. It is only 140 miles as the crow flies—not a great breadth, even if left completely open, for the deployment of the great army which Germany would place in the field. Germany's plan of action embraced campaigns in both West and East. A throwing of her main forces against France first, and then a return to the facing of her more slowly developing enemy, Russia. A quick victory over France was essential for final success. The frontier, fortified as it was, did not suit Germany's strategical conception of an advance, envelopment of the enemy by one or both flanks. She would not therefore face the French fortifications, since both time and geography were against her. She decided to attack France by means of a great enveloping movement through Belgium. Here, then, is a very definite effect of fortification upon strategy. Germany's fear of facing the French fortifications was in the end her undoing, for it brought in the British

Empire against her, and the brutal violation of Belgium lost her the sympathy of the whole civilized world. Moreover, the German General Staff miscalculated the effect on newly-mobilized troops of marching for weeks on end, and there can be no doubt that their plan did not take into account to a sufficient degree the administrative difficulties of such an operation.

Though Germany had avoided the French line of fortifications, her plan compelled her to deal with the Belgian fortresses. Let us examine the position of Liége. The Meuse, running as it does, divided the flat Brussels plain from the hilly and wooded Ardennes. It was essential for the Germans to cross the Meuse and gain access to this plain. The fortresses of Liége and Namur blocked the main crossings over the river. The crossings at Liége were the most important, for the Germans wished to spread out their columns on a broad front as quickly as possible. There can be no doubt that the Entente laid great hopes on Liége, and expected that it would delay the Germans considerably, should they come that way. There are several reasons why this delay was not secured in actual fact. Belgium was caught unawares. She received an ultimatum one moment and was attacked the next. Her army hardly knew whether the Government had decided to oppose the Germans or not. But, there were two main reasons for ill-success. The fortress consisted of a ring of isolated forts supporting each other with gun-fire. The forts were placed so as to block the main roads running into the bridges in the town, but there were no completed defences between the forts. The Germans, in their surprise attack, managed with one of their columns to penetrate between two of the forts and secured the precious bridges within. They secured these bridges intact long before the forts were finally reduced by the fire of heavy artillery. It had been the intention of the military authorities to complete the defences between the forts after mobilization. In this, of course, they failed for want of time. The second, and perhaps the more important reason, for failure, lay in the faulty employment of the field troops. The Division which should have operated with the fortress was withdrawn to the West, and the fortress was left with its own garrison only. There were probably mobilization reasons for this withdrawal, but the fact remains that, had the field troops been present in Liége, the Germans would never have penetrated into the town, and they would never have secured the bridges intact. Here, then, is a good lesson. Fortresses by themselves do not repay the money spent on them. They should be used in order to facilitate the operations of the field army.

The German method of dealing with Namur and Maubeuge was different to that employed at Liége. The communications they were guarding were not of the same immediate necessity to the Germans, and, therefore, it was decided to overrun them, isolate them, and

reduce them at leisure behind the main advance. In this the Germans were completely successful. Neither of these fortresses could stand up to the bombardment to which they were subjected. They were unable to affect the German advance either as regards the front troops or the building up of the line of communications behind.

The cases of Antwerp in Belgium and Königsberg in East Prussia are also interesting. Their positions in regard to the two great advances were precisely the same. They lay away to the right flank. They neither of them could be isolated, for they both could be reinforced by sea, the first from the Belgian coast and the second from the sea canal from Pillau. Antwerp was considerably stronger than Königsberg, but the Russians did not possess any heavy artillery in East Prussia. The Commanders of the two great advances treated the fortresses in very different manner. The Germans at first paid little attention to Antwerp, and merely observed it, strengthening the forces of observation as danger threatened. They did this despite the fact that it was well known that the Belgian army intended to withdraw within the fortress. The Russians prepared to blockade the area of Königsberg and to wait till guns were available from the Austrian theatre before they reduced it. They had no idea whether the Germans would allow any of their field forces to shut themselves up in Königsberg and made little attempt to find out the actual situation. They employed a force for the blockade greatly superior to the German forces within the fortress, to the detriment of their field forces continuing the advance.

A position to a flank, such as these two fortresses enjoyed, is an dvantage not to be despised, but one can exaggerate the importance of such a situation. It is very difficult to organize a sortie from a fortress, more especially if the troops have already been engaged and defeated in the field. One has only to examine the stories of the sorties from Paris and Sedan to realize the truth of this.

Now let us take the situation of Paris. Here we have a great entrenched camp in the centre of France. It is, indeed, the centre of communications, both road and railway. Here was an area of over thirty miles, stretching from East to West right across the German right wing's advance. In this area the French could manœuvre and the Germans could not. What was von Kluck to do when he came within a few days' march of this area? Was he to go to the East or the West of it? If he went to the East he laid himself open to an attack issuing from Paris against his right flank. If he went to the West he would be separated by several days' march from the army next to him. As you all know, he went to the East and was attacked in right flank by Manoury.

The lesson of Paris is that the field armies employed it at exactly the right moment as a pivot of manœuvre. Had the Battle of the Marne taken place further south, Paris would have lost its value in

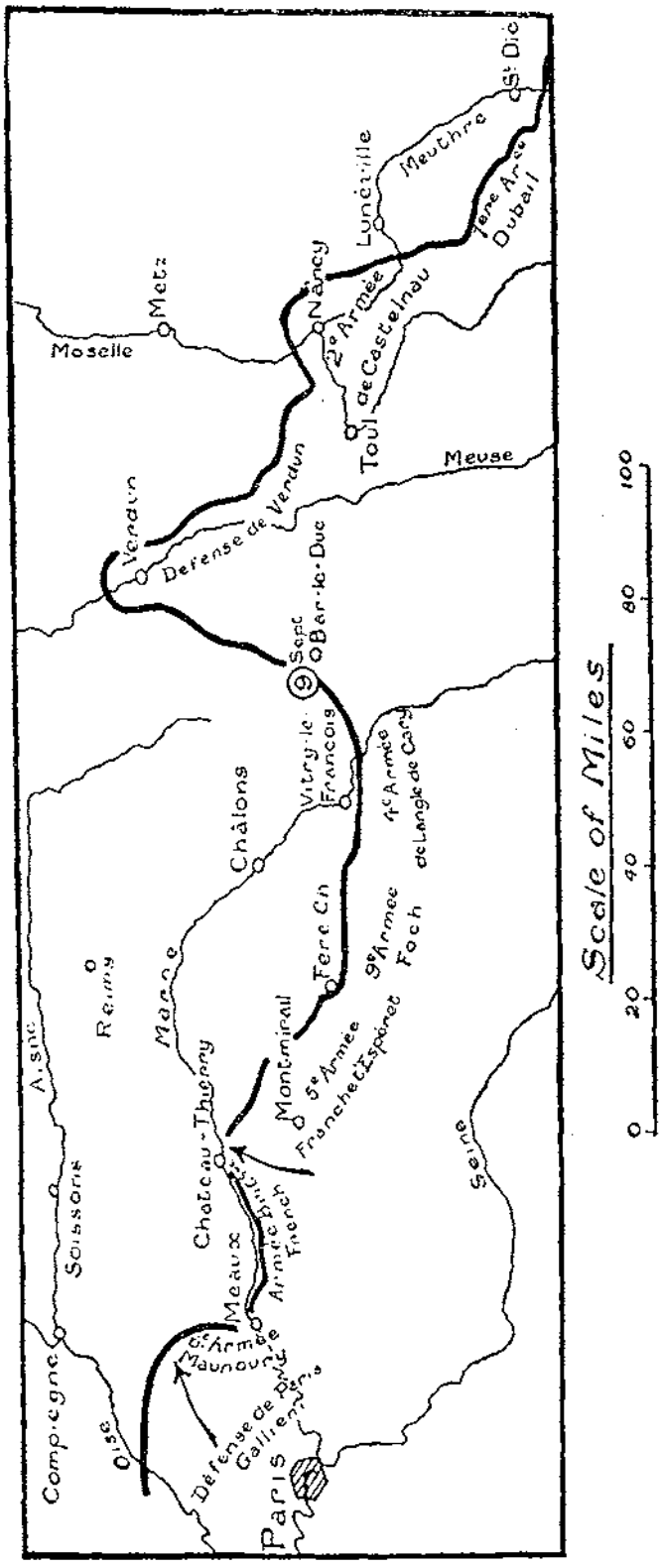
impeding the Germans, who would have isolated it and reduced it at their leisure.

There is always a difficulty in getting retreating troops to stand at all, and there is perhaps greater difficulty in choosing the correct moment at which to stand, but the Battle of the Marne will always stand as an example of wonderful timing under difficult conditions. The question of the deliberate withdrawal of an army in order to use pivots of manœuvre inside one's own territory has been much debated. It should never be forgotten that Governments and peoples are only human, and that they do not like giving over territory to an enemy, however great may be the strategic advantage. The French retreat was in no way a voluntary one. They were caught at a disadvantage and carried out an improvised manœuvre of great difficulty with brilliant success.

If anybody has any doubt as to the value of the French fortifications—obsolete as they were—let him examine the final line attained by the German advance in 1914. You will see the very definite bulges in the line made by the fortresses of Nancy, Verdun and Paris. There can be no doubt that these fortresses, used in conjunction with the field forces, did prevent disaster. (*See Sketch.*)

Now let us turn to the future. I have no desire to pose as a prophet, which is a thankless task indeed. As you know, it is the aim of all good strategists to prevent a campaign from developing into such static warfare as occurred in 1915–16–17. Armoured fighting vehicles have certainly come to stay and, whatever may be the degree of one's belief in them, one must admit that there is more likelihood of periods of mobile warfare in the future. That there will also be long periods of halt is equally certain, for no administration could possibly keep pace with continuous fast movement at the rate of modern motor transport. The three main factors which will bring about these periods of static warfare are—lack of machines, lack of petrol, and modern fortification. As I have already pointed out to you, fortresses have always been built to control communications, and with mobile warfare communications are more important than ever. However much one may desire to see an army supplied with complete cross-country transport, such an achievement is beyond the purse of any nation in peace-time. The bulk of the vehicles employed will be wheeled vehicles used by the nation in peace-time. The main principle governing our method of fortification must be the denying of road communications to the enemy, while retaining them intact for ourselves.

I have shown you some photographs of fortresses taken from the air by foreigners against our will and desire. From these you will realize the difficulty of concealing anything in the way of permanent fortification. With the present power and range of artillery, it will always be possible to reduce the best of forts, given the requisite time,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Metz
Moselle
Meuse
Verdun
Défense de Verdun
Sept
Bar-le-Duc
Vitry-le-François
4e Armée
de Langle de Cary
Châlons
Marne
Reims
Fere Ch
9e Armée
Foch
Montmirail
5e Armée
Franchet d'Esperey
Château-Thierry
Meaux
Armée Britannique
French
Soissons
Aisne
Compiègne
Oise
3e Armée
Maunoury
Défense de Paris
Gallieni
Paris
Seine
Scale of Miles
0
20
40
60
80
100

and this time will be reduced considerably if the enemy has accurate knowledge of the position of the fortifications he is going to attack. Is it worth while, therefore, embarking upon fortification of this expensive nature? I do not think it is, unless the actual geographical position of the chosen fortress is very favourable, such as would be the case in some of our isolated oversea possessions.

One cannot exaggerate the importance of the principle that whatever fortification is employed must be for the direct benefit of operations in the field, and must be so situated that it can be readily turned to account under several different strategical conditions. The importance of natural obstacles—such as rivers, lakes and forests—has certainly grown immensely. It seems to me that we ought to use these natural obstacles to the fullest extent, widening the area of their effect by means of fortification. We must employ some kind of pill-box defence, making whole areas impervious to anything but regular bombardment. What we require is something which can be put quickly into execution and which cannot be easily reconnoitred by the enemy. I have a vivid recollection of the pill-boxes erected by the Germans inside ordinary houses. It was not till we began to bombard in earnest that the houses fell apart to reveal the horror within.

In considering a modern theatre of war, I should attempt to analyse it as follows. There seem to me to be three distinct areas, the Base area, the Aerodrome area, and the Front area. The Base area will consist of one or more entrenched camps. Here one will find more or less permanent fortification, always the best adaptation of old and obsolete fortifications. The Aerodrome area will be something less permanent. It will contain the aerodromes for the aircraft working with the armies in the Front area. It will certainly be of large extent and may consist of one connected area or of several distinct areas with intervals between them. The Aerodrome area must be situated at an economic distance behind the Front area, or the machines will expend their energy unduly before coming over the fighting forces in front. The Aerodrome area must be capable of being moved forward by bounds. By saying this I do not mean to say that there will be much movement of aerodromes, for they are bulky to move with all their stores of bombs and petrol. When the distance between the Aerodrome area and the Front area begins to increase, recourse must be had to advanced landing-grounds, which will not require so much protection. Movement of the Aerodrome area will be by big bounds. If we protect the Aerodrome area as I suggest, we can use it as a pivot of manœuvre for the fighting troops and also as a haven of rest for the transport working from the Base area to the Front area. This seems to me to be the only method by which one can free the fighting troops for mobile operations. A

Commander can perhaps cut himself off from his communications for a period, but he cannot abandon them altogether. If he is thinking always of his rear he will not handle his troops sufficiently boldly

I should like to say a word about what we call combined operations. The matter is closely connected with the defence of our oversea fortresses. It should be remembered that we are the only nation which has much experience in these operations. We have made many mistakes in the past, but we have collected a vast experience in the subject. We realize that they are the most difficult of all operations of war. We can console ourselves that other nations are mere amateurs at the game when compared with us. It is the very isolation of an overseas fortress which constitutes its great strength. To attack one is a serious operation. I will give you an instance of one of the difficulties. The attacker will always find it difficult to gain superiority in the air, even if the fortress is meagrely supplied with aircraft. It is necessary to find a landing ground if you are going to use wheeled aircraft and this will entail a preliminary operation. If the defender of the fortress is alive to the situation he will turn your preliminary operation into a main operation, and will use his aircraft to prevent you establishing yours. If you propose to use aircraft with floats and to use some piece of water as a landing-ground, you will find your machines inferior in air performance to the land machines of the fortress. To use naval aircraft-carriers off a coast is a ticklish affair, not relished by the seamen, for they have to steam at high speed into the wind to take on their machines.

You will see that I am of opinion that the day of fortification is by no means over. I think, however, that they will be of a more improvised character, and much more extensive than has been the case in the past.

A WINTER IN WAZIRISTAN.

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

II.

MULLAH POWINDAH'S impassioned appeal met with little response, though an Afridi *havildar* (sergeant) and several sepoys had previously deserted from one regiment at Wana a night or two after the Mahsud attack on the Delimitation Escort camp. These trans-frontier men had gone off with their Martinis and a goodly supply of ammunition, obtained chiefly by a clever ruse from the other sepoys on picket duty that night. The *havildar*, a noted shot in this regiment, was now credited with being the Mullah's right hand, and the leader of the *budmashes* who had been firing continually from long ranges on the different columns operating in the country. Active as he and his gang had certainly been, their efforts, unsupported by the Mahsuds as a whole, were not likely to affect in any way the intentions of the Commander of the Field Force.

The Wana brigade now received orders to return to Wana, *via* Tank and the Gomal river route; the Bannu brigade was directed to proceed across country to Bannu, and thence up the Tochi Valley; whilst the Jandola brigade pushed west up the Shahur Zam to Kundiwam in the Khaisera Valley, some thirteen miles to the north-east of the former Wana camp. At Kundiwam a large *jirgah* (council) was to be held by Sir William Lockhart about January 20th, and if the Mahsud *maliks* then displayed signs of accepting the terms of Government the delimitation of the new frontier with Afghanistan was to be taken in hand at once.

The physical difficulties lying in the path of the Jandola brigade were known to be great; so both the 2nd and 5th Companies, B.S. and Miners, were attached to it for the purpose chiefly of road-making. Accompanied by an escort of an Indian battalion, they left Jandola on January 11th for Haidari Kach, distant eight miles up the Shahur; and during the next two days they were hard at work improving the rough track along the river bed for the passage of the main body and transport at Jandola. The Shahur joins the Takki Zam a short distance above the post, and almost immediately after entering it the cliffs commence to close in and culminate in the Shahur Tangi, some three miles up-stream of the junction. The defile is a very narrow one and shut in by lofty sandstone precipices;

whilst rocks and boulders in the bed had to be blasted and regularized to render the route through practicable for camels in single file. In other places ramps had to be made from the river bed on to small *kaches* and then down again, in order to avoid particularly bad stretches in the bed.

Thus, the main body and transport were able to march comfortably through to our camp at Haidari Kach on the 13th ; and next day the whole force proceeded together to Nana Khel Kot, another eleven miles on. We passed two tempting walled-in villages with towers, and several water-mills, but these, the Politicals said, belonged to "friendlies." They were spared, although our field telegraph line from Jandola had been cut twice at night during our three days' stay at Haidari Kach. Still, we had plenty to occupy us otherwise, for several plateaux had to be crossed to cut off sharp bends in the stream, which necessitated the rapid construction of roadways up to and down from these tracts of high ground. On the whole, however, the going was fairly good, as the country hereabouts opened out appreciably ; so all the camels reached the new camping-ground by daylight, which was a welcome change to the normal state of things.

Continuing next day along the bed of the stream, the hills closed in again; and though *kaches* existed at intervals, the river became much confined where joined by two other rocky ravines in the vicinity of some hamlets and water-mills. Nevertheless, the transport animals were got safely through this defile ; but eight miles after leaving Nana Khel Kot the force was confronted by an impassable *tangi*. We were compelled in consequence to clamber up to a plateau 150 ft. above the river in order to find a spot whereon the brigade could camp, Para Khel Kot by name.

The road to Kundiwam by the bed of the stream was effectually barred by an amazing cleft in the mountains. The hard limestone cliffs on each side rose almost vertically for several hundred feet out of the shingly bed of the river, and were separated by a space of only a few feet. In the fifty or sixty yards' length of this striking slit the shallow stream pursued a sinuous course ; and almost in the centre of the gorge the cliffs closed in until they were less than five feet apart. Here an immense rock, an irregular diamond in shape, had fallen from the frowning heights above and was firmly jammed across the narrow aperture. Sufficient headway remained for a person to walk underneath, but no laden camel could possibly pass between those immovable walls.

The up—and down—stream approaches to the *tangi* were strewn with great boulders ; and for another two and a half miles up-stream the bed of the Shahur was chiefly a confused mass of more boulders and huge rocks, some nearly as big as cottages. Thus, even had not that grim sixty yards of lower *tangi* existed, the construction of a

camel track through that chaos of rocks and water leading to Kundiwam beyond would obviously involve much labour and time. And of the latter there was little to spare if the big *jirgah* was to come off on the date arranged.

Three R.E. parties set forth, therefore, to examine the country on ahead—along the right bank, the left bank, and the river route itself. The last, it was reported, would require a fortnight's work to render it practicable for laden camels; and it was ultimately decided that a track over the hills on the left bank, well inland from the river, promised the least heavy work of the three alternatives.

All next day the sappers, assisted by infantry working-parties, toiled on the construction of a camel road over those bleak, wind-swept hills; and by nightfall a necessarily winding, but good, 8-ft. track curled its three-mile length to Narai Raghza. This plateau was up-stream of the Narai Tangi, the lower of the defiles described above; so that had been circumvented, and a path made down to the river, whence the water supply for the force was drawn during its two days' halt there.

Whilst the road-making parties pushed on with the work ahead next day, the force moved up to Narai Raghza; but the remaining four miles of track to Kundiwam proved somewhat more difficult than the three already done. In many places the alignment along the hillsides could not avoid rocky drops of seven or eight feet, which had to be ramped. Big rocks elsewhere had frequently to be blasted away; for one has to consider the comfort of the laden camel closely, as he does not show to the best advantage on hilly ground; and we had 1,700 of him to legislate for. Hence, dry stone retaining walls are required here to support the track; and there frozen rivulets crossed must be specially treated to save our awkward carriers from slithering over their glassy surface with their padded feet and, peradventure, spread-eagling themselves so badly as to necessitate their destruction. Nevertheless, by the end of the second day's work from Narai Raghza, an excellent track, nowhere exceeding a slope of 9°, was completed to Kundiwam.

The entire force marched to that place the following day without mishap, though the camels alone, stretched out in single file along this mountain track, would have occupied nearly two-and-a-half times its length between Narai Raghza and Kundiwam. One felt a glow of satisfaction, therefore, when the last of the 1,700 was safely settled in for the night, and the two obstructive *tangis* had been outwitted.

Camp at Kundiwam was pitched on a low plateau on the left bank of the Shahur, now known as the Khaisera, at an altitude of about 5,500 ft. above sea-level. The village of Kundiwam faced the camp, on the right bank; while that of Manzara, and several smaller ones, were visible farther up the valley. They differed somewhat from

those in the vicinity of Makin, in that they were completely surrounded by high mud and stone walls, and furnished with a low tower at one corner.

It was now the coldest season of the year; and the thermometer frequently registered 16° and 18° of frost—more than sufficient to freeze ink solid in its bottles within the shelter of a tent. Yet, in the early mornings, when most of us were shivering in "coats—warm, British," before the sun made his welcome warmth felt, the regimental *bhisties* (water-carriers) would be seen proceeding to the ice-fringed river, bare as to their legs, and clad in flimsy cotton garments only—purely from choice—to fill their *mussaks*, then frozen as stiff as boards. And presently a string of them would be seen wending their way back with these cheerless weighty skin vessels slung over their shoulders, and reposing against the region of liver and kidney. It fairly made one gasp, and wonder how these devoted menials could escape the ravages of pneumonia—to which numbers of sepoys fell victims during the expedition. It takes much, though, to curb the zeal of the Indian *bhisti* for tending to the wants of the troops by fetching them water at all hours of the day for cooking and other purposes.

The home of many of the worst *budmashes* among the Mahsuds, and the centre whence the large body of men issued to attack the Delimitation Escort at Wana, Kundiwam was very appropriately selected as the place to which the *jirgah* of Mahsud *maliks* should be summoned to hear the terms of peace offered them. The great Council was held on January 21st, and the Mahsuds informed by General Lockhart that they were to pay a fine of 12,000 rupees, to surrender all horses and other animals, rifles and cash, captured by them at Wana. Further, they were to hand in 200 *jezails* and 50 breech-loading rifles. Mullah Powindah was to be expelled from the country; and the Mahsuds were to keep open the road recently constructed between Jandola and Kundiwam, as well as the one to Wana, on which we had already begun work.

Though the Martini rifles of those days were valued by Government at roughly 30 rupees, they would fetch eight to ten times that price among the tribes living across our border, where a breech-loader was valued by a Pathan at little less than his life. The few rifles of this description then to be found in Mahsud territory had probably been obtained at the risk of the lives of skilful trans-frontier rifle thieves in India. The surrender of fifty such, out of possibly 300 in the country, was thus no mean test of whether the Mahsuds had had enough of our presence in their midst. The *maliks* were given until March 1st to comply with the terms; and the force would remain in occupation pending compliance.

Meanwhile, the sappers pushed on with the new road from Kundi-

wam to Wana, about thirteen miles distant through the hills to the south-west. Sir William and his staff left for Wana the day after the great *jirgah* was held, and Gen. Penn Symons assumed command at Kundiwam. As it was likely the Jandola brigade would be halted here for a month or more, the defences of the camp perimeter were much strengthened; and all proceeded to make themselves snug for the rest of the winter by constructing mud and stone fire-places as cheery adjuncts to the various mess and office tents. The chief drawback, however, was the scarcity of fuel for the troops, and grass for the animals, which necessitated parties going out long distances in order to collect a sufficient supply of these essentials.

In spite of occasional Waziri outbreaks near the L. of C. posts established between Jandola and Kundiwam, the Mahsuds as a whole seemed inclined to knuckle under, as a result of the privations they had suffered by the invasion of their secluded haunts. And here at Kundiwam they even went so far as to start trade by bringing in eggs and fowls for sale—needless to say at exorbitant prices—as well as grass and potatoes. The latter were fairly extensively cultivated in the neighbourhood, and formed a much appreciated addition to our frugal table. Within a few days of the *jirgah* also, several horses and rifles captured at Wana were brought into camp, and handed over to the Chief Political Officer, who retained his headquarters at Kundiwam.

The outlook was becoming so satisfactory that Gen. Symons now decided that efforts should be made to open out the river route between Kundiwam and Para Khel Kot. This would reduce by several miles the distance to be traversed by camel convoys required to ply between Kundiwam and Jandola, in order to maintain the force; and would greatly ease the strain on the camels by avoiding the hilly inland détour which had been constructed as an emergency measure to reach Kundiwam expeditiously. Owing to detachments, there was now only half a Company of Sappers with the Jandola brigade, but my C.O. and I had for some time past desired to try and make the two formidable *tangis* practicable for camel transport, so hailed the general's decision with glee.

The upper *tangi*, as previously stated, consisted of a chaotic mass of huge boulders and rocks in the bed of the stream, which was confined in this two-and-a-half miles of its course to a wild stony gorge. Along the broken slopes of the right bank, however, there ran a rough footpath, a mere goat-track in width, with numerous ups and downs but well above normal water-level. This, we believed, could be converted into a camel-road by much blasting, construction of retaining walls, and re-alignments to avoid unduly steep portions. Thus, work was started by the sappers, assisted by small infantry parties, on the 26th January.

The Shahur Zam was subjected to a terrible bombardment during the next few days, such perhaps as it had not experienced since the dawn of creation. Dynamite and gun-cotton were not stinted, and the booms of loud explosions reverberated far and wide amid the hill-tops, while boulders flew into fragments, and sides of the gorge came thundering down. All seemed senseless and wilful destruction; yet, out of the débris, dry-stone walls steadily began to rise aloft. And, as day succeeded day, order emerged from confusion until, towards the close of the fifth day, behold a broad well-graded roadway hugging the hillside, along which one might have driven a gig throughout the entire length of two and a half miles to near the mouth of the lower *tangi*, the Narai, or "narrow tight place," in Pushtu interpretation.

Grateful as we had been for the assistance of infantry working-parties hitherto, we now decided that the sappers alone should tackle the tricky task on the Narai *tangi*. There was no avoiding the river bed in this last sixty yards of beetling defile; and the space was too limited, and the work somewhat too technical for infantry aid to be of much service. The first job was to clear the up—and down—stream approaches to the gloomy cañon of the great boulders which impeded entry; and these were blown to smithereens with dynamite as a preliminary to further operations.

We could now concentrate our attention on the jammed rock, two ends of which rested on either side of the chasm, the other two pointing upwards and downwards respectively. We estimated that this huge diamond-shaped obstruction weighed not one whit less than twenty tons; and this mass would have to be entirely disintegrated before the five-foot opening spanned by it near the base of those smooth-faced cliffs could be sufficiently widened to permit the passage of laden camels through the orifice. By means of a rough ladder, sappers were able to clamber on to the top of the rock, about twelve feet above the bed of the stream. Icy blasts hurtled through this sombre sunless slit in the mountains, and in their cold and confined position the men required frequent reliefs while they toiled, for the greater part of the day, drilling holes into the upper half of the rock.

Towards sundown the requisite number of holes were bored and filled with dynamite. The sappers were then sent out of the *tangi*; my C.O. and I took their place on the top of the rock, and adjusted detonators and fuses to the several charges. "Are you ready?" "Right." "Then, fire away."

We lit the fuses, and, when they were satisfactorily spitting out their jets of flame, we scrambled down from our precarious perch in next to no time. Reaching the bed of the stream, we seized the rickety ladder between us and carried it off with considerable celerity up the icy rivulet. A thirty-yard paddle lay before us ere we gained

the mouth of the *tangi*, whence we hurried to join our men in the zone of safety without.

A few moments of eager anticipation followed, and then a terrific detonation smote the quiet of the fading day. It seemed to issue from the very heart of the mountain, and caused the earth to tremble beneath one. Allowing time for the smoke and dust within the cañon to dissipate, we mounted our ponies to view the result of the explosion. The top half of the rock had been completely cut away, as we had hoped, but the débris effectually blocked the narrow passage below save for a small opening through which the stream, formerly six inches deep but now banked up to a depth of two and a half feet, was pouring. Shades of night were falling, and we were an hour's march from camp, so we attempted nothing further then.

It was desperately cold work removing the débris next day, for much of the morning was spent standing in icy water nearly up to the knees; so pine log fires were kept burning at each end of the *tangi*, where relays could thaw themselves at intervals. The whole day were we employed in the gloomy gateway clearing the bed of the stream, and jumping fresh holes into the half of the rock that still remained suspended between the cliffs. This in its turn was duly pulverized during the course of the day, and all débris removed before nightfall.

We were now able to work on the face of the cliffs throughout the next two days by rigging up rough scaffolding of pine logs to support a few boards. Holes could conveniently be jumped from these into the solid limestone sides, which had become worn almost as smooth as glass by æons of flowing waters. Blast after blast was got off, and by the end of the first day's work on the cliffs the five-foot orifice had been widened to seven feet; and this was increased to eight feet when work ceased next evening.

Thereupon, the Narai Tangi was put to its first test as a highway the following morning. A large convoy of camels left Kundiwam by the river route for Jandola, and before noon the last camel had passed safely through the upper and lower *tangis;* but it was deemed advisable to remove yet a few more chunks of cliff at awkward corners in the sixty yards of twisting *tangi*. These were subsequently blown to dust, and the defile trimmed throughout its length to a minimum width of eight feet six inches, which proved ample for the requirements of the Field Force during the remainder of its sojourn in those inhospitable regions. The *tangis* had been conquered; but in spite of the cold and discomfort of working in that sombre rocky cleft, I think we one and all experienced a tinge of regret when this labour of interest and excitement came to a close.

Even on service in remote regions the British officer contrives to snatch an occasional day for relaxation; and towards the end of

January a party of fifteen of us, accompanied by a small escort of Indian cavalry, set forth on a mounted trip to Wana and back. The distance was but thirteen miles there, and leaving Kundiwam at 10 a.m. we reached the Wana brigade camp in good time for lunch, thanks to the fine road through the hills recently made by the sappers. It was refreshing, after being for long surrounded by mountains and hills, to emerge again on to the open Wana plain. It is treeless, roughly 13 miles long by 11 wide, and situated at an altitude of about 4,500 ft. above sea-level. The brigade was camped near the site attacked by the Mahsuds in that grim hour before dawn in November; so there was much of interest in visiting the more important spots connected with that affair, and having events described by those who had been present at the fight. During our return journey we made several halts in the hills to shoot chikor, large numbers of which red-legged partridges were seen tearing about the stony slopes.

Now that we were settled down in a stationary camp, steps were taken to construct a miniature race-course on a comparatively flat *kach* just outside our perimeter. Although we could not run to a larger circuit than 550 yards, still we got up some very enjoyable gymkhanas, athletic sports for the men, and so forth; and even blossomed out into a Kundiwam First Spring Race Meeting towards the middle of February. This was restricted to local entries; but ten days later the Second Spring Race Meeting was held, and for this a contingent of officers arrived with their mounts from Wana, and spent the night with us. Our remaining half-company of sappers also rejoined from Wana the same day, after erecting numerous pillars during the recent delimitation work beyond that place.

Being once more re-united, the 5th Company, B.S. and Miners, received orders to march some six miles north up the Khaisera, with an escort of 38th Dogras, to construct a road from the eastern side of the Inzar Kotal down into the Shakai Valley. A track up the western slopes from Wana had already been made by the 2nd Company when that brigade advanced to Kaniguram in December, and we were required to continue it on this side of the hills. We made a defensible camp near the village of Torwam, a few miles to the north of which lay the Sharwangi Kotal, the scene of an engagement with the Mahsuds during the campaign of 1881.

In order to start work from the Inzar Kotal next day, we had to tramp a distance of six miles from Torwam before we reached the point where the other Company's road-making ceased, the pass proving a very ill-defined one. Commencing from the far end, however, we completed one and a half miles of road over difficult ground before returning to camp; and next day added another similar length of heavy work homewards, in spite of our C.O. meeting with a most regrettable accident.

At a certain corner it was found necessary to blast away four big rocks that impeded the path. When the holes had been prepared and the mines charged, we lit the fuses and retired to what we regarded as a safe distance, beyond an intervening spur. Following the explosion, a piece of rock weighing six or seven pounds was hurled close on a hundred yards. It topped the spur and struck our C.O. a violent blow on the point of the right hip-bone before he had time to see and dodge it. He was knocked completely off his feet, and lay on the ground in great pain, quite unable to move. Although a huge lump rose at once on the injured part, we hoped no bone had been broken, and sent three men off on mules to bring out a stretcher from camp, which was more than four miles distant. He was there carefully examined by a medical officer who came out from Kundiwam next day. To our relief he stated no bone was broken, but that if the blow had been dealt two inches lower the thigh would probably have been fractured.

Our C.O. had thus to be thankful for small mercies, and was removed to Kundiwam in a *dhooly;* and there he was confined to his camp-bed for the next ten days. Meanwhile, the work on the road continued, and two days sufficed to complete what remained of the six miles odd that constituted our task, when we, too, returned to Kundiwam.

By the end of February the Mahsuds had complied with all the terms imposed on them, and even asked the Chief Political Officer to try and arrange that the Indian Government should take over their country, and administer it for them! This request was not regarded seriously, however, by the then Lieut.-Governor of the Punjab; but one cannot now help thinking that, had this unsolicited opportunity been taken advantage of thirty years ago, much subsequent trouble, loss of valuable lives, and staggering expenses might have been avoided.

The ingrained perversity of these truculent mountaineers, who have frequently since kicked over the traces, might by now have been guided into saner channels, and some sort of law and order established in their midst. But only of late, after all this lapse of time, would it appear to be recognized that in the permanent occupation of part of their territory lies the sole solution of curtailing the activities of this restless tribe.

The month of March was ushered in by highly inclement weather, much rain falling; and on the 8th, the 5th Company, B.S. and Miners, was transferred to the Wana brigade, where we arrived to find that Gen. Turner had left with a column that morning for the Dana Valley, to the north-west, whither we were to follow him next morning. Heavy rain fell during the night, thus greatly increasing the weight of all tents for the mules when we started across the plain at

9 a.m. Whilst traversing a low range of hills bordering it to the north, we obtained a magnificent view of the entire Wana plain stretching for a distance of 10 or 12 miles in a southerly direction to the hills, beyond which the Gomal river flowed east to join the Zhob. Four years before, I had been working with the first party of British officers who had ever visited the gorge of the Gomal thereabouts, on a strategic railway survey along its course. Wana, though known to us by name then, had not been entered by Indian troops, and the plain was hidden from our sight by the confused mass of rugged hills through which the Toi, draining the Wana plain, threaded its way to join the Gomal at Toi Khula.

The view conjured up visions of a miserable Christmas Day spent in the Gomal near the junction of the two streams, where we were trounced by a piercing gale straight from the snows, accompanied by fierce squalls of rain. And, indeed, our present plight was little better, for throughout the whole march, rain continued to fall intermittently; and, as we gradually ascended to higher altitudes, it became exceedingly cold as well. During the last three miles of our fourteen-mile tramp, we passed numbers of small hamlets with their inevitable tower; but conditions remained distinctly depressing, and we were relieved to catch a glimpse of Gen. Turner's camp shortly before 2.30 p.m. Luckily for us the column had not marched that day, owing to the steady rain and threatening outlook at dawn.

The camp was pitched on a very rough restricted plot of ground at a point where the Dana valley contracted considerably. Dana village itself was perched on a knoll about a quarter-of-a-mile downstream; and as we were more than 1,000 ft. above Wana the spot proved a cheerless one, for sleet and snow fell ceaselessly all that afternoon and night. We were to have marched nine or ten miles farther up the valley, despite the weather next morning, but the general received an urgent message from Force Headquarters, then in the Tochi, to despatch two Gurkha battalions of his brigade to Tank at once. He therefore returned to Wana with detachments of these two battalions that formed part of the column; and the remainder of the column followed next day, after being able to accomplish little in the way of reconnaissance or road-making on account of the incessant rain, sleet and snow.

Stirring events were evidently afoot elsewhere; for, when we reached Wana, the Gurkha battalions had already left for Kundiwam, in order to join the remnants of the Jandola brigade starting for Tank, and the 38th Dogras arrived from Kundiwam to take their place in the Wana brigade. We now learnt that serious trouble had broken out in Chitral, where Umra Khan of Jhandoul was in rebellion against the local princeling. Thus a fresh expedition was being rapidly organized to deal with the threatening situation which had

arisen in that region of our far-flung frontier. But the 5th Company B.S. and Miners, alas, was to remain attached to the Wana Brigade. And so we embarked on further road-making, and other useful works, in the neighbourhood.

At the end of March I received orders to join the 2nd Company, then with the Tochi Valley Field Force; and accordingly left for Bannu on April 1st, with a convoy bound for Kajuri Kach to bring up more supplies to Wana. Travelling along the seven miles of road we had recently made to Karb Kot, we there swung away from the Toi stream and continued to the Katina camping-ground, another seven miles on. A further march of twelve miles next day over plains and through low hills, now bright with spring flowers, such as tulips and crocuses, landed us at the new Kajuri Kach Post on the right bank of the Zhob—at its junction with the Gomal.

Four years before, nothing had been located there save a miserable little Waziri Levy post, the wild occupants of which were supposed to afford protection to travellers spending the night without the shelter of its walls. Actually, they were not above participating in raids on those camped outside, if such happened to be Sulaiman Khels, or of some other enemy tribe. These sparkling *jeux d'esprit* were now, however, a thing of the past, for an imposing fort had taken the place of the levy post, and was garrisoned by three companies of Indian infantry and a troop of Indian cavalry. Within its precincts were a large commissariat establishment, transport lines, a post and telegraph office, and at least three British officers always in residence. In short, all the comforts of a home obtruded themselves at this outpost of Empire.

Below their junction, the combined streams of Zhob and Gomal enter a formidable series of rocky defiles known as "Browne's Gorge," after the late General Sir James Browne, a noted frontier officer, who was the first European to view them. Through these awesome cañons no passage for man or beast exists; so the traveller at once strikes away from the river on leaving the Kajuri Kach post, and clambers to the summit of the Gwaleri Pass. Thence, threading his way 'mid a network of hills, he descends gradually to the banks of the Gomal below the gorges at Nilai Kach, distant about sixteen miles from Kajuri Kach. Accommodation is there provided in a dâk bungalow within a fort, constructed at the junction of a large nullah with the Gomal. On the top of a bluff of surprisingly variegated colours is perched another post, held by a company of Indian infantry; whereas the lower one affords shelter for Waziri levies employed on escort duty to Jatta, the next stage towards the plains of India. Between Kajuri Kach and Nilai Kach this duty devolved on regular troops.

Shortly after leaving Kajuri Kach at 7 a.m. we met the advanced

portion of a multitude of Powindahs, bound for their homes in Afghanistan now that the approaching hot weather in India had put an end to their trading activities in that country. Soon we were in their very midst; and during the greater part of the day's stage we floundered through this host, who carried their cherished goods and chattels on immense droves of camels, and even diminutive donkeys loaded to the gunwale. Men, women and children were all agog urging forward their slow-moving beasts of burden, and flocks of sheep and goats, along the narrow roadway. This was in many places cut deep into the steep hillsides, and here the passing of the cavalcade was frequently a matter of delicate calculation to avoid a plunge on horse-back down forbidding slopes. We, too, were accompanied by camels and mules, thrusting in the opposite direction, so progress at times was laboured. Particularly was this the case near the summit of the Gwaleri Pass, where the greatest congestion occurred, and where the serpentine track was much intersected by numerous small *nullahs* which made it difficult for the contrary currents to cross without mishap.

I had often previously seen caravans proceeding up and down the Khyber, to and from Central Asia, but there was an air of novelty about this Powindah migration which made it far more attractive in my eyes. The men were fine specimens of humanity with frank open faces, and were mostly armed with swords and daggers, though a few carried rifles. The youngsters were the jolliest set of rogues I had ever seen out East, laughing and shouting in the highest of spirits, and evidently in enjoyment of the most robust health by reason of their rough outdoor existence. Many of them were very fair, and not a few had quite light hair and blue eyes. The young women, too, were often really pretty; and one damsel observed would have reigned as a beauty anywhere. She seemed to be about eighteen years of age, was unusually fair of complexion, and gazed on the turmoil around through large blue eyes. Her smiling countenance displayed a perfect set of snowy teeth, which enhanced the Madonna regularity of her features; whilst a fringe, cut straight across the forehead, peeped out from below the dark blue cloth thrown over her head. Her practical woman's garment of pyjama trousers fitting tightly about the ankles, and surmounted by a loose dark blue gown falling to little above the knees, completed her picturesque appearance. The beauty of these females soon fades, however, owing to their hard life on the road and at home; and by the time a woman reaches thirty she usually looks old and wrinkled, though still full of work.

That the life of these wanderers is a hard one a few words will make clear. The term Powindah is applied to the great warrior traders of Afghanistan, who yearly bring down goods from distant

Bokhara and Afghanistan for sale in the Indian markets. They belong, in the main, to the important Ghilazi tribe, whose chief town is Ghazni, between Kandahar and Kabul. At the beginning of each cold weather these people collect their families, thousands of camels, sheep, goats, etc., to the east of Ghazni, and set out for India with their goods. They march in regular armies, and are well organized, in order to resist attack by hostile tribes—more especially the Waziris about the Gomal, who for generations have carried on war to the knife with these hardy traders. On reaching Tank their arms are deposited under the charge of the Indian Government; and whilst many of the men penetrate to all parts of India with their goods, their families remain in the neighbourhood of Tank, where ample grazing grounds exist for their numerous camels and flocks, under the protection of perhaps two-thirds of the fighting men. The approach of the hot weather recalls the itinerant traders to Tank, with goods purchased in India after selling what they had brought from Central Asia. Their arms are now handed back to them, and when the multitude is once again assembled the homeward march to Ghazni begins.

But their travels do not cease there. The women and children are again left behind, as at Tank, while the men continue into Central Asia to trade in the goods brought from India, for which they find a ready market in the bazaars of Turkestan and other remote parts. Still, they are always back at their homes in time for the annual migration to India as soon as the cold season sets in. Thus the men are ever on the move, and their organization, with all this wealth of experience behind them, reaches a high pitch of excellence for Orientals. The rapidity with which their animals are loaded up in the mornings, and the absence of confusion on the line of march is remarkable. Every man has something to do, and does it. Likewise, every woman, boy and girl has some allotted task; and though all appears babel and bustle, there is method in the din, and the show works smoothly.

It is estimated that about 50,000 of these nomads enter the Dera Ismail Khan district every year by the Gomal route between the middle of October and the middle of December; and return between the 20th March and 10th May. The advent of these warlike traders, at the time of which I write, was no small boon to the Indian Government if some frontier expedition was about to be undertaken; for these men willingly hired out their camels for transport purposes, and accompanied them in the field. It is probably no exaggeration to say that three-quarters of the camels employed on this particular Waziristan Expedition, amounting to several thousand in all, were the property of Powindahs.

In the twelve-mile stage from Nilai Kach to Jatta the road ran

at first along a plateau on the right bank of the Gomal. The left bank was here bounded by a mass of low pinnacle-shaped hills, beautiful in their kaleidoscope of colour, and much furrowed and fluted by the torrential downpours to which they are at times subjected. These became gradually replaced, however, by magnificent vertical cliffs of austere conglomerate on both banks, and between them the road wound its sinuous course for some distance. Four or five miles short of Jatta we crossed the now comparatively narrow Gomal by a wooden pile bridge. Continuing our way through the low out-lying hills of Waziristan, we soon emerged on to the plains of India and reached the Murtaza post. In the remaining three miles to Jatta we followed a broad open road leading through green fields of tall wheat; and as the trees were also bursting forth into their fresh young leaves, the scene was a striking and smiling change from the barren wastes of Waziristan, to which we had grown accustomed during the past four months.

At Jatta post, too, accommodation for the British officer travelling on duty was provided in a dâk bungalow; and thence an easy ride of fifteen miles over level plain, and along a veritable Queen's Highway, landed us next day at the relatively important post at Tank. Here we were once more on familiar ground, and as the mail tonga plied the forty miles between Tank and Dera Ismail Khan, this part of the journey was covered comfortably in less than six hours the following day.

Thus the winter sojourn amongst the Mahsuds was brought to a close on April 7th. In order to reach the Tochi Valley, however, a further tonga journey of ninety miles northwards along the fine frontier road to Bannu had to be undertaken on the 8th. And in the Tochi, near by, but only entered shortly before by British troops for the first time, it was my lot to pass another fourteen strenuous months with the Field Force.

THE FUTURE OF MILITARY ENGINEERING.

By COLONEL J. F. C. FULLER

THERE have always been two forms of war—sieges and field battles. At times the one has preponderated, and at times the other, but until the introduction of cannon the capture of fortresses and fortified cities was one of the most difficult and costly operations of war. Once the cannon challenged the stone wall the gunner took over much of the sapper's work, and the sapper from a siege specialist became an assistant to all the arms and services in the army, whether its object was to carry out a siege, fight a battle, or undertake a march.

To assist is to do what others cannot do, or if they attempt to do it will detract from their own particular work and duties; further, to do something which is essential to the economy and the smooth running of the army as a whole. For example, an army may be compared to a clock. In a clock each wheel, lever and spring does something, which each other wheel, lever or spring, cannot do; and the more perfectly each individual part performs its work, according to the plan upon which the clock is designed, the more perfectly will time be registered. The difficulty to-day is that no one as yet has settled on the design of our military clock, and until this design is fixed no single part can clearly see its object and economically carry out its work. This should not, however, be made an excuse to do nothing, for otherwise, when the time comes to effect a change, mentally we shall be unprepared.

THE PURPOSES OF THE ENGINEER.

In order to see clearly, freedom of thought is essential. All interests and prejudices must be set aside, and basic principles must be laid bare, examined and applied. To understand in what way engineers can economically assist the other arms to-day, and how far the method of this assistance must be kept elastic, so that it may change as the other arms change, a good deal can be learnt from past history. It is by looking backwards and by discovering the reasons for success and failure that we best teach ourselves how to prepare for the future.

In quite early times the fighting troops themselves were their own engineers, but as armies became more organized, and walled cities more numerous, it was found necessary to train a special body of

men to work the catapults, battering rams and other siege engines. The word engine (Greek Organon and Latin Organum) gave them their name. They did not construct defended camps or dig trenches, for these duties were performed by the fighting troops, they were essentially constructors, maintainers and workers of engines.

In the French Army, at a very early date, we find "Ingénieurs," and in our own army we find that William the Conqueror had an officer called "Ingeniator." Later on, when cannon came into use, we find that it is the engineer who is placed in charge of this new "engine," the "Ingeniator" becoming the "Attillator," from whom is descended the present Master General of the Ordnance.

In Henry VIII.'s reign the Chief Engineer was one William Pawne, who, having fallen out with Cardinal Wolsey over certain fortifications at Tournay, wrote to him as follows: "Not daring to be tedious remembering your Eminence's manifold services. I am not fumous as report has been made. My fumes never hurt any man so much as myself;" which clearly tells us that his main business was connected with artillery.

The general adoption of artillery led to a rapid development of fortifications, and the result was that the engineer concentrated more and more on the building of fortresses, and in the carrying out of siege operations, the artillery becoming a separate arm. In France, under Marshal Vauban, the "ingénieurs" change their name and become known as the "génie," and in this change there is more than meets the eye. "Génie" is not derived from "engine," but from the Greek "geno" or "geneo," which means to procreate, a word allied to the Latin "genius"—a supernatural guardian spirit which attends the birth of every child. From simple workers of machines they, in their own estimation, had grown into a vastly superior class of soldier. Guibert, writing in 1773, says of them: "The Engineers do not know how troops manœuvre, nor how they are commanded. They do not even want to know these things, for they look upon their art as the first of all arts." In fact they had, in their own eyes, become a military mystery—a guardian spirit which presided over the birth and destiny of the common soldier.

THE FOUR GUIDING FACTORS.

To turn now to the present problem. To co-operate with the other arms is to do something which is essential, and yet which cannot be done efficiently or economically by these arms themselves. The first problem of the engineer is to know accurately and in detail what the troops can and cannot do, and until this problem is solved there can be no economy of work. The second problem is to foresee what the troops will be able and will not be able to do in the future, and until this problem is solved there can be no certain direction of progress.

These two problems solved, the path is made easy, for then all that remains to be done is for the engineer to examine what he is now doing, and if necessary to amend it.

In solving these problems there are certain factors which I think can assist us, and which throughout history have been common to all types of troops. These are as follows: All soldiers require information, protection, offensive power and power to move.

To-day the troops can reconnoitre, but they cannot make maps; they can dig their own trenches, but they cannot construct elaborate fortifications; they can assault a position, but they cannot mine it; they can swim a river, but generally they cannot bridge it. These are only four examples, important ones though they be, out of a host, but I think they illustrate the point I am driving at, namely, that true co-operation is based on economy of force, which demands a *proper* distribution of work.

The Changes which face us.

The second problem is not so easy, but it must be solved, if only provisionally. Unlike the first, we cannot see things, and consequently have in place to imagine them. We know, however, two things, namely, that the next war will be unlike the last, and that the four factors I have mentioned remain constant.

Our present means of waging war are slowly changing, but there can be no doubt that a change is taking place, and further that if a great war broke out to-morrow, either in Europe or in Asia, these changes would develop with amazing rapidity.

In brief, the main change is towards mechanization, which is mainly a problem of movement. It is not one of replacing men by machines, but of moving men in machines, far more rapidly than they can move by means of leg-power. To-day in military organization we are faced by the same problem which faced industry on the introduction of steam-power, and which faced road transport on the introduction of petrol-power. In the middle of the last century, willy-nilly, the Navy had to change from sails to boilers. At first many sailors were against this change, but it was inevitable, because steam-power could establish a greater economy of force. To-day in the Army the general introduction of the internal-combustion engine is equally inevitable and for an identical reason.

As steam-power changed sea strategy and tactics (in fact it changed naval tactics out of all recognition), so will petrol-power change land strategy and tactics. If comparison and inference are any guide, then the land battles of the future are likely to be as different from those of the last war as the Battle of Jutland differed from the Battle of Navarino.

STRATEGICAL AND TACTICAL CHANGES.

To-day, we are confronted by many new means of waging war, such as armoured cars, tanks, aeroplanes and gas, which must, and will, radically change our existing conceptions of strategy and tactics.

To-day, land strategy is almost entirely woven on roads and railways, but cross-country machines, though they will not abolish roads and railways, will give to strategy another dimension. Armies will be able to move as organized units where they never moved as such before, and this increase in strategical power will radically change present-day tactics. Heretofore, great battles have generally been fought in the close vicinity of strategical avenues of approach; so much so has this been the case that it was often possible to predict where they would take place. But if these lines of approach widen in all directions, battles may take place anywhere in an extended and extensive area. The old conception of fronts may vanish altogether, fronts may be anywhere.

The type of war which faces us will be very different from the types which have faced us, because our means of fighting are changing, consequently, if the fighting troops are to pull their full weight, the engineering services of the Army must keep pace with these changes.

I will now attempt to outline what some of these changes are likely to be, and I will make use of the four factors I have mentioned, and will consider these changes from two points of view, namely, how the engineer of the future can directly assist his own side, and how he can resist enemy action.

THE PROBLEM OF INFORMATION.

The means whereby the engineer can supply information to the Army must remain surveying and map-making. Mapping has now been reduced to so fine an art that on first thoughts it may seem there is little room for improvement. This would be a correct deduction if the armies of the future were to be similarly organized to those of to-day. But this is not going to be the case, consequently what I will call "roadless" strategy and "area" tactics will demand a different type of map. To know where roads, railways and rivers run, where cities, villages, mountains and forests are situated will not be enough. All these common geographical features will be useful, but besides them must be added a host of strategical, tactical and administrative "features." For example, ground will have to be coloured to show where tanks and roadless vehicles can move at ease, can move with difficulty, and cannot move at all, so that at a glance a commander is able to see from his map how best to deploy his mechanized arms. Possible aerodromes, as well as existing ones, will also have to be marked down, as well as the direction of prevailing winds at various periods of the year; this latter information will be import-

ant should gas be employed. Petrol supply and petrol stations, repair centres, motor works, machine shops, etc., should also be shown by conventional signs, for in a rapid mechanized war these will be as important as the marking down of wells, water holes and oases in desert warfare.

In brief, the surveyor and map-maker must more and more turn from purely civil map requirements to future strategical, tactical and administrative military requirements, on the accurate knowledge of which the movement and supply of armies will depend. Here is opened up to us a completely new theory of military cartography, and its development is essentially one of the duties of the engineer. The side which possesses the best maps will strategically move the quicker, and tactically commit fewer blunders. Consequently, the better these maps are, the more will the engineer be able to assist the Army, and to the detriment of the enemy, should he be less well provided.

The Problem of Protection.

I will now turn to the problem of protection, which is an immense one, since the protection the engineer afforded in the past will, in my opinion, have to undergo a radical change. To-day, much of his protective duties fall under the headings of fortifications, demolitions and fieldworks. The first are normally used to block roads and railways, the second to delay, or prevent movement, and the third to protect the infantry and artillery arms.

Though in the future permanent fortifications will continue, since roads and railways will still possess great use, it must be remembered that, when armies can move across country, the circumvention of fortresses will be far easier than it has been in the past. In 1914, the capture of Liége was essential to German success, for though it was possible to pass infantry round the fortress, it was not possible to supply this infantry until Liége was captured, since its chain of forts blocked the main road and rail communications.

Besides permanently fortifying centres of communication, other centres will also have to be protected. A mechanized army will require what I will call "land-ports," into which it can retire and refit. On what plan should they be built? Will it be necessary to protect them against the heaviest types of guns? Will a rapidly moving invader be able to equip his army with such weapons without serious detriment to his mobility? Will not gas attack be a better weapon than gun-fire, and will not gas attack come from the air? Here are a host of questions which must be answered before efficient land-ports can be constructed.

I do not propose to answer these questions, for their answers will take years of careful thought. In brief I feel that their correct answers will be very different to existing problems of fortifications.

The present immensely strong concrete works, I imagine, will be replaced by a large number of weaker gas-proof strong points which will be so distributed over areas suitable for cross-country movement, that the greatest strategical, tactical and administrative use may be made of these areas.

Besides the defence of land-ports and centres of communication, aerodromes and industrial cities will have to be defended. A mechanized army will depend not so much on supply of man-power as on the industrial power of its country. The protection of industrial towns and areas will demand, therefore, as much attention in the future as the protection of communications has in the past. Here again are presented to us a host of complex and difficult problems in engineering.

The present theory of demolitions is to destroy. When, in 1915, the Russians retired from before the Germans, and when, in 1917, the Germans on the Western Front retired to the Hindenburg lines, the country abandoned was converted into a desert. In the future it may be sometimes necessary to do this, but the use of persistent chemicals will enable whole cities and areas to be rendered uninhabitable and uncrossable for days if not weeks at a time, without destroying anything. Such inundations should, I think, be the work of the engineers, and engineers must be equally capable of rapidly clearing inundated ground so that our own troops can cross it.

A point which should be considered is the relationship between new means of mobility and our present theory of demolitions. For example, the existing idea may be illustrated as follows: If Belgium were to prepare the area east of Liége for demolition, should the Germans once again attempt to occupy the Liége gap, will these demolitions prevent them from doing so? Is such a protective scheme feasible in the future? I do not think it is, because no country will demolish its own property until the last moment, and when faced by a mechanized adversary who can move at extreme rapidity the chances are that, unless demolitions are carried out before war is declared, there will not be time to do this work once it has been, and any partial destruction is unlikely to be an impediment to cross-country machines.

Demolitions of this nature will, I think, be replaced by gas inundations, and an elaborate protection of river lines, by anti-tank defences, and by land and water minefields; for there is every probability in the future of certain types of tanks being able to cross water. Here again are a number of new and interesting problems.

I will now turn to the third point I mentioned, namely, field defences. To-day, our theory of field defences is mainly based on leg-power—on infantry and gun tactics. Infantry and guns fight in lines, they have definitely a front, two flanks and a rear, and the front,

as long as it remains intact or unturned, protects the rear. In the future, as I have pointed out, fronts may be anywhere, therefore field defences may be required anywhere. It cannot be expected that an army will be able to grid a whole area with trenches. In mechanical warfare time will be totally insufficient for this; besides, tanks can cross all but very wide trenches, and aircraft can fly over them. Some new system must therefore be devised.

Our present theory of field defences is based on the static theory of digging; in future this theory must be rendered mobile. There will be little or no time to dig, for fronts may be anywhere. The solution of this problem lies, I think, in the land-mine. In the past, wire entanglements have restricted the mobility of infantry, in the future, the land-mine may well restrict the mobility of the tank. Arrangements will have to be worked out which will enable the engineer rapidly to lay mines, take them up, and move them from front to front. In this lies a whole new theory of field fortification. Will these mines be laid in lines or set out in groups? I think the group system will prevail. In place of the block-houses we made such use of in the South African War, will be established anti-tank strong points—guns protected by a "wall" or "moat" of mines, and between them will be held in readiness our mechanized counter-attacking forces.

Problems of Offensive Power.

The offensive powers of the engineer are obviously closely connected with his protective powers. In the past, his main offensive duties have been: to carry out siege work, to lead the assault of a fortress, and to carry out mining. These duties will still hold good, but in changed forms.

Lines of circumvallation, and all the elaborate earth works and underground mining of the past are, I think, things of the past; in any case they are likely to form the exception and not the rule. Heavy artillery may still be used, but that its object will be to pound to pieces great concrete works is in my mind doubtful. The true tactical object in a siege is to protect or destroy *the garrison*, and not necessarily the fortifications. It would appear, therefore, that gas attack will often replace high-explosive attack, and mining will rarely be necessary, but that minefields, to restrict sorties from a besieged fortress, will frequently be used.

In besieging a fortified industrial centre, the true object is surely to capture it *with the least possible destruction*, so that when it is occupied use may be made of its resources and machinery.

In the sieges of the future is opened up to us an all but entirely new problem, based on the theory of gaining something which will be of

use to ourselves, and not on that of merely denying its use to the enemy. Here is a multitude of problems for the engineer to think out.

PROBLEMS OF MOVEMENT.

At the beginning of this paper I stated that mechanization is mainly a problem of movement. Consequently anything which the Royal Engineer can do to facilitate the movement of the other arms, and restrict the power of movement of the enemy, is of the utmost importance. In the past, railway construction, road making and repair, and the building of bridges, have been essentially the work of the engineers, and they will remain so. Whilst railways and roads will become less important, bridges will become more important, for, except for mountains, water obstacles are the most formidable which confront a mechanized army.

The rapid clearance of ground for aircraft landing is another problem of mobility, and there are many others of a similar nature which I must leave to the reader to think out for himself. There is, however, one problem, and probably the most important one of all, which I will now examine, namely, the problem of repair.

A mechanical army is one which must depend for its mobility on the efficiency of its machines. Efficiency demands maintenance and repair. Maintenance is the duty of the fighting troops, but repair is beyond their powers.

Before the war the question of repair was comparatively a simple one. The medical service repaired the men; the veterinary service the horses; the transport service the vehicles, and the ordnance service the weapons. Mechanization is now influencing all arms, for all types of soldiers are beginning to be transported. It seems to me, therefore, that in the near future we shall have to establish a Corps of men whose duty it is to repair the "new engines," and I am of opinion that the Royal Engineers are the Corps which should do this work. We do not want new Corps, we have already got too many, and every additional one introduces complication. What we now want to think out is the redistribution of work, and it appears to me that the work of repairing machines is essentially the duty of the engineer. In any case this suggestion brings us back to the original idea of the engineer, namely, a man who deals with engines, and not necessarily with the spade, or with the mason's trowel.

I do not intend to elaborate this suggestion, as I am far from certain in my own mind how it can most effectively be carried out, but I cannot help feeling that it is a sound one; consequently, that the main duties of the Royal Engineers in the future will be divided into three categories, namely—(i) survey, (ii) tactical protective and offensive assistance to the other arms, and (iii) the repair of warlike machines other than actual weapons, such as guns, rifles, etc.

Conclusion.

I have now placed before the reader a certain number of ideas; some may be sound and others the reverse, but, so I think, all are worthy of examination because the Army is to-day entering a period of transition. Mechanized warfare faces us, whether we like it or not, and as certainly as it faced horse transport from the opening of the present century until this day. Mechanized warfare means rapid movement in all directions over a plain and unbroken surface, and it must be obvious to all that if we can restrict our enemy's power to move, as well as enhance our own, the advantage will be ours. To do so we must discover and develop a new system of fortifications, and unless we do so others will, for as night follows day so do static periods follow mobile periods in tactics. In fact, the one begets the other of necessity. If this contention is accepted—and I fail to see how it can be refuted—the military engineer is faced by a host of new and difficult problems, on the solution of which will depend the economical use of mobility itself.

To examine these problems thoroughly two categories of knowledge are required—sound general knowledge, and accurate special knowledge. No man can possibly be efficient as an engineer unless he knows all about engineering, as well as a good deal about the work of the other arms. Assistance does not lie in doing other people's work, but in doing something which will enable others to do their own particular work more perfectly.

There is no mystery about engineering, save to those who are ignorant of what it entails, and assistance to the other arms is not to be sought in encouraging fools. If Sappers make their work a mystery, they will only encourage others to become mysterious out of self-preservation, and eventually the army will become a box of tricks—as it is, I am afraid, very much so to-day. And the result in war will be that we shall surprise ourselves in place of surprising the enemy.

HEAVY EARTHWORK, USING DIGGERS OR STEAM NAVVIES.

By MAJOR I. SIMSON, R.E.

INTRODUCTION.

(1) The art of earthwork, better known to officer, N.C.O. and man as "muck shifting," is one that sooner or later has usually and in varying degree to be undertaken by the R.E. officer on active service. In peace time, whenever any large excavation is required the contract is usually placed outside to a civilian firm well versed in the art of removing a mountain and depositing it elsewhere in another shape. In these circumstances for the R.E. officer the question becomes mainly one of finance in peace time, or of watching and hurrying up the contractor to see that various stages of the work are completed to schedule time. The contractor as a rule has to worry out his own salvation, with the result that the R.E. officer, not being directly responsible for solving the many organization, technical and transport problems that arise, seldom gets really first-hand experience of this subject. In many cases this experience may have to be bought later on active service, while the army perhaps waits for the completion of a railway or road longer than it otherwise need.

RELATIVE IMPORTANCE OF EARTHWORK IN WORKS.

(2) The following figures for labour only on railways are illuminating as to the relative importance of earthwork, and show the percentage of the total job for railway construction in *average country*. In difficult country the importance of earthwork (and bridges) rises enormously. The Table shows also the reduction in earthwork and bridging in war, as compared to peace.

Detail. (4' 8½" gauge railways.)	Railway construction by British Troops in France, 1914/18	Railway construction in peace time in America before 1914.
	Based on time. (Men-days.)	Based on cost. (Dollars.)
	Labour only.	
1. Survey and drawing office ...	About 5%	5% to 10%
2. Earthwork and culverts ...	40% to 60%	55% to 65%
3. Bridges	About 10%	About 15%
4. Linking	15% to 20%	5% to 15%
5. Ballasting, lifting, packing ...	15% to 20%	5% to 15%
Total	100%	100%

Corresponding figures for road construction are not known to the writer, but such figures would probably show that earthwork is again the predominating factor.

(3) The above figures clearly show that, whereas speed in minor bridging or linking (*i.e.*, actual laying of rails and sleepers) may save days on railway construction, and can easily be seen and appreciated by the "average man," real care and attention to detail on earthwork may save weeks—and yet the saving is by no means so obvious to the "average man" or even to many a trained engineer. Confirmation can be had in peace time by the fact that the most successful civil engineering firms are those that are able to deal expeditiously with large volumes of earth, as in the construction of dry docks, railways or arterial roads. Moreover, contracts for the earthwork portion of such works are now frequently sublet to firms who make a speciality of this work and do nothing else.

(4) It may be noted here also that the above Table brings out another very important point, viz., that, as one of the primary objects of survey is to reduce earthwork, a very little extra time in men-days spent on a full and proper survey and examination of a project reaps a really golden harvest in cutting down earthwork time later. Although this fact is generally realized, it is frequently overlooked in the hurry-scurry of active service, when working parties are sometimes thrown a little prematurely at the head of the R.E. officer.

Definition.

(5) All earthwork can be divided into three subheads:—

(*a*) "Getting," *i.e.*, digging and loading into some kind of vehicle ready for transport, *e.g.*, a basket, wheelbarrow, G.S. wagon, railway wagon, etc.

(*b*) "Carrying," *i.e.*, transporting it to the site ready for off-loading. The "carry" varies from a few feet for a single throw from a shovel, to several miles which is common in railway or arterial road work.

(*c*) "Off-loading" to waste or to form an embankment, station platform, etc.

In this note, "heavy" earthwork is understood to mean the process of "getting" earth by means of machinery to supplant the large numbers of men, otherwise necessary to obtain the same output. The machinery employed consists of drag-line excavators, grabs, and diggers or navvies. Of these the machine most likely to be employed on active service is the "digger" for road and railway work through hilly country. The following remarks are based entirely on the digger,

but apply to other machines also in principle. Carrying and off-loading are not considered except in so far as they have an effect on "getting."

DIGGERS.

(6) Diggers are now on the market ranging from about a ¾-yard bucket (or even smaller) up to a 4-yard bucket. The former is a No. 6 size machine, the latter a No. 30 machine, this number representing the bale pull in tons. If mounted on rails the corresponding *working* gauge varies from about 6½ feet to 12 feet. When mounted on rails and driven by steam or oil-engines, these machines weigh from 17 to 120 tons respectively. For active service, machines on rails are unsuitable owing to the continuous delay in laying, slewing, and pulling up track built with heavy rails and long crossing timbers. If mounted on road wheels, similar objections exist because a roadway of sleepers or timbers is essential. The same-size machine, mounted on caterpillar tracks is slightly heavier, but far more mobile and adaptable, and the majority of makers now fit such tracks. For stability the gauge of all three types is roughly the same. Caterpillar tracks enable the machine to move short distances from job to job without dismantling or building a special railway track or roadway; and at once cut out the large number of men otherwise essential for digger track construction and maintenance, which is a heavy and continuous item. For service purposes caterpillar tracks are ideal and, in fact, essential.

With regard to stability, when on the move, most machines are capable of travelling up or down or at right angles to gradients of about 1 in 6. This limiting gradient can always be obtained from the makers. When digging, if the bucket teeth strike an obstruction, the engine is usually designed to stall before the machine pulls itself over.

OUTPUT OF DIGGERS.

(7) Assuming no serious delays for trucks, coal or water and in easy soil, the capacity of a digger in charge of a good driver is really remarkable; and on this basis a No. 6 digger (¾-yard bucket), manned by one shift of 4 men in all, can comfortably load about 400 cub. yards in 8 hours, working in a 5 ft. deep trench, 22 ft. wide. A No. 20 digger (2¾-yard bucket) on railway track in France was once loading between 2,000 and 2,500 tons of mine-earth or ballast (*terre de fosse*) from a 30 ft. face, during 9 hours of darkness, with screened lights and occasional interruption from enemy shelling. All such figures are, however, valueless without detailed conditions being known, the limiting factors being, in practice, seldom the digger itself, but the supply of wagons, coal and water. Big output depends literally and entirely on a solution of these three problems.

Man-Power Equivalents and Principles of Operation.

(8) The best size of all-round machine for excavating railway or road cuttings on service is probably a No. 6 or No. 10 digger on caterpillars. Any larger machine will seldom attain a larger output under the conditions involved in driving railway or road cuttings, because of the difficulties of wagon supply. It will be seen that a No. 20 digger ($2\frac{3}{4}$-yard bucket) as regards output can be considered the equivalent of, say, 300 tireless men working *at one point*. This congestion increases the difficulty of truck supply. A proper appreciation of man-power equivalent of the machine is essential by all officers, N.C.O.s *and men* concerned because the basic principle of any heavy earthwork job is to keep the digger itself working hard and continuously at all costs. To get maximum output, practically everything wants subordinating to the digger, as regards the supply of locomotives and trucks, water and fuel, and the operating and off-loading arrangements elsewhere. Further down the line the loss of time is obvious if, say, 60 men are kept waiting 20 minutes because the train they are to off-load is late. But it is seldom realized that this loss is less serious than the digger being delayed five minutes by possibly one dilatory man, such as a shunter. Moreover, the 60 men can usually be switched on to other work temporarily, whereas the digger can do nothing without trucks to fill.

On this basic principle of keeping the digger at work continuously, the lay-out of the "getting" end and the whole organization for getting, carrying, and off-loading must be built up so that every link in this chain is as strong as the first link—the digger—in order to reach and *maintain* maximum output.

Deep-Cut Method of Cutting.

(9) There are two main methods of driving a road or railway cutting:—(*a*) the deep-cut method, (*b*) the layer method. In the former the digger works through at the final formation level and grade, filling trucks *behind* it, and these trucks can only be hauled out *to the rear* to make up banks. The system is illustrated in Fig. 3. It is clear that trucks cannot easily be sent forward to make up embankments in front of where the digger is working. For service purposes this method will thus seldom be used. The digger, moreover, usually requires following up with three tracks. After two trucks on each outer track have been filled, shunting must be done because the digger cannot reach the third truck. The centre track is usually kept for coal and water wagons and for shunting. A serious disadvantage is that all three tracks require extension by special short rails every few hours, so that track-laying is continuous, and the length of shunt increases as the digger eats into the hillside away from the turnouts. In shallow cuttings the addition of track is continuous, and it may be difficult to keep up with the advancing digger.

Layer Method of Cutting.

(10) The layer method is usually of greater adaptability for active service. It consists essentially in driving a series of shallow cuttings through the hill until the full depth is finally reached. These shallow cuttings *run parallel to the final formation grade*; and their depth and width depends on the digger and rolling stock dimensions. The digger loads into trucks on a track running the full length of the cutting site and *above* the level at which the digger is working. This track is temporary; built to construction grades of 1 in 15 or so to start with, so that in ordinary country a rough railway line can be built along the final route to embankments ahead (as well as in rear) of the digger; and this track is relaid to a lower level through the cutting itself as the digger starts on a new and deeper "slice" through the hill. Track-laying is thus occasional (instead of continuous, as in deep-cut method), but involves a considerable length whenever a slice is completed. While the track is being relaid to a new level, the digger can be washed out and have minor repairs done. The digger must move back into position for the new slice before it is immobilized, and before new track is laid on the level just completed. An example of a cutting driven on the layer method is given in detail later, and is illustrated in Fig. 4.

Digger Limiting Dimensions.

(11) In Fig. 1 the depth (D) of each "slice" clearly cannot be greater than the clearance (K) between digger floor level and open bucket door at maximum height and reach, less the height (H) of highest railway wagon to be used, and track on which standing.

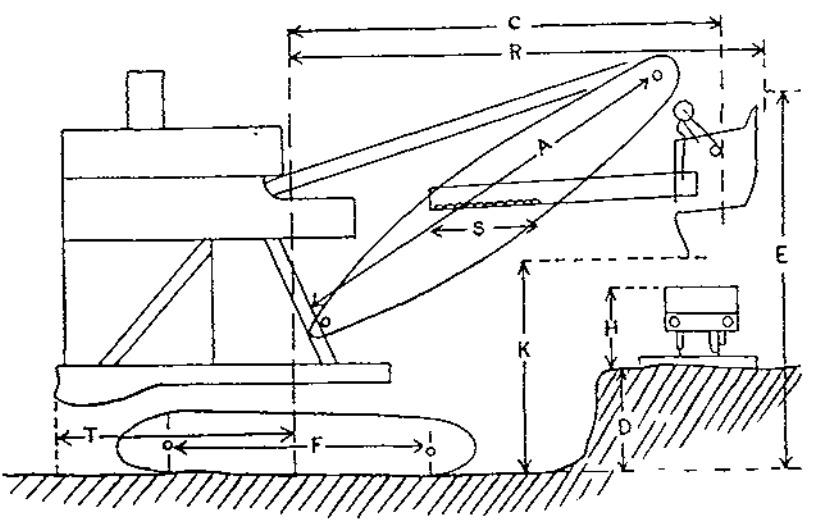


Fig. 1.

Owing to uneven floor and railway track, in practice the driver must have a safety margin of about 1 foot between open bucket door at maximum height and top of truck, or his speed will drop seriously in order to avoid overwinding the bucket. Therefore :—

$$K=D+H+1 \text{ (all in feet).}$$

K is easily determined and is laid down by maker for each size of digger. Fig. 2 gives the leading dimensions of standard digger as made by one of several English manufacturers.

From Fig. 1 also it will be realized that in the deep-cut method there is a limit to the height of face on which any digger can safely work. The dimension E (*see* Fig. 1) is a fixed one, and if the height of face exceeds about $1\frac{1}{2} \times E$, there is a risk in certain soils of the digger burrowing under and then getting damaged by the fall of considerable volumes of earth. If there is any risk of this, that portion of face which tends to get undercut must be brought down, from time to time, by other means.

Layer Method Example.

(12) The scheme of work prior to starting excavation deserves careful thought, in order to save time by reducing the number of track, digger and water supply changes. The whole layer system is well exemplified in Fig. 4, which illustrates a 60,000 cu. yard cutting driven by a No. 6 Ruston digger at the Railway Training Centre, R.E., Longmoor Camp. In this case K is 12 ft. 9 in. (*see* Fig. 2), and with the particular rolling stock used economical depth of slice (D) was 5 feet. This example deserves careful examination in detail. The limits of each cut at each level require pegging out on the ground in plan, and the provision of level pegs during each slice is also a point requiring attention and frequent checking.

In this particular cutting sand, easy clayey sand, and veins of hard sandstone were met in turn. The sandstone dropped output to 200/300 yards per day, but previously 400 cub. yards per 8-hour day was maintained comfortably in wet weather under reasonably good conditions of water, coal and wagon supply, which were carefully worked out. The " carry " was up to $1\frac{1}{4}$ miles in one direction and $5\frac{1}{2}$ miles in the other direction, out of the cutting. Two locomotives were required continuously ; one with a single crew, the other with a double shift, enabling this locomotive to work before and after the digger had ceased work. A learner driver worked the digger during the dinner-hour of the regular driver, the machine thus working continuously for 8 hours. To avoid delays locomotives were watered at different times. The trains should be as long as the locomotive can handle loaded. This reduces the number of train movements for a given volume of earth moved. The weight of train depends on gradients—and the strength of off-loading parties, who must deal

with trains expeditiously. In the particular case under review there were at first three trains each of ten 10-ton wagons. These were found to be insufficient if there was the slightest delay in the working of trains.

Later on, when the second or learner driver had become more skilled, when four trains each of ten 10-ton wagons had been put into service, and all lost time due to coal and water had been eliminated (*see* para. 14), when every man in the 6½-mile chain had realized his own importance in the sequence of events, the output reached 500/550 cub. yards (700/800 tons) per 8-hour day—in spite of bad weather. In the circumstances this can be taken as the maximum rate for a No. 6 digger, because the machine was working fast and continuously.

The steady progress in output (as all ranks became experienced and combined to eliminate delays) is clearly shown in the following Table :—

Period.	Average output per 8-hour working day.	Remarks.
First week	30 trucks	30 trucks used. Coaling and watering direct from truck.
Second week	40 ,,	
Third week	51 ,,	
Fourth week	62 ,,	40 trucks used. Coaling from dump. Watering by gravity pipe line.
Fifth and subsequent weeks	70 to 78 trucks	

The trucks were 10-ton capacity ; which equals about 7 cub. yards. On the average it required 12 bucketfuls to fill one truck.

LABOUR.

(13) The labour engaged in producing the above result was :—

	Men.	
	Skilled.	*Unskilled.*
1. Digger crew (driving, firing, coaling, trimming and watering by gravity). Continuous work throughout 8-hour day	4	1
2. Three train crews, each of driver, fireman and shunter (2 locomotives, 1 working double shift)	9	—
3. Front off-loading gang, 1 mile ahead of digger, including lifting and packing on banks extending over ½-mile	—	15
4. Track maintenance party for 1 mile of temporary track in front of digger	15	—

		Men.	
		Skilled.	*Unskilled.*
5.	Railhead party, inserting culverts, extending track, building passing-loops, etc.	18	10
6.	Rear off-loading gang, 5½ miles in rear of digger, including lifting and packing on bank ¼ mile long	—	40
7	Rear track construction and maintenance party for ¼ mile bank under construction	12	—
	Total	58	66
	Grand Total ..	124	

Average output per man per 8-hour day was thus 4½ cub. yards (nearly 6 1/3rd tons), including getting, carrying 5½ miles, new track construction and maintenance, placing in embankment, and lifting and packing as work progressed.

The above excludes a few men engaged on lighting up locomotives, maintaining locomotives, digger and rolling stock, and on maintaining and operating the 5½ miles of old main line behind the digger, over which earth-trains were running.

Photographs of the works described in the layer method example are shown at Figs. 5, 6 and 7.

Coal and Water.

(14) Diggers on service will almost certainly be driven by oil or steam, and not electrically. Steam involves frequent coaling and watering. The amount of coal and water usually carried by the digger itself is sufficient only for about 1½ hours' work. If water and coal is taken each time direct from a railway wagon (which is frequently done) much time is lost per day in shunting up the appropriate trucks; and it pays handsomely to arrange that these wagons come up only once a day if possible. With coal this is easy. Boxes and baskets can be filled prior to digger starting work, and kept as an easily-moved dump near the digger itself. Water-tanks can be similarly sited and the digger-tank replenished therefrom by hand-pump. These tanks can be filled from a tank-wagon once a day prior to digger starting work; and moved forward when empty at night prior to refilling. A better scheme can sometimes be arranged by siting a tender or large water-truck on a temporary spur at the summit of the cutting and leading thence a pipe-line coupled permanently to the digger. If the last 50 ft. or so are flexible, the digger pulls this along as it moves forward; and the digger-tank is replenished by

FIG. 2.—DIGGER LIMITING DIMENSIONS (APPROX.).

THE DIMENSIONS REFERRED TO ARE SHOWN IN FIG. 1.

Size of machine.	Centres of jib. A (ft.)	Maximum centres discharge C (ft.)	Stroke of bucket S (ft.)	Wheel base F (ft.)	Working gauge (ft.)	Tail radius T (ft.)	Height open bucket door K (ft.)	Maxim. horizontal reach R (ft.)	Maxim. vertical reach E (ft.)	Bucket capacity cu. yards	Net weight (empty) on rail wheels (Steam driven) tons.
No. 6 Digger	20	22	6½	7	6½	9½	12¾	24	18¾	¾	17
No. 10 ,,	24	28	8	8½	7¾	11½	17½	31½	26	1½	32½
No. 15 ,,	28	29	10	8¾	8½	13½	17	32½	27	2½	42
No. 20 ,,	31	32	12	10	9½	15	19	36	29	2¾ or 3½	56
No. 30 ,,	36	38	12½	12	12	21	20	43	32½	4	120

Note.—Longer jibs and longer racking-arms can be fitted with corresponding reduction of bucket-capacity, in each size of machine.

gravity by opening a stop-cock at the lower (or digger) end whenever necessary. This arrangement was adopted in the example quoted in previous paragraphs.

Railway Gauge Problems.

(15) As explained earlier, the fundamental problem is to keep the digger supplied continuously with empty trucks actually at the digger itself. This raises questions of principle. A small digger with ¾-yard bucket with a good driver in average soil can easily take three mouthfuls per minute, *i.e.*, it can load, say, 2½ cub. yards per minute. The larger the digger the slower its cycle; but the actual number of cub. yards loaded per minute increases because the bucket size is larger. From this it can be seen at once that the unit for "carry" should be as large as possible—otherwise a very large number of wagons are required with corresponding traffic congestion. On road work one frequently sees the 60 cm. railway and tip-truck used with a digger, because a standard-gauge railway is perhaps not worth building to the site. One bucketful of even a small digger fills one 60 cm. gauge tip truck. The number of tip-trucks required to get full value out of the digger can therefore never be provided in practice; in fact, if they were, traffic congestion would soon bring matters to a standstill. In every case of works which have been visited, where the 60 cm. trucks have been used, the digger has been standing idle (waiting for trucks) for half its time in steam. The remedy is obvious. Wherever possible, build a standard-gauge railway (of the gauge already in the country) and use the highest-capacity trucks available, but of a type suitable for rapid off-loading.

Track Problems.

(16) The track used for heavy earthworks is largely on banks which are continually settling. The track is usually unballasted and temporary, *i.e.*, built with sleepers and rails which have to be respiked repeatedly as the track is moved forward (deep-cut method) or lower down (layer method). On service, locomotives heavier than the usual light contractors' engine will invariably have to be used, and the loss of time and disorganization due to even minor derailments necessitates a strong permanent-way maintenance party of, say, 10 to 12 men per mile. Periodically this party requires strengthening from off-loading gangs when relaying track to a lower level takes place in the cutting itself.

Near any large cutting it is imperative to have at least one temporary service-loop—preferably one at each end of the cutting. A service-loop near a big embankment is also essential if delays are to

be avoided. These loops need only be just long enough to pass the maximum earth-train length, including engine or tractor, and brake-vans if any.

RAILWAY OPERATING STAFF.

(17) Each locomotive should have with it a staff of one engine-driver, one fireman and at least one shunter. Two shunters are preferable for standard-gauge trains, owing to the length and necessity of pinning down or unpinning each wagon-brake when negotiating severe construction gradients. Owing to the low speeds on tracks under construction, ground staff of all sorts (*e.g.*, blockmen, flagmen, etc.) can as a rule be dispensed with, and trains work "at sight" between the various passing service-loops. This may cause loss of time, however, if distance between passing-loops exceeds, say, 1½ miles. Time spent on temporary passing-loops is usually time saved in the case of big works.

ORGANIZATION OF DIGGER PERSONNEL.

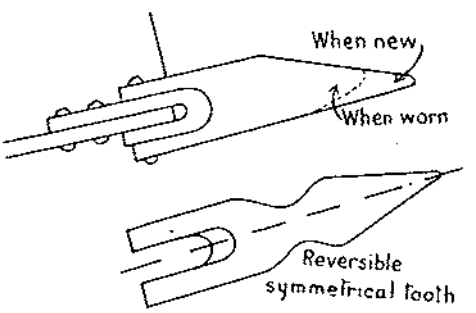
(18) The digger crew consists essentially of one driver, one fireman, and at least one man on the ground. For maximum and continuous work throughout the day one other relief driver, and a fifth man, can be employed on trimming the ground, coaling (by basket) and on water duties. One driver should definitely be in charge and responsible for oiling and maintaining the machine. The digger should not as a rule cease work during the meal or rest time of any of the men, providing empty trucks continue to arrive. It is advisable, however, to lay up the digger one day per week for minor maintenance, examination and cleaning of wire ropes, pulley blocks, caterpillar tracks, etc. As regards mechanical failures, prevention is better than cure. Digger-driving is hard and exacting work when working at top pressure. In bad weather the driver is exposed, and there is always a strong tendency to overwork a good man, particularly when output drops. This must be resisted, and output can frequently be raised by looking elsewhere than at the digger itself.

An officer or experienced N.C.O. should be within range of the digger throughout, and will be responsible for arranging reliefs, coaling, watering, and shunting movements well in advance. He is in effect the Officer Commanding a company of 300 men, in the case of a large digger, concentrated at one point, the bucket of the digger. His duty is to see that his "300 men" work continuously without delay from any cause whatsoever. A really good man in charge at this point has invariably an incredible effect on the output. It will be appreciated that the actual driver is far too busy to attend to all these complementary details.

Other Points of Importance.

(19) A digger is not a tool of great precision. It is waste of time to make the driver dig to nearer than say six inches in level, and final trimming to formation level on the final cut should be by hand. Side slopes should be trimmed down as each layer is carried through. Otherwise in a deep cutting considerable volumes are left " high and dry," so to speak, and may involve several throws by hand later before this soil can reach a wagon. If a digger digs the formation out too deep this can always be filled in. If, however, it gouges out a hole in the side slope this should never be filled in, as the filling will always wash into the cutting in wet weather.

(20) The layer or slice taken by a digger at each level should be made self-draining in wet weather by always making the digger advance *uphill.* This should always be possible to arrange on the layer system—except possibly for the first slice, which is the least important from a drainage point of view—because roads or railways in cutting are invariably on a gradient. On the " deep-cut " method drainage may become a serious problem if the advance is downhill—another disadvantage of this method of working.



(21) Another point of importance is to keep the bucket-teeth sharp. When new, they are generally to the shape shown in sketch. When worn, the teeth will not lead the bucket into the face of the cutting, and it is difficult to get a full bucketful at one " bite." The loss of efficiency is most marked in hard soils. The teeth can then be ground or reversed, if reversible teeth are fitted. The latter is preferable, as being quicker, and it avoids changing the shank. Normally four teeth are fitted to a bucket irrespective of size of bucket.

Teeth are made of manganese or carbon steels, depending on the soil. Soil which causes heavy wear on manganese steel will not be so

destructive to carbon steel. The latter is usually better in sandy soils, but the wear is very uncertain, and it is not easy to foretell which material will wear the better.

OFF-LOADING.

(22) The organization and strength of off-loading parties depend so much on the method of forming the bank, type of truck and time available for off-loading, that it is only possible to state that the number normally varies from 2 to 4 men per 10-ton truck. There is usually a shortage of trucks. Therefore, the moment a train arrives, gangs should start off-loading and stop lifting, packing, slewing, spreading or whatever else they may have been doing. All this can continue after the train has been sent back empty. Meal-times should also be arranged between trains. Four unskilled men should empty a 10-ton drop-side truck in about 25 minutes, off-loading both sides.

In off-loading, it is important to tackle the job on as broad a front and *as evenly as possible*. If, in the early stages, an embankment is formed with local " pockets " or places where there is a shortage of earth, sooner or later trains have to be broken up and trucks placed opposite these pockets for off-loading. This means delay, possibly involving a shortage of empty trucks later at the digger.

For similar reasons when loading trucks the digger should take out the excavation evenly and fully, before moving forward in a cutting.

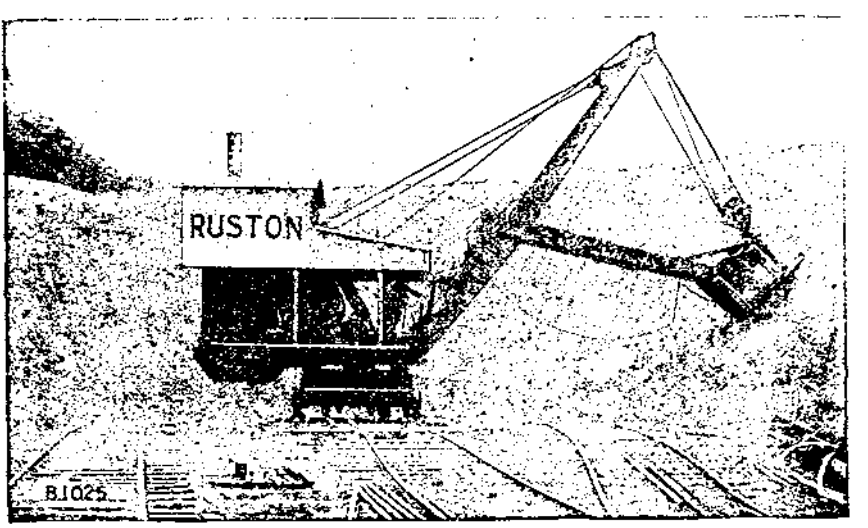
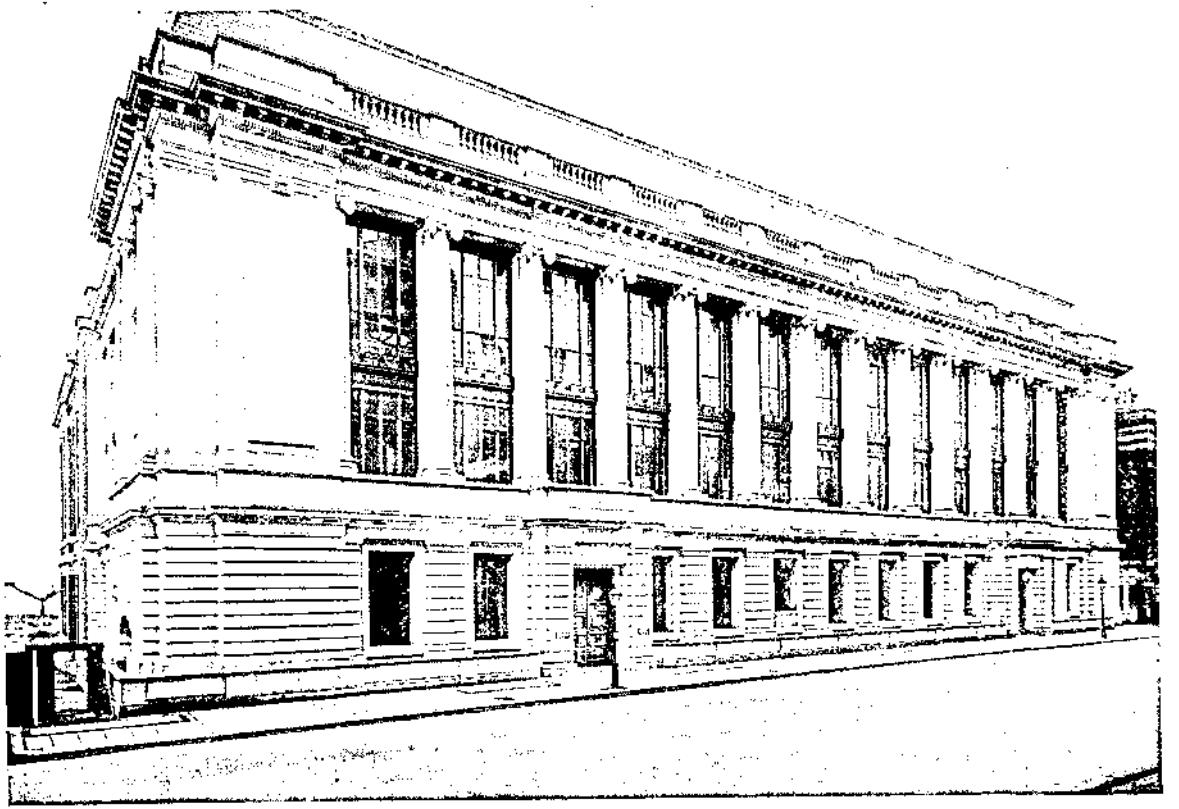


FIG. 3.—Ready for track laying.

THE NEW SCIENCE MUSEUM BUILDING AT SOUTH KENSINGTON.



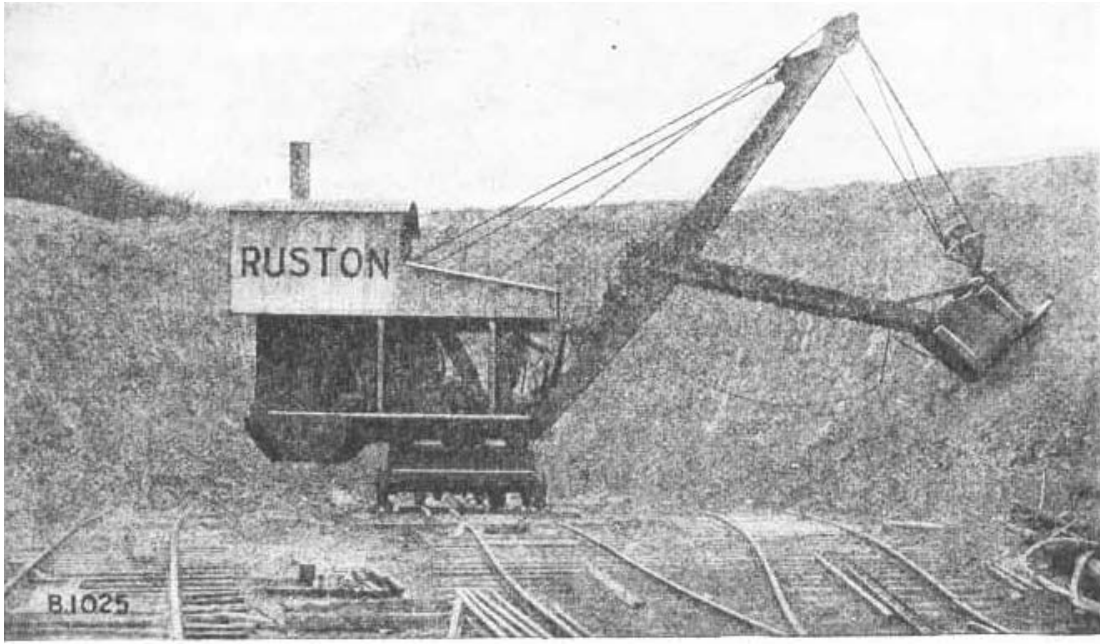


FIG. 3.—Ready for track laying.

Excavator

FIG. 4. The layer method of working No. 15 size Digger. In this instance two loading-trucks are available. This reduces losses due to shunting, but will seldom be feasible for narrow cuttings driven on active service.

FIG. 5.—Boiler washout and minor repairs. Where the track disappears, it dips suddenly at 1 in 20 to reach the embankment shown in Fig. 6.

Heavy Earthwork

FIG. 6.—The embankment at S. end of cutting in process of construction.

FIG. 7.—Looking towards Liss, track falling at 1·5 per cent. (1 in 66).
Trimming of side slope completed for half the length of cutting, spoil to be loaded by digger on cutting the next layer. The track shown is 10 feet (2 layers) above the final formation level. The pipe for digger water supply can be seen behind the officers. High-level track for tender supplying water is on the left and above camera level.

Digger-Drivers.

(23) It remains to state that really good digger-drivers can be recruited from the ranks of any steam-engine drivers and firemen, but they are not produced in a day. Speed takes time to acquire, and should not be forced upon men. With inexperienced drivers (and they will mostly be that on mobilization) *safety* is the first consideration—otherwise they are apt to cause an accident and put the equivalent of " 300 men or more " into hospital at one fell swoop. The heavy repairs may take days or even weeks, and the result on the work as a whole may well be disastrous. Safety first, therefore, and speed will develop naturally and very quickly. As might be expected, the younger men pick up the art quickest, and many of the older and more experienced drivers of other more staid types of steam-engine (*e.g.*, locomotives) seem incapable of ever mastering the bucking, swaying digger.

Conclusion.

(24) All engineering work as a rule can show the value of co-ordinated effort, but none more truly so than a constructional job involving heavy earthwork. Graphical charts of output at the cuttings and input at the embankments should always be kept, and carefully watched. Once any figure which proves to be a maximum up to date has been reached at any point, an effort should be made to hold it regularly, and with certainty, by checking over details and timings over the whole job. The reason why the maximum was not reached before may then perhaps be found to be a link several miles away which was not always giving its best.

Figs. 3 and 4 in this note are reproduced by kind permission of Messrs. Ruston & Hornsby, Lincoln.

THE FUNCTION OF THE MILITARY ENGINEER IN THE ARMY OF TO-DAY.

"PAS DE CULTE SANS MYSTÈRE?"

(Reprinted from *The Army Quarterly*.)

THERE is a very distinct feeling abroad to-day that all those who deal in any particular branch of science take especial pains to surround their profession with mystery. Whilst it may be possible to afford the luxury of this atmosphere in civil life, such a practice, by any arm or branch of the Army, is at once fatal to the attainment of that high degree of co-operation which is demanded to-day, more than ever before, if the various arms employed are to attain success in battle.

And therefore, whilst a layman may argue that the military engineer is beyond his comprehension both as regards method and mentality, it can be said from bitter experience that no one can suffer more from being misunderstood and misapplied, than can the military engineer, and consequently the laity can rest assured that he does not consciously strive to extend the alleged atmosphere of mystery. *Esprit de corps* is a wonderful thing, but ignorantly and shortsightedly encouraged it may promote a state of self-sufficiency, an air of aloof mystery, resulting in a total incapacity to understand, and consequently to co-operate with, another arm. Of latter years, the function of the military engineer has become somewhat dimmed even to the engineer himself, and it is therefore not altogether unprofitable to sit down quietly now and then and consider this matter.

The Army is designed to deal with two kinds of war—a small war and a world war. In the first case, it will rely upon existing resources within the Army; in the second, it will cover and train a striking force to be raised from that portion of the nation's man-power to be allotted to the Army.

It would seem fair to say that the magnitude of the jobs to be undertaken will be greater in a world war than in a small war. It is also considered accurate to say that, whilst in a small war the existing military engineering personnel will usually be sufficient for all demands made by the Regular Army, in a world war the majority of the engineer officers will be drawn from civil life.

In a small war the greater proportion of the regular military engineer officers will be employed in an executive, as opposed to an administrative, capacity, whilst in a world war the situation is likely

to be reversed, and we shall find a larger proportion employed as administrators. They will be required to handle the civilian-recruited engineers who will be brought in to carry out executive duties.

There is no mystery about the executive side of military engineering to-day. (Probably the term " military engineering " is daily becoming more and more of a misnomer, and some such expression as " the adaptation of engineering practice to military requirements " explains the profession of the military engineer much more faithfully.) Consequently, a civilian engineer, as was proved in the years 1914–18, can soon take his place on the executive side. It is on the administrative side, however, that the necessity for military experience is required.

The military engineer should not be, and humanly cannot be, an expert in every branch of engineering, but this does not imply that there does not exist a very definite profession, having a technique peculiar to war, which it is the duty of every engineer cadet and junior officer to master in due course. But the employment of the military engineer during the early years of his service in an executive capacity is only part of his training to arrive at the finished product and therefore, in the subsequent discussion of this subject, it is not the subaltern or captain who is visualized when referring to the military engineer, but rather the holders of the higher appointments open to the profession.

One of the basic principles on which our Army is prepared in peace and operates in war is that it should rely on civilian resources to the greatest possible extent, not only for man-power, and material, but also for its technical experts. (The exceptions to this principle are the man-power, material, and technical experts peculiar to the art of war.) These latter make up the peace-time Army, in its broadest aspect, from and on whose framework the National Army is expanded in a world war.

Just as in peace we require a certain proportion of the nation's man-power in the Army for training, experiment, and as a shield under which the National Army may be trained and developed when a world war arises, so we require to possess, in peace, certain material which is peculiar to the art of war. In no less degree do we require certain professional experts included in the Army in peace, whose attainments are peculiar to war and it is amongst these that we can number the General Staff, and the military engineer—to mention only two around which this discussion will centre.* It has been hinted at the commencement of this article that the functions of the military engineer are not too commonly appreciated, and, in fact, as its title

* Care must be taken not to confuse the professional experts within the Army—the General Staff and the military engineer—with the engineering specialists of detail—the designers. The General Staff are expert soldiers ; in no less degree is the military engineer an expert at his profession as herein defined. The technical specialist is the designer who is expert in *one* only of the following—automobile engines, 6-in. guns, 15-in. guns, chassis design, armour, bridge design, etc., etc.

suggests, this article is an attempt to elucidate that very point. And so it is considered that the best starting point will be a brief examination of the influence on engineering of the art of modern warfare.

The late war was remarkable for a number of things, but one of its more outstanding features was the tremendous fillip it gave to scientific development. Recall the advances made in chemistry as evidenced by poison gas, new high explosives, smoke, and synthetic oil; in metallurgy, as demonstrated by the guns evolved, and the increased efficiency of the internal-combustion engine, with its far-reaching effect on the aeroplane, mechanical transport, tanks and the greater use of power to increase the output of the individual; in electricity, as witness the improvement of wireless telegraphy and the "arrival" of radio telephony. Whatever the branch of science considered, wonderful achievement and development was recorded, and since it was the urge of war that begat all this progress and development, it should not be a matter for surprise that the Army of to-day stands on the threshold of a new era.

Chemistry, Metallurgy and Electricity—it is hard to know in which order to place the first two—have possibly made the greatest mark on the military machine so far, but we are only at the beginning. Chemistry, poison gas—can so completely and absolutely revolutionize the military machine that the question, "Are we giving the potentialities of gas sufficient weight in our present policy?" must be left undiscussed in this article.

At the present moment, however, it is the fruits of metallurgical research which have made the deepest mark on the Army, for it is this more than anything else that has made possible the development of the internal-combustion engine. This prime mover has freed the Army for all time from the limited tractive effort of the horse. It spells to-day increased mobility, and this reacts in numerous directions to re-establish tactical manœuvre, to reduce distance, to conserve physical energy, to provide a greater degree of human comfort, and to build up morale. It also provides power—almost unlimited power—which can be transported even into the battle area, the utilization of which will increase the capacity of the individual man to do work.

Up to date, the development of the science of electricity has been mainly in the direction of improved communications. That improvement was required, before the Army attained its new mobility, will not be denied. How much greater will be the responsibility placed upon communications as a result of this new mobility, in order to ensure that the standard of co-ordination and co-operation does not decline? Even as we write comes the promise of the transmission of electrical power without the use of wires. To what use will the Army put such an achievement?

During the course of the War the journalists evolved a series of epithets—the "chemist's war" blazed forth one day; then the "gunner's war," whilst the "engineer's war" was used almost to exhaustion point. The journalists may not always be right, but there will be few who will quarrel with the broad but moderate assertion that engineering science is to-day a rapidly increasing influence on the Army.

At the moment, the greatest problem before the Army is what is popularly called "mechanization," but which is not always defined, as it should do, to mean the utilization of mechanically-produced power both to gain increased mobility and to conserve physical energy, or alternatively, to increase individual output. No one is likely to minimize the various problems which, it may reasonably be expected, will be met with in effecting this "mechanization," and the several scientific developments "pending," which are likely to materially affect the Army, can be relied upon, in no less degree, to produce a similar number of problems.

The situation is really this. The urge which the late War gave to science has placed us in possession of a number of tremendously potential developments of the science of mechanical engineering. The potentiality of these developments is so immense that we suddenly find ourselves with a huge accumulation of engineering knowledge requiring assimilation into the technique of war. Hitherto the evolution of the technique of an Army has been spread over a period of time measured in centuries. It has been so gradual as almost to escape notice. It has been measured, as it were, by the hour hand of the clock.

To-day, we are faced with something much more in the nature of a definite operation. There is so much new knowledge to be worked in—it is no longer a gradual process, we have to move with the minute hand of the clock. It can no longer be described by the term evolution—it becomes much more nearly a definite military operation of peace.

Let us now discuss the three professions which must co-operate to effect this operation of peace. We have the General Staff, and the Military Engineer, both of whom are peculiar to the Army, in peace as in war, and we have the Engineering Designer, who is invariably outside the Army, but who may spring from either a military or a civilian source.

First of all then, there is the General Staff—the professional soldier, the director, the man responsible for the policy and the framework of the Army, but who is, nevertheless, a layman in the face of engineering science. Now civilian engineering endeavour does not normally aim at producing a weapon of war. Consequently it is not to be expected that the General Staff can, as it were, go up to the counter of engineering development and pick off the shelf those inventions and

ideas which it considers it can utilize for the better prosecution of war. It must be clear to anyone that this would be a wasteful process—wasteful of money and wasteful of effort. The man who goes to the counter should be a military engineer. The military engineer has a definite and continuous duty of an operative nature in the Army. That is to say, he has to put through the current and ordinary engineering work of the Army, but he should also have this other highly important, highly skilled function—he should interpret the policy of the General Staff in terms of the engineering developments of the age. It is not the duty nor the intended function of the General Staff that they should be able to speak the language of the science of engineering. They are the high priests of the art of war, and that is a full-time job.

It will be readily conceded that the necessity for the military engineer acting in this consultative capacity has not existed for some years now. When fortification bulked largely in Army affairs, we found the military engineer definitely established and his profession was duly acknowledged. Since then there has been a hiatus, nothing has arisen on such a predominant scale to take the place of fortification. But now—overnight—mechanical engineering has appeared and the niche of the professional military engineer has suddenly become patent to all. Perhaps the day after to-morrow it may be that the military engineer may require to possess a chemical bias, just as to-day he requires to have a mechanical leaning. And thus arises the urgent necessity for a re-orientation of view and a recognition of the necessity for utilizing the technical abilities of the military engineer in the highest councils of the Army.

The military engineer should be required to appreciate and analyse the purely military requirements as enunciated by the General Staff, he should then weigh them against engineering development as it stands at the moment, he should advise the General Staff of the limitation which the current stage of development may impose on their stated requirements, and finally, having reached a compromise with the General Staff, he should be the agent to present to the particular engineering specialist a picture which his engineering knowledge tells him is feasible.

The engineering specialist is the third party in the triumvirate now under consideration, and it is essential to realize clearly his functions and his limitations. No portion of the Army subject to military law is trained with a definite view to the production of engineering specialists in those branches of military maintenance which fall under the heads of research and design, except as mentioned below. The cadre Army of peace, no less than the National Army, cannot train from amongst its officer personnel the automobile designer, the bridge designer, the metallurgist, the chemist, or the electrical designer, whose services it nevertheless requires. As far

as possible the Army adapts and utilizes civilian design and practice; over and above this, the requirements pertaining solely to warfare must be obtained by the subsidization of certain civilians, together with a number of officers drawn from all Corps and arms who display especial aptitude and are mentally fitted for this very specialized work. For example, since the gun is peculiar to war, the Army trains a limited number of artillery officers as gun designers. Too much stress therefore cannot be laid on the difference between the two professions of engineer designer, whatever the particular branch, and the military engineer. There is much ignorance on this point amongst the laity, and it is as well that it should be clearly recognized that the designer is the highest degree of specialist in one branch of engineering only, and that this is precisely the last quality required of the military engineer.

There is, however, little doubt that the misunderstanding is largely due to the fact that it has become less and less the habit of mind to look upon military engineering as a very clearly defined profession. The mechanical engineering maintenance work of the Army until 1914 consisted mainly of artillery repair and maintenance, and was cared for by a corps separate from the accepted military engineers.

The appearance of further mechanical work in the shape of mechanical transport saw a third corps undertake maintenance work of a mechanical nature. Whilst this latter development was doubtless largely done under the stress of war conditions, the fact remains that it is this splitting up of the mechanical engineering work of the Army among several corps, coupled with the absence of any co-ordination of the *control* of engineering design and research (not the actual design and research) under one military engineer, trained as such, which has created the anomalous position, greatly aggravated on the appearance of wholesale "mechanization," that to-day the professional soldier has not one professional military engineer to advise him on modern engineering development as a whole. Now it is here contended that this is the true function of the military engineer. He must be the consultant—the counterpart of the general medical practitioner—the diagnoser, the appraiser. He must speak the language both of the General Staff and of the civilian or military expert designer.

Whilst the existing organization within the War Office provides certain branches which are charged with the duty of interpreting as between the General Staff and the particular section of engineering design with which they deal, these branches are not, as an accepted rule, staffed by military engineers, although they carry out work which is essentially military engineering. Staffing these branches in this manner is bound to result in design and research being pursued along restricted channels, with consequent waste and limited results.

The staff of these branches, from the director down, should be chosen from amongst the most highly trained military engineers available for each grade, versed in all branches of engineering science, and practised in the application of their knowledge, so that they can appraise to the full the significance and possibilities of inventions and discoveries in respect of the particular duties with which they are charged. Some idea of the type of work expected of these branches may be gathered from a hypothetical consideration of tank design. The General Staff desire a weapon to combat the machine-gun and stipulate that it shall be capable of travelling 40 m.p.h. cross-country, carrying an armament of 4 machine-guns and one 3-pr. gun, and armour which is proof against 3-pr. shell. Co-ordinative work of this type is essentially the military engineer's. He, as a combatant officer, can appreciate the niceties of the purely military proposition which he is directed to solve; he knows the users' requirements and appreciates the natural obstacles met in the field. On the other hand, he knows in general terms the ratio of power to bulk of the internal-combustion engine, as well as its inherent limitations; he realizes the painfully low efficiency of the track, and consequently he can say to the General Staff, without hesitation, that to produce such a tank, until the track can be improved, is, at the moment, impossible. The low efficiency of the track, and the engine in its present stage of evolution, make the carrying of such a load of armour and armament at such a speed impossible unless a 4,000 h.p. engine is used. This will reduce the space available within the vehicle by some 200 cubic feet, and results in its being unfightable. He may say, we can give you an unarmoured vehicle to move cross-country at 20 m.p.h. with no room in which to fight four weapons, or we can give you a 3-pr proof vehicle to move 4 m.p.h., but if a balance between armour and speed and fighting ability is desired, then the tank will be ·303 inch proof and travel 15 miles per hour cross-country.

It is not for the layman to appreciate, for example, the inherent inefficiency of the track as opposed to the natural efficiency of the wheel; it is for the military engineer to point out the necessity for further research on the track before expending further money on a complete tank. The military engineer is also in the best position to report to the General Staff on such a subject as the commercial progress of the utilization of power to increase the output of the individual employed on field engineering. He will be technically able to advise that instead of doubling the number of men in a field company, the possession of a prime mover within the unit, operating the requisite tools, will enable each sapper to double his output when dealing with the multifarious requirements of fortification, demolition, and obstacles in the field.

Again, in the criticism of what may be termed erectable equipment he will play his part. It will be his responsibility to explain to the

civilian designer those general military requirements which influence bridge design. He will show that loose bolts, odd pins on chains, long lengths of vulnerable screw thread, are so much waste of time, labour, and money, if incorporated into a military structure. For the expert does not necessarily appreciate that simplicity of design, which is demanded of a structure that has to be assembled and erected by night under fire, and only the military engineer can explain this efficiently.

But there is a still wider aspect of this linking of civilian and military experts by several War Office branches which it is contended should be staffed by military engineers. The military engineer is peculiarly fitted to fill the higher rôle of co-ordinating all these branches. In such a position a military engineer is technically fitted to realize, so soon as he sees the General Staff using fighting vehicles in the forefront of the attack and in support of reconnaissance troops, that heavy assault bridges will be required, and he will be in the best position to direct the bridge designers on to this problem.

Every new device, every single application of a new weapon, has its reaction on a number of other devices, weapons, and previously existing conditions. If you produce a highly efficient anti-tank gun, you influence tank design, you may require a faster or a more highly armoured tank. If you produce a heavier tank, you need a stronger bridge. If you can successfully utilize the anti-tank mine, the calls on anti-tank gunnery are lessened. If by mechanical means your field engineers can remove woods overnight, the demands on your tanks are decreased. If by means of a more efficient mounting you can improve tank gunnery, you may require to increase the armour on your anti-tank gun or your self-propelled 18-pounder gun. The anti-tank gun may make the tank a mere death waggon, but the successful control of smoke may revivify the tank and make it a practical proposition again.

And so it is that, whilst reconciling the desire for a heavy tank with the necessity for progress in bridge design in order that a heavy, and, at the same time, quickly-erectable bridge may be available, the military engineer must also correlate the progress in these two branches with the current stage of evolution of obstacle construction, anti-tank gun development, with smoke and with gas. In order to attain the greatest all-round efficiency of the Army, the fighting machines must be evolved as a co-ordinated whole; otherwise, it is not difficult to visualize at some future date that the advanced evolution of one part of the military machine may be nullified by lack of progress on some other part, or alternatively, that one part of the machine may be advanced along a special line, and be at total variance with the most likely avenue of advancement of some other part. It is undoubtedly in this highest position of all that the technical, consultative advice of the military engineer will tend to the more

rapid production of what the Army really needs in the way of engines of war.

Not only will such co-ordination produce the New Army in the most efficient form in the shortest time, but much money will be saved. The military engineer can lay down the lines along which development can most economically proceed. Instead of building the complete experimental unit, he can show that economy lies rather in research and experiment on the weak link of that unit, until such an appreciable advance has been achieved that it is justifiable to include the improvement in the standard unit of which the Army is in possession. But make no mistake of this fact—the military engineer who can explain the military limitations which, of necessity, must be superimposed on the pure engineering design, could not himself produce the detailed design for the vehicle or the bridge or the gun, or whatever it may be. It is not his business; he is required to stand back, and get a much larger view of the situation. He does not deal in 3/16 inch here and 5 mm. there. He simply writes the specification. The foregoing merely suggests some of the functions which should belong to the military engineer, more particularly on the mechanical engineering side.

There may be some who will argue that the production of such a man as the military engineer has been described to be, is not possible —but it is only a question of degree. Just as the C.I.G.S. interprets the arms of the Army to a lay Cabinet, without himself being an expert in every arm of the service, so it is necessary to-day to have a military engineer placed in such a position that he is charged with interpreting to the General Staff the numerous specializing experts of the engineering profession in terms of the policy of that Staff. If the military engineer's training is right, there is no shadow of doubt that such men can be produced, and are, in fact, available to-day. It should be realized that this is a professional affair. The military engineer should stand apart as the co-ordinator of a number of experts in different branches of engineering, for just as the commander cannot win his battle if he is for ever shooting with the infantry or ranging with his gunners, in similar degree he cannot afford to entangle himself with his many engineering experts.

Now it has been shown that military engineering is a very definite profession, requiring very definite qualifications from its professors. For many years now much money has been invested in the education and theoretical training of one particular corps—the Corps of Royal Engineers. This training comprises the broadest possible theoretical engineering education at Cambridge University. A period of applied practical training in military material at the School of Military Engineering. A period of wide and varied practical apprenticeship with civilian mechanical and electrical manufacturers and consultants. Experience in combatant duties and co-operation with the other arms

of the Army through its Field Companies. On foreign service its officers gain experience under every conceivable climate and set of conditions as mechanical, civil, electrical, and railway engineers, and as surveyors. As a result of the possibilities offered by this unique training and experience this corps alone possesses the officers with the necessary qualifications to fulfil the functions to be required of the military engineers of the Army.

In view of the large sums invested in the Royal Engineer's education, it is not unnatural that the General Staff—the professional soldier—should require to see a very definite return for all this investment, and no one realizes better than the Corps of Royal Engineers that they are not giving all they could to the common cause—the efficiency of the Army. But unless he is invested with the responsibility, the Royal Engineer cannot produce the desired results. He is merely one of the still small voices crying in the wilderness, hoping against hope that one day he will be utilized as he should be.

It is not a piece of professional jealousy if the military engineer points out that the gunnery expert, the automobile expert, or any other expert, cannot, on those qualifications alone, fulfil the professional requirements of a military engineer. We have only to turn to recent history to see how the military engineer has fulfilled his true function in spite of lack of official recognition. It was his sound military training, coupled with his knowledge of engineering, which enabled General Sir E. Swinton (late R.E.) to appreciate the situation on the Western Front in 1914 and write a specification for an engine of war—the tank—which successfully dealt with the hidden machine gun. More recently still, it was Major Martel, R.E., who, appreciating the need for individual mobility above that possible with limited human powers, evolved the tankette, and demonstrated the way in which the internal-combustion engine might be utilized to gain increased mobility for the individual.

Recognition of military engineering as a profession may be hailed as something new; in point of fact, it is more in the nature of a revival, since it is only of recent years that the influence of engineering on warfare has once again accumulated sufficiently to be obvious to the layman.

All that the Royal Engineer asks is to be officially charged with duties which have been usurped by either non-technical corps, or by specializing experts, and he will produce the results and pay the dividend on the capital invested in his education.

It may then be asked, assuming that he is charged with the co-ordination of the experts, why should he also require to be charged with the maintenance of the machines of war? The reasons are two in number. The military engineer requires in peace all the practical experience and training that he can get. Everyone realizes the difficulty of finding practical training for the Royal Engineer economically

in peace. Why then bestow all the highly theoretical training on this one corps, and divide the practical training afforded by the maintenance of the engines of war among two other corps? The other reason is financial. If mechanical maintenance is to be carried out by the R.A.S.C. for the supply lorries, and by the R.A.O.C. for the guns and so-called mechanized vehicles, it will inevitably entail duplication and overlapping. Mechanical maintenance, whether of 4-wheelers, 6-wheelers, half-track or full-track vehicles, or of guns, can all be carried out under one roof in one mechanical engineering workshop. The materials and processes of manufacture and maintenance are in all cases the same.

In the next few years we shall undoubtedly see the Royal Engineers in possession of a great deal of mechanical plant for use by their field and army troops companies. Are they to open their own workshops for the repair of these engines, too? Are there to be three separate sets of mechanical engineering workshops in each divisional, corps, and army area?

To place the mechanical maintenance under one corps will save machine tools, buildings and power. It will economize in labour and supervision. It will economize in the number of boys' technical training schools required. Can the Army, on its present reduced Votes, afford to neglect the consummation of these far-reaching economies?

In conclusion, to summarize. It must be realized that the situation has materially changed since 1914. There exists to-day, owing to the ever-increasing importance of engineering within the military machine, a most definite niche for the military engineer as the co-ordinator of the many specialized branches of engineering. The Army has already complained that it is not receiving the benefits which it has a right to expect from the costly education of the officers of the Corps of Royal Engineers. This Corps is anxious to shoulder the responsibilities for which it has already been trained, and only asks to be definitely charged with them. These responsibilities mean —within the War Office—a co-ordination of the many engineering experts who work outside the War Office, and in the field or in the commands, responsibility for all mechanical maintenance, in addition to the responsibilities already possessed in respect of field engineering, railways and survey.

By such re-allocation of responsibility the Army will draw dividends on the capital invested in the education of the Corps of Royal Engineers; economy will be effected in expenditure, time and effort; and the General Staff will receive unbiassed engineering advice, commensurate with its needs, which is of such vital importance to-day when the foundation of a mechanized Army is being laid.

RAPID BRIDGE CONSTRUCTION IN SOUTH INDIA.

By A. LAMOND, ESQ. (LATE R.E.).

THE following article will doubtless prove of interest to members of the Institution in that the methods of construction are new, and the rate of progress in erection exceedingly rapid. Applied to modern railway extensions, involving large bridge projects, considerable saving in time is effected in actual construction, which in turn reduces the cost of new schemes and enables a return on capital expenditure to be realized very much earlier than is possible when the usual more prolonged methods of construction are adopted.

The construction of the Chord Line from Villupuram to Trichinopoly on the South Indian Railway involved the bridging of eight large rivers. Referring to the accompanying map and commencing from the north, the following rivers had to be bridged :—Ponniar, Malattar, Manimuktanadi, Vellār, Marudiyar, Nandiyar, Coleroon and Cauvery. The Gadilam River was not bridged by the same methods as these other rivers, owing to the prevalence of rock close to the bed surface.

Very careful consideration was given in the first instance to the type of bridge to be adopted, and ultimately a scheme for the supply and erection of screw-cylinder bridges, put forward by a Calcutta firm, was accepted by the South Indian Railway Co.

The beds of the rivers in general consist of a deep layer of sand overlying a stratum of clay of various degrees of hardness. The first six rivers are subject to floods only in the north-east monsoon, which covers the period from early November to the end of January. The Cauvery and Coleroon are subject to floods during the south-west as well as the north-east monsoon, as their source is up in the Western Ghats in Mysore State.

The working season, therefore, for the first six rivers was between the beginning of February and the end of October, and for the Cauvery and Coleroon between early February and the end of May. During the working season the beds of the rivers are more or less dry.

The economic span of these bridges was found to be 65 ft., and the distance apart centre to centre of piers was fixed at 65 ft. 3 in.

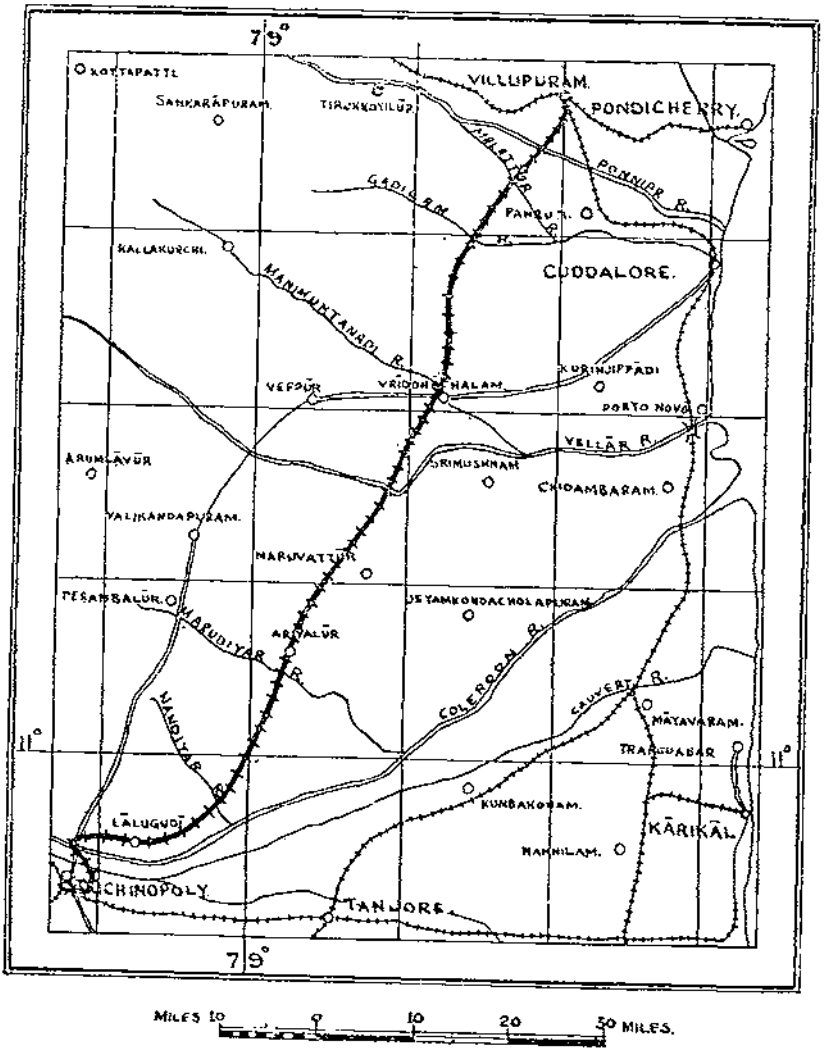
The advantages of the type of construction finally adopted are :—

(*a*) Rapidity of erection of sub-structure in founding at large depths.

(*b*) Consequent early completion of the whole work, permitting earlier opening of the line and yielding a quick return on capital expenditure.

(*c*) Any bridge can normally be completed in one working season.

It was decided to commence operations at the northern end of the line, the actual construction commencing at the end of March, 1926.



The Ponniar and Malattar bridges (28 and 12 spans) were commenced first, and, although a period of seven months only was available, these were completed before the break of the north-east monsoon at the end of October. The plant was then transferred to the southern end of the line, and the bridges over the Coleroon and Cauvery

(45 and 30 spans) were completed in the short working season of four months in 1927, *i.e.*, before the floods of the south-west monsoon came down.

This rapidity of construction was made possible by the adoption of the methods which will now be briefly described.

The sub-structure of each bridge is designed to carry a single-track broad-gauge railway, although for the present the line consists of a metre-gauge track and the girders are designed accordingly. It is possible that in the future this line may be converted to broad-gauge, which is the reason for making the sub-structure of the bridge capable of taking the increased loading when necessity arises.

Each pier or bent consists of two cast-iron cylinders, the outside diameter of which is 3 ft. The metal in the cylinders is 1 5/8th in. thick. The cylinders are placed at 9 ft. centres, and are cast in sections of 9 ft. long, each piece weighing about 2½ tons. The sections have internal flanged joints, the faces of which are machined, thus ensuring a close joint. Sixteen turned steel bolts 1¾ in. diameter connect these flanges together.

The two cylinders are braced together above bed-level by heavy bracing consisting of steel clamps fixed round the cylinder, connected at the top and bottom by channels and braced diagonally with 6 in. by 3 in. angles.

The amount of bracing used varies with the height of the cylinders above bed-level, and it will be noticed from the photographs of Ponniar and Coleroon piers that single-bay bracing was used on the former, and on the latter,* the piers of which are 13 ft. high above bed-level, a double system was adopted.

This bracing is fabricated and sent to the site in one piece, where it is drilled and fixed to the cylinder clamps by 1¾ in. dia. turned bolts.

The cylinders, which vary in depth in the river beds from 30 to 50 ft., are filled with sand. A steel cap-plate is then bolted to the upper cylinder clamp. Steel stools are then bolted on to this cap-plate, and the cross girders which carry the main girders are fixed to these stools.

The use of screw-cylinders as bridge piers has been in practice for many years, but the size of cylinder, until more recent years, had not exceeded 30 in. diameter. The limitation of the diameter of the cylinder has been due to the methods available for screwing cylinders into the river bed. The earliest bridges of screw-cylinder construction were carried out by screwing the cylinders by means of a wooden capstan with projecting radial arms, which were manhandled. Later, oxen were harnessed to the radial arms of the capstan and walked round on a suitable floating raft. Still later, these methods were superseded by the capstan being turned by means of an endless rope from a winch. These methods, however, have proved clumsy and

* Not reproduced.—ED.

laborious, and are quite eclipsed by the present-day methods adopted on the bridges under review.

Messrs. Braithwaite & Co., Engineers, Ltd., are the patentees of the electric capstan for pile and cylinder screwing and for many years the use of the electric capstan has been confined to solid pile work, where the diameters of the piles were 6 in. to 7 in. After experiment the use of the capstan for cylinder screwing has been perfected, and the rapidity of construction of these bridges has been made possible through the use of electric capstans of this type.

The capstan is a self-contained piece of machinery, having a steel frame on which are mounted two 15 h.p. motors acting as a couple, and with suitable reducing gear a torque of roughly 40,000 ft. lb. is produced on the capstan driving wheel and transmitted to the cylinder. When operating, the capstan sits on the top of the cylinder, the connection between the driving wheel and the cylinder of lesser diameter being made by a steel conical adapter which has four projecting lugs which fit with four corresponding sockets in the rim of the driving wheel. No other connection is made between the capstan and cylinder. The capstan is quite free to be lifted off and on to the cylinder, without having to make any disconnections whatever.

To prevent the capstan rotating round the cylinder two guy ropes secure the capstan.

At the bottom of the cylinder is an ordinary cast-iron screw blade to which the cylinder is bolted. The diameter of this screw is 5 ft. 8 in., giving a bearing area of 25 sq. ft. Neglecting skin friction on the sides of the cylinder, this gives a bearing pressure on the screw under maximum load on the bridges of 3 tons per sq. ft. It can further be safely assumed that in deep screwing the value of skin friction on the cylinder sides is roughly 2 tons per linear ft. of cylinder.

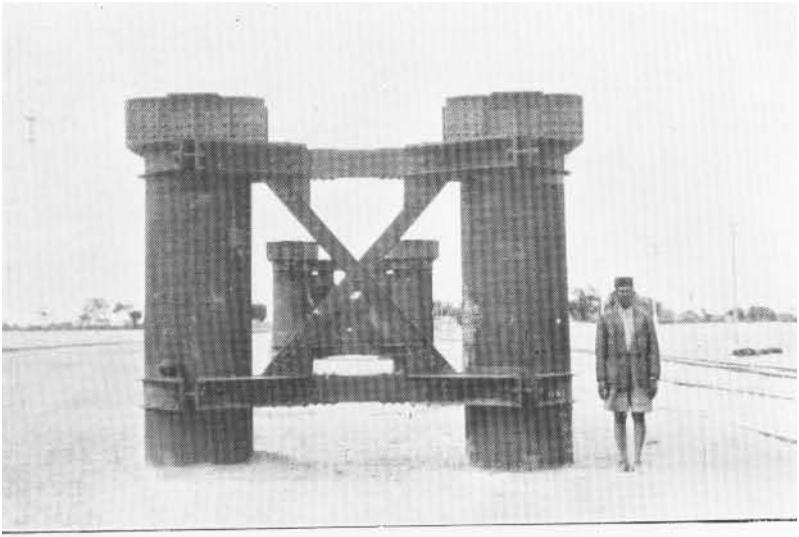
The pitch of the screw blade is nine inches, and under normal conditions each revolution of the cylinder, which takes 2 to $2\frac{1}{2}$ minutes, results in a penetration of nine inches; so that a nine-foot length of cylinder can be screwed into the river bed in about fifteen minutes.

Allowances must, of course, be made for delays and difficulties in screwing in encountering a hard stratum, assembling of material and movement of plant, but, as a general idea of the rate of screwing, it may be taken that at the Coleroon, where screwing was continued to a depth of fifty feet into the river bed, two cylinders per day were screwed to their correct level, giving a rate of 100 ft. of screwing per day.

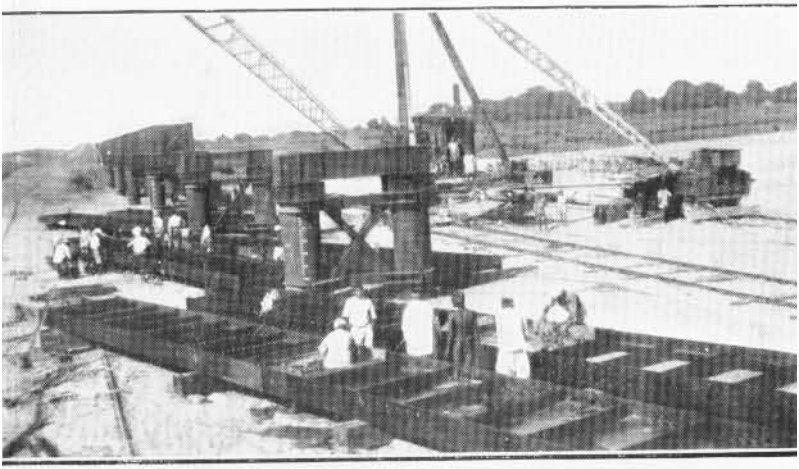
Such progress will doubtless be regarded as phenomenal. Two months to erect the substructure of a bridge of 45 spans with foundations 50 ft. into the river bed!

From the photographs showing the capstan at work, a box-like

Coleroon bridge



No. 2.—Pier at Ponnair.



No. 3.—Girders being assembled.

Girders

No. 4.—Capstan being lifted on to cylinder.

No. 5.—Capstan about to commence screwing.

No. 6.—Cylinders and capstan at Ponnair.

Capstan

No. 7.—Cage being removed.

No. 8.—Cylinder with screw bolted to it.

No. 9.—Cylinder and screw bolted together.

Cylinders

arrangement will be noticed at the base of the cylinder. This is a steel cage, the function of which is to keep the cylinders in position when they are first being screwed.

The cage, which is made out of ordinary steel plates, has two compartments, into each of which a length of cylinder with screw attached is placed.

Each compartment has a top and bottom guide, which consists of a steel frame fitting into the square compartment, with a circular opening in the centre for the cylinder and carrying rolls which lightly press against the cylinder and revolve when the cylinder is being screwed.

The centres of the circular openings of the adjacent guide frames are exactly 9 feet apart, and after the cage has been fixed in its correct position and the guide frames put in, it will be realized that the cylinders naturally fall into their correct positions, and are restrained in that position by the whole cage, which may, if necessary, be weighted down with sand or stones from the river bed.

By this means accuracy in screwing the cylinder is maintained, and only very rarely has the maximum error in the position of any one cylinder been as much as 2½ inches, such errors being allowed for and corrected in the design of the superstructure steelwork.

When the cylinders are screwed to level, the cage is bodily lifted off after removal of the guides.

In the erection of the bridges under review, during the working season the river beds are dry, with the exception of narrow or shallow channels. The scheme for erection is therefore simplified in that direct access to the river bed is possible.

During construction, the line which is being laid from railhead for bringing out materials is usually carried right across the river bed.

Between this track and the line of the bridge a track is laid, on which one or two 5-ton loco. cranes operate for unloading plant and material and assisting in the assembling of the cylinders and steelwork.

For handling the capstan and lifting the main girders a 10-ton Scotch derrick is utilized, which is erected on the other side of the bridge, and travels on rail tracks laid in the bed of the river.

Electricity at 460 volts is generated at the site and transmitted to the capstan by a cable mounted on poles in and across the bed of the river.

All field-riveting is done pneumatically, the girders arriving in halves and being riveted together in the river bed and hoisted into position by the 10-ton derrick crane.

TANKS AND ARMOURED CARS : THEIR USE AND THEIR ANTIDOTE.

A lecture delivered at the S.M.E., Chatham, on October 27th, 1927, by MAJOR V. V. POPE, D.S.O., M.C., R.TANK CORPS.

" Mobility implies the power to manœuvre and act with rapidity, and is the chief means of effecting surprise." *F.S.R.* II, 2, vii.

" Surprise . . . is the most effective and powerful weapon in war. Whether in attack or defence, the first thought of a commander must be to outwit his adversary." *F.S.R.* II, 2, iii.

I HAVE been asked to say something about the use of tanks and armoured cars in co-operation with other arms, and their antidote. Each of these subjects presents matters for many lectures and, in the time at my disposal, I can only hope to touch on what appear to be the main principles which should govern action in either case. I trust, therefore, that you will forgive me if I seem to skim somewhat sketchily over details.

I.—SCOPE OF LECTURE.

I propose to deal with such armoured fighting vehicles as now exist, both in type and numbers. My remarks refer, therefore, solely to the army in which such vehicles are not, numerically, the preponderant arm.

This limitation is important, since it has a direct bearing upon tactics. Tanks, not being commercial vehicles, cannot be supplied from civilian sources in large numbers during the early stages of a war, and finance is always likely to forbid the retention in peace of a large reserve which may at any moment—and must eventually—be rendered obsolete by the production of a new and better design. Similarly, though suitable chassis for use as armoured cars may be available from commercial sources, the armour will not. A commander, therefore, whose armoured resources are limited and whose powers of replacement are low, will tend to conserve those resources for the decisive blow and to " ca' canny "—as far as they are concerned—in the early stages of the campaign.

The doctrine at present laid down in *Field Service Regulations* is largely based upon a recognition of this fact. As a result, it has been somewhat severely criticized by that school of thought which prefers fancies to figures. The customary resurrection of the dead, which takes place daily during manœuvres, also tends to make us forget how few machines we really have and how difficult they will be to replace in the early days of a war. It must further be remembered that, at any one time, a proportion of our machines will be undergoing repairs or routine overhauls, and that our small

reserve will be called upon to complete units' establishments long before battle casualties have occurred. In bringing these facts to your notice, I do not wish to deprecate an audacious policy in the use of armoured fighting vehicles—far from it, since the legitimate issue of audacity is security and surprise—but I do deprecate the tendency to expect the Royal Tank Corps to live what may be described as a Rolls Royce life on a Ford income.

In the Appendix will be found a Table showing the types of vehicles now in service, together with a rough estimate of their capabilities. All these machines, with the exception of the Crossley armoured car, are in use in this country. The Crossley is in use in India, but it is not wholly satisfactory and may be superseded by a later type of car. I do not now propose to discuss the figures given in this Table which, however, I hope may be of some use to you when you are considering problems in which the employment of armoured fighting vehicles arises.

So much by way of introduction. Now let us consider how we can best employ such machines as we may reasonably expect to possess at the outbreak of war.

II.—Elements of Offensive Action.

It will be generally agreed, I think, that to achieve decisive success in battle an arm must be in possession of three fundamental attributes:—(*a*), Striking power; (*b*), Security; (*c*), Mobility.

The claim of the armoured fighting vehicle to inclusion in an army to-day consists of the fact that, under the conditions of the modern battlefield, it combines in itself a higher degree of these three interdependent elements than does any other arm. In addition it possesses a higher proportion of security and mobility to striking power. These three elements are, as I have suggested, interdependent; but I would submit that striking power can become active only when it is based on security and mobility, for too low a degree of security tends to produce retrograde mobility and too low a degree of mobility weakens security so greatly that striking power can be easily countered.

Armour is one of the oldest devices by which man has sought to obtain security in battle, but the motive-power at his disposal has until quite recently been insufficient to enable him to retain mobility in the face of the counter-measures of his opponents, and without mobility armour becomes an encumbrance and a target rather than a protection. The internal combustion engine has given us the means of making armour mobile, and it is to this mobility that I would draw your attention.

Mobility, as *F.S.R.* tell us in the quotations at the head of this lecture, is the chief means of effecting surprise; and surprise is the

most effective weapon in war. If, then, we can use the mobility, which the internal combustion engine has placed at our disposal, to effect surprise, we shall have made the best possible use of it. That I take to be the basic principle which should govern the employment of armoured fighting vehicles in war; the use of mobility to effect surprise: the rapier, not the battering-ram.

I would submit, moreover, that the mobility of a force does not merely imply its rapidity of physical movement but includes the rapidity of its reaction to a given situation; that is, rapidity of thought and of the translation of that thought into action. It is, for example, of little use to increase by intensive training a boxer's quickness of limb, if his processes of thought remain so slow that his brain can be "seen thinking." To take advantage of the increased physical mobility offered us by the internal-combustion engine, we must produce an increased rapidity of thought and decision on the part of all leaders. How this can be done lies outside the scope of this lecture, but it is a matter of importance which cannot be ignored.

We must then ensure that the rapid decision is transmitted rapidly. Staff duties and the Signal Service play their parts here. As regards the first, it may well be that short orders amplified by "instructions" will be found the quickest and most satisfactory method of enabling armoured fighting vehicles to execute the commander's plan. The latter presents a more serious problem. Communications, both internally and externally, are at present the "Achilles' heel" of the armoured fighting vehicle. Much experimental work is being carried out and a satisfactory solution is hoped for shortly; but, at the moment, control of an armoured force, once it has been launched into action, is practically impossible. We suffer here a serious check to our potential mobility. You will appreciate how serious this is when you consider that a machine moving at ten miles an hour covers about three hundred yards a minute. A commander will, therefore, constantly be basing his plans on situations which no longer exist unless the means of transmitting information and orders can be correspondingly accelerated. This difficulty was continuously apparent during the manœuvres on Salisbury Plain this year.

As regards physical mobility, I would point out that, as *F.S.R.* implies, it consists of two kinds: the power to act rapidly and the power to manœuvre, or what may be called intensive and extensive mobility. There are great technical difficulties in designing a machine which will combine a high degree of both characteristics, and as a result we have at present two types in service: the armoured car with a high degree of intensive mobility but with little cross-country power, and the tank with great extensive mobility but with a comparatively low maximum speed.

III.—The Armoured Car.

The armoured car is peculiarly suited for strategic reconnaissance duties in which it forms a valuable auxiliary to the Royal Air Force, confirming and amplifying air reports. Indeed it has several advantages which the aeroplane, as yet, does not possess. It can maintain a continuous watch over a given area without relief: it can operate by night and in misty weather; it can secure identifications. It is obvious, that if full use is to be made of armoured cars in this rôle, the very closest co-operation will be required with the air. That brings us again to the problem of communications of which I have already spoken. Only the most elementary means at present exist of communicating from car to car, from car to air, and from car to headquarters, though we hope for something better shortly. There is, therefore, the more need for instructions to an armoured car commander to be explicit. It cannot be too often repeated that definite questions produce definite answers. Armoured car commanders must be told, too, the degree of importance of their mission, so that they may know whether they are to fight for their information or no. It must be remembered that the armoured car is not suited for use as an assault arm owing to its lack of manœuvrability and that normally, like all other reconnoitring troops, it will use its radius of action to obtain information rather than its striking power.

For this reason the armoured car is at a disadvantage when it is employed on tactical reconnaissance, and the fact that its employment with the advanced guard is contemplated is due, I think, to the shortage of suitable tanks. Necessity may compel such employment, but care should be taken that the cars are never closely engaged and that they are withdrawn and utilized on the flanks, or as a mobile reserve, immediately the opposition begins to stiffen. If this is not done, the casualities in cars will be out of all proportion to the results achieved by them.

But perhaps the most obviously attractive use which can be made of armoured cars is the raid. You will, however, remember the great cavalry raids of the American Civil War and how often the absence of the cavalry deprived its army of the means of obtaining information of far more importance than the transitory results obtained. We may say, therefore, that the use of armoured cars for raiding will not be justified unless the service of information is not thereby impeded. Provided that this principle is adhered to, raids may produce striking results and will certainly produce much disturbance.

The ever-increasing number of cars on the commercial market will render it easy for a guerrilla raiding force to be improvised at the very outset of a war. Such a force, even if largely unarmoured, will be capable of causing much delay and annoyance to the enemy whilst an armoured force strikes at the more important objectives,

These objectives may be described metaphorically as the brains, eyes, nerves, feet and stomach of the enemy, care being taken always to avoid his clenched fists. Headquarters, aerodromes, signals, railways and roads, and the supply systems form, each and all, admirable objectives for such raids. The mere fact that they are threatened will cause the detachment of fighting troops from the main armies, and if they are successfully assailed, those armies will be, temporarily at all events, partially paralysed. Mechanization has made the uninterruption of the supply service more important than it has ever been before, since machines, unlike men and horses, have no better feelings to which appeal can be made and will not move when they are empty; nor can they be turned loose to feed upon the countryside. The immensity of this problem of supply and the magnitude of its importance are well exemplified by the following figures. It has been estimated that a force of five divisions with a proportion of ancillary troops, moving an average of fifty miles a day, will require 73,000 gallons of petrol daily when it is not in action. In battle the same force will require over 110,000 gallons daily. This force is not a so-called "mechanized force"; it is composed of horse, foot and guns, with a few tanks and armoured cars such as might be raised from existing armies. It is its transport, which is mechanized, that demands this immense amount of petrol; and it is its transport, of course, which will cover the daily average mileage given. The petrol-supply system of a modern army, therefore, forms a very tempting bait and we may be sure that an enterprising enemy will do more than delicately nibble at it.

In the pursuit the Armoured Car will prove invaluable, always provided that full use is made of its radius of action to produce surprise. In this connection I would again repeat that the armoured car is not an assault weapon, that its primary *rôle* is reconnaissance, and that it is, when used offensively, a "weapon of opportunity": in other words, that it obtains its demoralizing power far more by surprise than by striking power.

IV. The Small Tank.

The next type of vehicle we have to consider is the small tank, the so-called "tankette." There are two types of this form of vehicle in existence at the present moment. Both of them are very much in the experimental stage, and neither of them is technically satisfactory. It is probable that their performance will be greatly improved in the near future as the result of experimental work now being undertaken.

There are various opinions as to their best use, but there can be no doubt that some such machine which is cheap to produce and maintain, and easy to handle and replace, is needed to reconnoitre for the fighting tank; to act, in fact, as its light infantry and to force the enemy

anti-tank guns to disclose themselves. Such a machine would also be useful as cross-country transport for anti-tank guns, smoke projectors, and possibly small arms ammunition and machine guns. A more debatable view is that which holds that these small machines can be utilized in large numbers as the assaulting arm. It is difficult to see how machines of this nature can be given sufficient striking power, mobility and security to enable them to fulfil this *rôle* effectively, without immensely adding to the cost of production and maintenance—in fact without turning them into light tanks. Designers may eventually solve this problem, but I think it is safe to say that they have not done so yet, and that the present machine can be effectively used only for reconnaissance.

V. The Light Tank.

The General Staff has laid down three main governing considerations regarding the employment of the light tank. It is to be used for a decisive operation : against definite opposition : in an organized attack. Its use is, therefore, at first sight considerably restricted. There is, however, a rider : tanks may be used whenever there is a likelihood of attack by enemy tanks. As the enemy is not bound by our regulations, it is obvious that he may see fit to use his tanks in other circumstances than those envisaged therein ; and it is equally obvious that we shall have to be prepared for his doing so.

Certain conditions must, however, be fulfilled when tanks are employed if they are to have a reasonable chance of success. First, the ground over which they have to operate must be suitable. I need not describe to you the conditions under which the Third Battle of Ypres was fought. It is sufficient to say that the tanks quite literally could not pull their weight through the morass of mud that eventually engulfed most of them. That was an extreme instance, perhaps, but you may be assured that ground will always be a vital factor in any tank action.

Secondly, tanks must be employed in sufficient numbers to enable them to attack in depth with an effective reserve. What constitutes a sufficient number is still, I fear, largely a matter of individual opinion. There was a time when it was customary to call for one tank: later it was admitted that tanks should not be employed singly, and two were demanded: now it is agreed that the unit is the section of five: very soon, I trust, it will be realized that the larger the number of tanks employed on any one task, the greater will be the chances of success and the less the risk of casualties Then unsupported attacks of solitary sections will be definitely anathema.

Thirdly, tanks must not be dispersed. Prior to the German offensive in March, 1918, the greater part of the Tank Corps was scattered along the fronts likely to be attacked. Nearly all our tanks were lost without achieving anything. As Colonel Fuller has said, we were punching with our fingers extended instead of with a clenched fist.

So much for the major considerations, now for a few minor though not less important ones. Before tanks are committed to any action, they must have information regarding the enemy they have to fight and the ground they have to traverse. To obtain this information, a reconnaissance will generally have to be made. There is a certain school of thought which maintains that preliminary reconnaissance is not necessary for a mobile arm. I fear I cannot agree. Of course, it is possible to attack without reconnaissance, just as it is possible to run a race without training, but in both cases much unnecessary strain will be put on the organism. Moreover, when co-operating with infantry, tanks will always have ample time for reconnaissance.

Having obtained his information, the tank commander is in a position to make his plan. That plan must be framed so as to enable the infantry co-operating with him to get to their appointed objectives at the appointed time; but it must be remembered that the formation's plan of attack must be framed so as to enable the tanks to secure those objectives and that everything turns upon the success or failure of the tanks, which have become definitely the assault arm on any front on which they are attacking. The tanks must, therefore, be at liberty to operate on a line of advance distinct from that of the infantry if it so suits them better, and they must receive first consideration in the disposal of artillery and machine gun support, and in the employment of smoke.

It is extremely likely that at some stage of the attack the enemy will try to restore the situation by means of an immediate counter-attack with his own tanks. It is laid down that in this eventuality all tanks will immediately abandon all other tasks to engage the enemy. Apart from the fact that such action on the part of the attacking tanks would probably leave their infantry in an extremely hazardous position, it is by no means certain that those tanks, intent as they would be on their immediate objectives, would become aware of the approach of the enemy's tanks until it was too late to take effective action. It is, therefore, now held that each attacking echelon of tanks should be followed at a convenient distance by a reserve echelon whose sole task would be to watch for and deal with such counter-attacks as might develop. Batteries of self-propelled guns might also well be employed to follow up the attack and to blind anti-tank guns with smoke as they revealed themselves.

But, above all, in any tank action let us seek to secure surprise: to use the rapier rather than the battering ram.

So much for the main principles, which, it seems to me, should govern the employment of armoured fighting vehicles. Let us now consider briefly what counter-measures we can best take against those vehicles.

VI. COUNTER-MEASURES.

Our object is to destroy, or at any rate nullify, their striking power. This we can do either by attacking their mobility and making it

impossible for the machines to reach us, or by destroying the security which makes the effective use of their striking power possible. Of course, as I mentioned at the beginning of this lecture, mobility and security are largely interdependent, and may be expressed to a considerable extent in terms of each other; but I would suggest that, broadly speaking, the methods employed to destroy mobility will be mainly passive, whilst the attack on security will be definitely active.

The attack on mobility will be carried out by the use of obstacles, both artificial and natural. Artificial obstacles were used by the Germans in the Great War on a fairly extensive scale. Generally speaking, they were of value when they amplified natural obstacles, but were of little use when isolated. When the immense time and labour required to construct an effective obstacle is taken into consideration and a comparison is made between the radius of action of the modern armoured fighting vehicle and that of the war-time tank, I think it will be generally agreed that, except in siege operations and during position warfare, the construction of such obstacles will generally prove to be labour in vain.

I think, however, that we may expect to see an increasing use of natural obstacles, such as forests, mountains, inundations, rivers and bogs, in war. Though no natural obstacle has of itself ever yet stopped a determined attack, it does undoubtedly gain time, and so may detract from surprise: moreover it confers a great sense of security. The increased radius of action of the armoured vehicle is, however, likely to render this sense of security false, or at any rate fleeting, and I do not think that we can accept the natural obstacle as anything more than a valuable auxiliary for our means of defence.

For the attack on security we must employ destructive weapons. Small-arms fire is generally thought to be innocuous to tanks. Actually, close and intense machine-gun fire does produce "splash," which is distinctly unpleasant to the occupants of an armoured vehicle. It is not, however, even at its worst, sufficient to stop a machine, and measures are in sight whereby it will be effectually counteracted.

Though an efficient tank-mine can be, and indeed has been, easily produced, the difficulties to be overcome in making effective use of it are considerable. To lay a minefield requires time, labour and much transport; and when it is laid it is quite possible that few or no enemy machines will come near it, for lack of numbers alone will prevent more than chosen sections of the front being so protected. Moreover, the mine is a two-edged weapon. In March, 1918, we expected to be attacked by German tanks on the Fifth Army front, and a minefield composed of 60-pdr. trench mortar bombs was laid near Ronssoy. No tank attack did, in fact, take place, and the Germans advanced without disturbing the mines and, apparently, without discovering their existence. When, six months later, the wheel had swung full circle and we were attacking over the same ground, the 301st Ameri-

can Tank Battalion struck that minefield with disastrous results. Very careful organization is, therefore, required in the laying of mines; but provided that too much reliance is not placed upon them, there can be no doubt that they do form a valuable auxiliary in anti-tank defence.

Gas, strangely enough, is comparatively ineffective against tanks, its penetrative effect into machines in no wise specially protected being in the most favourable conditions exceptionally small. There is also little difficulty in making a tank completely gas-proof, though the problem of protecting the crew against the effects of a persistent gas, such as mustard gas, when cleaning the tracks, etc., is somewhat less simple. We cannot, therefore, rely upon gas to help us much against the tank or armoured car.

To employ a field gun for anti-tank work is, to my mind, rather like using a sledge-hammer against the attacks of a swarm of hornets: the weapon is too slow and cumbersome, and the expenditure of energy is in no wise proportionate to the results achieved. Nor can the light gun be regarded as being less unsuitable. The problems of transport, concealment and ammunition supply, together with its slow time of flight, handicap it immensely in such an action. An anti-tank machine gun certainly appears to be a more formidable opponent, but there are great technical difficulties in the way of its production, and the problems of transport and ammunition supply have still to be solved.

All these weapons suffer, moreover, from a common and a very serious—indeed, I believe a vital—disability: they wholly lack mobility in the face of the enemy. Like the mine, they may be sited to cover fronts which the enemy tanks ignore, and their cumbersome and vulnerable means of transport renders it extremely unlikely that they can be moved to the fronts so threatened after action is joined. They stand stationary, therefore, to be destroyed in detail. The self-propelled gun does not suffer from this disability, though I believe that technically it is not wholly satisfactory. But what is it when all is said? A tank without the security of a tank. As it fires standing still, and must come within machine-gun range to fire at tanks with any chance of hitting them, its crew will regret that lack of armour very early in the fight. Give it that armour and it becomes a tank.

And so we come to the only solution I can offer you to the problem. To meet the tank we must produce the tank: to counter the combination of mobility, security and striking power which I have endeavoured to describe to you, we must produce a similar, and if possible a better, combination. The armoured fighting vehicle has re-introduced protected mobility into the battle, and it can be countered effectively only by protected mobility, the chief means of effecting that surprise which is the most effective weapon in war.

APPENDIX.

Particulars and Capabilities of certain Armoured Fighting Vehicles.

Type.	Speed.		Crossing power.		Climbing power.	Circuit of action.		Armament.	Crew.	Weight fully equipped.	Engine.	Petrol capacity.
	Max.	Average.	Trench.	Water.	Slope.	Cross-country.	On road.					
Light Tanks, I and II. ...	15 m.p.h.	6–7 m.p.h.	6 ft.	3 ft.	40°	135 miles	200 miles	1 3-pdr. Q.F. gun, 2 ·303 V.M.G., 1 ·303 Hotchkiss gun.	5	11 tons (Mk. I), 12 tons (Mk. II)	90 h.p. 8 cyl. Armstrong Siddeley	90 galls.
Rolls Royce Armoured Car	50 m.p.h.	25 m.p.h.	6 ft.	1 ft. 8 in.	—	—	132 miles	1 ·303 V.M.G.	4	4 tons 2 cwt.	40/50 R.R.	22 galls.
Crossley Armoured Car	40 m.p.h.	20 m.p.h.	—	1 ft. 10 in.	—	—	120 miles	2 ·303 M.M.G.	4	4 tons 11 cwt.	40/50 Crossley	20½ galls.
Morris Martel	15 m.p.h.	11 m.p.h.	4 ft.	2 ft.	40°	40 miles	60 miles	1 light M.G.	2	2 tons 4 cwt.	16 h.p. Morris	8 galls.
Carden Loyd ...	20 m.p.h.	15 m.p.h.	3 ft.	—	45°	40 miles	80 miles	1 light M.G.	2	14 cwt.	23 h.p. Ford	8 galls.
Independent Tank ...	—	10 m.p.h.	(a)	(a)	(a)	(a)						

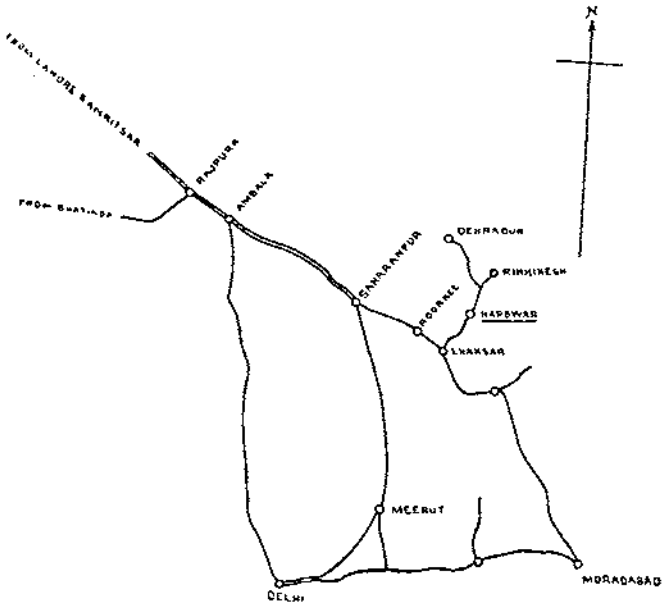
(a) Trials not yet completed.

THE INCREASE OF SINGLE-LINE TRAIN CAPACITY, KUMBH MELA, HARDWAR, 1927.

By MAJOR F. H. BUDDEN, M.C., R.E.

THE problem which had to be solved was how to deal with the very heavy traffic at Hardwar during the Kumbh Mela. Hardwar is situated on a branch single line from Lhaksar to Dehra Dun, about 17 miles from Lhaksar. Lhaksar is a station on the main line of the East Indian Railway between Lucknow and Saharanpur and this main line is also a single line. (*See* sketch.)

SKETCH SHOWING RAILWAYS, HARDWAR AREA.



The Kumbh Mela occurs only once in 12 years, and although there are various *melas* every year and a larger *mela* half-way between each Kumbh Mela, yet pilgrims visiting Hardwar at any of these smaller *melas* do not approach the numbers visiting there for the Kumbh Mela, and so it would not pay to make the line double between Lhaksar and Hardwar merely for carrying a heavy rush of traffic for a few days in 12 years. The Kumbh Mela lasts for about six weeks, but there is one important day which fell this last time on April 13th ;

the majority of the pilgrims who visit Hardwar stay for this day, and then they all try and get away as soon as possible. Previous to this big day there are certain less important bathing days, when there is an inward rush before the day and an outward rush after the day, but the traffic is quite easy to handle.

The following account describes what was done in March and April, 1927, to deal with the traffic at the Kumbh Mela, as it is thought that this might be of interest to officers who may have to deal with a heavy concentration of troops, etc.

Before describing the steps taken, it is necessary to explain that the majority of the traffic comes *via* Saharanpur and Lhaksar to Hardwar and only a comparatively small amount comes *via* Moradabad and Lhaksar. At Saharanpur the traffic splits up into two main directions, one towards Delhi and the other towards Amballa, Rajpura, Amritsar and Lahore. (*See* sketch.)

The traffic towards Amballa, Rajpura, Amritsar and Lahore again splits up into various directions, as a large number of passengers change at Amballa, Rajpura, etc., and leave the main line, which proceeds to Amritsar and Lahore. It was therefore essential that the sorting arrangements at Hardwar should be carefully worked out, as otherwise the sorting of pilgrims would have to be done more than once; this would create trouble all along the road, specially as the majority of the pilgrims has no idea of where they are going, except that they know the name of the station from which they started. The sections which required most careful watching were the sections

Hardwar to Lhaksar	.. ..	17 miles
and Lhaksar to Saharanpur	..	33 miles,

as the traffic at Saharanpur is split up into two directions. Moreover, the line from Saharanpur towards Amballa and Lahore is a double line, and so there would be no difficulty in dealing with the number of trains which the single line section Lhaksar to Saharanpur could hand over to Saharanpur. It was not possible to have an absolutely free hand, as there already is a service of seven passenger trains in each direction between Lhaksar and Saharanpur which had to run to their fixed timings and to keep time, as otherwise they would disorganize train-running on adjacent sections. It was, however, possible to shut down all goods traffic temporarily during the outward rush, and this was done for three days before the outward rush started and as long as it continued.

In a *mela* of this importance steps had to be taken many months before the date of the *mela* to ensure that the Civil, Medical, Police and the various railway authorities worked in together.

Hardwar is a town situated between the Ganges and the Siwaliks, which are the foothills of the Himalayas, and there is a very limited space available for pilgrims. It was estimated that the maximum

number that could possibly be taken into Hardwar was one million, and even then this would only be possible under the most careful arrangements. It can be easily understood that, when a million people visits a town with a regular population of about fifty thousand, the sanitary arrangements, the arrangements for feeding this number, etc., need the most careful thought.

Moreover, on the important day the great majority of the pilgrims wish to bathe in the holy pool, which is only reached by a number of steep steps. The traffic control in Hardwar itself on that day is one of the most difficult problems which the police of any country have to deal with, as the pilgrims start bathing at midnight and continue to bathe until all are finished. A regular circuit has to be arranged, and every pilgrim has to follow this circuit. Barriers are erected so that the pilgrims cannot rush the pool. The problem is made more difficult by the fact that there is a number of religious houses called Akharas, which bathe *en masse* and parade with a large number of elephants, camels, horses, etc., arrangements for which have to be made so that they are kept on one side until the bathing is finished and then picked up by the Akharas after the bathing. The Akharas are very jealous of each other, and there is a definite order of precedence which has to be followed, and it would be fatal if one Akhara met another Akhara on that day. Akharas have been known to sit down and refuse to move when they thought that the arrangements made on their behalf were not satisfactory, or as good as those arrangements made on behalf of other Akharas. The above will give some idea of the problems which have to be solved from a traffic control point of view, and now details of the arrangements made for carrying away by train the pilgrims after the big bathing day will be given.

The arrangements can be summarized as follows :—

(1) Increasing the capacity of the section Hardwar-Lhaksar-Saharanpur.
(2) Building an avoiding line at Lhaksar so that trains from Hardwar to Saharanpur need not pass through Lhaksar.
(3) Increasing the facilities for entraining and detraining passengers at Hardwar.
(4) The introduction of a local train control with headquarters at Hardwar.
(5) The installation of a central control at Hardwar to supervise the working at Hardwar.
(6) The provision of sufficient passenger "rakes."
(7) The provision of extra staff to deal with the increased traffic.
(8) Deciding on the method of working trains.
(9) Working out in detail the various steps necessary to enable the railway authorities to deal with the traffic.
(10) Creating a spirit of emulation amongst the staff.

Dealing with each of these in turn,

(1) The capacity of a single-line section can be increased by introducing extra crossing stations on those sections which are long, and by providing stabling accommodation for rakes. There is a limit, however, to the number of crossing stations which can be introduced, as if the number is too large it only means that the traffic is delayed due to the time taken in starting and stopping trains. Three extra crossing stations were provided, and the limiting section was finally six miles long on a grade of 1 in 300.

(2) The building of an avoiding-line at Lhaksar was essential, as otherwise trains would have to run into Lhaksar and the engines would have to be turned and be attached to the other end of the train. This would delay working considerably.

(3) Hardwar station normally consists of a main platform and an island platform with two faces, or a total of three platforms for dealing with passengers. This is quite insufficient, and so two extra island platforms were built, and each island platform was divided into two by a palisade which ran down its centre. At the end of these four platforms were four long narrow enclosures, into which pilgrims were sorted, and as soon as a passenger rake was available the gates were opened and pilgrims were allowed to entrain. Other enclosures were also provided so that pilgrims could be sorted for trains leaving from the three main platforms.

In India there are four classes, 1st, 2nd, Inter. and 3rd, and so it was necessary to provide enclosures for the different classes, *i.e.*, one enclosure for 1st and 2nd class passengers, three enclosures for Inter. class passengers, seven enclosures for 3rd class passengers. Passengers were sorted for eight directions, and to enable the staff to deal with pilgrims for stations of which they have never heard, the tickets for each direction were superscribed with a special mark, and so all that the ticket checker's staff had to do was to make sure that only pilgrims with a certain superscription on their ticket were allowed into an enclosure marked with the same superscription. This simplified very much the instructions issued to the directing staff. A large number of pamphlets and posters were issued explaining that if a pilgrim wanted to go to Lahore he should go to a booking office marked with a red circle, and then go to an enclosure marked with the same red circle, and he would find a train which would go straight to Lahore; and the same for other stations.

At the same time, a very careful check had to be kept on the numbers booking, so that only sufficient were booked to fill the trains leaving that day. Sometimes it was necessary to close down temporarily all booking except for one or more directions in order to fill certain specials. Each special at a particular timing could be arranged for more than one direction, and it was necessary to decide in ample time for what direction each special was to go.

(4) The main line to Saharanpur and the branch line Hardwar to

Lhaksar is normally controlled with headquarters at Moradabad, but during the *mela* a local train-control was introduced at Hardwar, which controlled the section Hardwar to Lhaksar, and Lhaksar to Saharanpur, and the control was extended to the station on the Dehra Dun side of Hardwar, so that early information could be received of any trains arriving from that direction. It was then possible to see at a glance, by going into the train-control room, the position of any train, stabled passenger-rake or engine on the section, and this simplified the orders that had to be issued.

(5) In addition to this train-control, it was necessary to have a central control regulating all operations in the Hardwar area. This control was situated in the next room to the train-control, and was connected by telephone to all the important points in the Hardwar area, such as to all platforms, booking offices, loco foremen, enquiry office, civil authorities, etc. The supervising controller in charge was responsible for co-ordinating all the work, and nothing was done without first asking his permission. This central control was absolutely essential to the success of the work, and without it it would have been impossible to handle the number of trains that were handled with ease during the outward rush.

(6) In previous Kumbh Melas sufficient passenger stock was not available, and goods stock had to be used. For this *mela* special arrangements were made, and 50 rakes of passenger stock were provided on the basis that it would take an average of two days for the turn round of each rake, and that about 24 rakes would be required daily. It must be remembered that many of the specials travelled long distances, such as 300 miles.

(7) A large number of extra staff were required in the *mela* area, and these had to be obtained from other divisions and other railways. The staff already in that area had to be tested, as although a man may be quite fit to deal with normal traffic, yet he might be totally unfit to cope with the very heavy traffic during the outward rush. It was necessary to have certain inspectors and officers at various points, so that they could take charge if anything happened which had not been allowed for.

(8) Various methods of working trains were considered, and it was found that in employing the usual methods the capacity of the single-line section would not be more than 42 trains, *i.e.*, 21 trains each way. It was accordingly decided to employ what might be called the "flow" system of working, a system which had not been employed in India before. Under this system of working, trains would run in one direction only for certain definite periods during the 24 hours, and so there would be no crossing except with regular passenger trains, and trains would run through all stations except for watering. It was found under this system that the single-line capacity of this section could be increased to 60 trains a day, in spite of the fact that

the length of the ruling block-section was six miles on a grade of 1 in 300. It was accordingly decided to divide the 24 hours into four periods—7 to 11 hours, 11 to 15 hours, 15 to 23 hours, and 23 hours to 7 hours. Specials would be despatched one after the other from 7 to 11 hours, and again from 15 to 23 hours, while empty rakes would be brought in from 11 to 15 hours and from 23 to 7 hours.

This presupposes sufficient stabling accommodation at the starting station, but, if suitable timings are selected so that specials do not clash with the regular passenger trains, it is possible to arrange that every line holds an empty rake at the time when the first outward special of any flow is due to start. At Hardwar it was possible to hold seven empty rakes, one at each of the seven platforms, and six more in the yard.

A detailed time-table was worked out and printed, and issued to all concerned. Each loaded special and empty rake in this time-table was given a special number.

The interval between the despatch of two successive specials was 20 minutes, as this was the average time it took a special to clear the longest block section and for the Stationmaster to get line clear for the next train. This interval of 20 minutes also allowed time for placing the next empty rake at a platform after the departure of the loaded special from that platform. The actual sequence was the departure of the loaded special, the backing in of an empty rake, the return of the pilot to the next empty rake to be placed, and the attaching of the train engine from the engine shed. As many of the points were non-interlocked, the necessity for working out beforehand the correct sequence of movements can be understood, as the number of reversals of points had to be reduced to a minimum. Care was also taken that all important points were well ballasted and that the sleepers used were in good condition.

The advantages obtained through working trains on the "flow" system were :—

(1) The capacity of a single line section was increased by about 50 per cent.
(2) It was possible to work to a definite time-table for the despatch of trains. Pilgrims knew exactly at what time trains were leaving.
(3) The work at stations was decreased, as all trains ran in the same direction for certain definite periods of time, and it was not necessary to reset points, etc.
(4) The average speed of trains was very much increased, as except for watering it was not necessary for them to stop.
(5) It was possible to arrange to give definite periods off to the various members of the staff, as, when inward rakes were being brought in, there was no booking and so no work for

the staff on the platforms or for those directing pilgrims. After the first two or three days, the work of controlling all operations in the yard became automatic, and the various members of the staff carried on with little supervision.

(6) When no trains had to be crossed, it was possible at times to join two empty rakes together and so decrease the number of movements over the block-sections. The engine of the second train merely joined on to the back of the first train and then ran through all stations.

The results obtained speak for themselves, as on the first day of the outward rush twelve inward loaded specials were received and eighteen outward loaded specials were despatched. During the next five days 135 outward loaded specials were despatched, in addition to the regular passenger trains.

(9) The correct sequence of all movements in the *mela* area was worked out in detail, and this included :—

(a) The sequence of movements in Hardwar yard and station during the outward and inward flows, so that the work entailed was reduced to a minimum. It was found that, by a change in the sequence of movements, the number of points to be set for each operation could be considerably reduced, as explained in the previous paragraph.

(b) The times at which engines should be ready at Hardwar, Lhaksar and Khan Alampura were all worked out and supplied to the loco-foremen. It was not necessary for Control to requisition for any power, and the loco-foreman knew when power would be required for each of these trains, unless he was informed that any particular special was cancelled.

(c) The return of empty rakes which had to be cancelled by Control, if one or more specials were cancelled in any of the flows, was worked out beforehand, so that there should be no possibility for mistakes.

Detailed instructions were issued to all the staff concerned, and these were explained to them, and the staff were invited to ask questions and to make suggestions after studying the instructions.

Many other special details were also carefully worked out, such as :

(i) The provision of special watering coolies at Roorkee, where all trains took water, so that the engine crew should attend to their engine while the engine was being watered. The halt at Roorkee was accordingly cut down to a minimum, and there were no delays.

(ii) A platform assistant was detailed to see that the driver was ready to start some minutes before his booked departure, and that he left as soon as the signal was lowered and he had received line clear and the guard's signal. Under the "flow" system there is no harm in trains running before time.

(iii) Special steps had to be taken to ensure that all passenger trains (regular and special) arrived complete and required no shunting at Hardwar.

(10) There can be little doubt that, however good are the arrangements made, the results will never be good unless the staff employed really try their best, and so special steps were taken to create a spirit of emulation among the staff by visiting all stations in the *mela* area before the outward rush and telling them that the Moradabad division was out to break the record for India, by supplying good food to all the staff, and making them as comfortable as possible, etc. The results were excellent, as all previous records were easily beaten, and 60 trains a day, *i.e.*, 30 trains each way, were run on two successive days.

The above is only a short report of what was done, but it will show how careful attention to detail and the employment of the latest ideas in train-working can be used to increase temporarily the capacity of single line sections.

Many other problems had naturally to be solved, such as:

(a) Accommodation and supply of food for the staff.
(b) Sanitary arrangements, supply of food and cool water for the pilgrims.
(c) Counting, safe custody, and transfer of cash to the treasury.
(d) Cleaning and charging of passenger rakes.
(e) Inspection of pilgrims for cases of cholera, plague, smallpox, etc.
(f) Reservation of accommodation for important pilgrims visiting Hardwar.
(g) Handling of thousands of inward parcels at a station where no proper facilities exist.
(h) Arrangements for dealing with accidents blocking the running lines.

Various public bodies passed resolutions thanking the railways for the excellent arrangements which were made, and many of the pilgrims as they left thanked the officers on the spot for what they had done to help them.

GOVERNMENT BUILDING RESEARCH STATION.

By COL. D. M. F. HOYSTED, D.S.O.

BY the courtesy of Major-General Sir Gerard Heath, K.C.M.G., C.B., D.S.O., Chairman of the Building Research Board of the Department of Scientific and Industrial Research, and by arrangements kindly made by Dr. Stradling, M.C., the Director of Building Research, a visit was paid to the Building Research Station near Watford, Herts.

The Department of Scientific and Industrial Research is an independent Government Department under the Lord President, and is charged with furthering the good of the public by means of both original and suggested research of a scientific or industrial nature. Under its inquiring purview are passed the problems concerning economy in use and manipulation of fuel, the fatigue of industrial workers and how it can be controlled and lessened, and the efficient production and employment of all manner of building materials, to quote but three of its activities. For the last-named purpose the Building Research Station came into being, first of all in temporary huts at East Acton, but now in a permanent building, as a central laboratory at which the necessary scientific work could be carried out and correlated on a wide basis, with the broad aim of affecting economy and improvement in building materials and construction.

The new organization owes much, of course, to the pioneer work of earlier Government Committees, for when the scattered results of the previous investigation were co-ordinated, in 1920, by the Building Research Board, it became obvious that, before practical problems could be tackled with any real prospect of success, much more knowledge was required of the fundamental physical and chemical properties of materials themselves, and of the basic principles underlying constructional design. This could only be secured as the result of a combined attack by architects, engineers, chemists and physicists in very definite co-operation, all pressing towards limited objectives one at a time, each of which must be secured as a reliable jumping-off point for the next assault. Owing to the urgent necessity, in those days, for very early information on special difficulties with which the building industry was beset, and which involved the wise outlay of large sums of public money by the Government, work on both general and special lines was, perforce,

carried out side by side. For instance, attention was given to certain roofing materials, to sand-lime and concrete bricks, to the possibility of improvements in jointless flooring, and to the utilization in building of what would otherwise have been waste material. Other Government Departments, deeply implicated, all desired more help towards the immediate solution of special problems.

The necessities of post-war reconstruction brought difficulties to a head, especially in relation to national housing. The urgency and magnitude of these problems made it essential that all matters affecting methods of construction, supply of materials, organization of labour, economy and despatch in execution, should be overhauled and reconsidered, as it was patent that small savings in different directions meant considerable economy in the aggregate. Scarcity of certain materials made it imperative to test the potentialities of new kinds, or of alternative methods, of construction.

The Building Research Station worked on these lines till 1925, when it was decided to expand its sphere of activity still further. Industry as well as the Government urgently required more help towards the immediate solution, or partial solution, of special embarrassments. It was thought that in many directions sufficient advance had already been made to enable suggested new materials to be satisfactorily compared with old ones, whose qualities were well known by long experience, and to determine the value of newly proposed methods of construction. It must be realized that the building industry has been for many centuries hidebound by tradition, because of the great expense of full-scale experiment, the only kind which has been hitherto available. We use burnt clay for bricks, and lay them one upon another in the same way as the workmen of the Pharaohs of the Second Empire during the time of Moses. Masonry was not introduced into this country till the Romans came, and the art of using it died out when they left us, not to be revived till Norman times. In the past, the materials used and the methods of construction employed have, in most cases, been developed and standardized after a process of trial and error extending back through the ages. Tradition has become the controlling force and practical experience the main guide. It will thus be observed how the efficiency of this craft has depended upon the spread of knowledge gained by experience. As is well known, that spread was anything but quick or even, and the result can be seen all over the country to-day; different methods are in use in different counties not many miles apart, and local builders often do not know the underlying reasons for the application of their local processes.

Still is whole-scale experiment in full swing. Walls can be seen split and cracked from the use of unsuitable material, buildings

covered with efflorescence and discolouration, bricks and stone disintegrating after a comparatively short exposure. Traditional habit of thought dies hard. Considering that the Great Pyramid was built some fifty centuries ago, surely we ought, by now, to be able to design for durability as well as for strength. Besides which, modern society is making demands on the building industry far beyond those which led to the evolution of our traditional materials and methods. Such demands include the vibrational stresses caused by modern traffic and modern machinery and the absolute necessity for cutting expense to the last mite. Trial and error is far too slow and costly for us; it is only by the application of up-to-date scientific methods that a satisfactory solution can be found in time to be of economical use.

One of the objects of present-day research is to replace those long and expensive full-scale tests by rapid and economical proof in the laboratory. For this purpose the Building Research Station includes engineering, chemical and physical laboratories, with a testing plant ranging from small and ingenious mirror micrometers to a five-hundred ton press. There is also a detached structure to represent a small villa, but constructed so that careful investigation can be conducted to find the best practical conditions for solving the heating and ventilating problems involved. The material of which the exterior is built in panels, can be changed at will to enable comparative tests to be made, while leaving the main skeleton intact.

The work of the Building Research Station is organized in two main divisions: general research and intelligence. The nature of the former has been indicated. Under the latter are grouped Special Investigation, Publications and the Information Bureau. The general research section is endeavouring to study the fundamental properties of building materials and to devise quick weathering tests, etc., while the special investigation section applies the information so obtained to the solution of special problems submitted to them by various enquirers. Information collected by the bureau either locally at the Station or through English and Foreign periodicals, is freely available to anyone, and unless the enquiry necessitates special experimental work, no fee is charged.

The general work of the station is published through H.M. Stationery Office in the following forms: Special Reports dealing with matters of immediate practical application and intended primarily for the industry; Bulletins or summaries of information on different aspects of the trade written for the most part in non-scientific language; Technical papers, generally of the nature of scientific memoirs; and Communications made from time to time to the technical journals and the daily Press.

The work is grouped under four main headings. Efficiency of

Buildings from the standpoint of the User: deals with such subjects as ventilation, heating, acoustics, etc., and tests are carried out in experimental buildings erected for the purpose. A method of recording continuously the heat flow into the wall of a living-room has been devised, and it is proposed to compare the heat losses through different types of construction for different weather conditions; also different types of heating and ventilating installation are to be compared. Weathering: endeavours to find the reasons for the weathering of various materials. Why does the form of weathering in one stone differ entirely from that in another? What are the relative values of temperature, moisture, chemical and frost effects, and how can they best be resisted? Is the use of stone preservative of any value whatsoever? When the mechanism of weathering is better understood, there will be more possibility of devising reliable accelerated weathering tests upon various substances. Materials: under this heading are studied the physico-chemical properties of building materials, including cements of various kinds and the possibilities of new ones, limes and plasters, pozzolanic materials, bricks, tiles, terra-cotta, etc. Structures and Strength of Materials: this heading includes a great variety of research; both the effect of vibration on buildings and the effect of repeated stresses on building material other than metals, which are being studied elsewhere, the effect of wind-pressure upon roofs and other structures; adhesion and shear in reinforced concrete; foundations and earth-pressures, strength of brickwork and masonry, and the standardization of test methods generally.

The Director emphasized the fact that the Station exists to help the industry, but the value of its work must greatly depend upon the help given to the Station by the industry in its turn. He would appreciate any information about matters of interest or difficulty. Even puzzling minor difficulties or successes are of importance, as they may hold the clue to the solution of much larger problems. Probably at the present time as much may be learnt from failures as from successes.

The most urgent requirement of the present day is to broadcast the results obtained from known and proved successes and failures, as well as those which are the outcome of substantiated tests, so that the information may be available for everyone concerned. R.E. Officers will be particularly interested. Their work lies in scattered localities and detailed technical information on the matter in hand is seldom procurable in the time available. For us, to attain real and progressive efficiency in this branch of our activities, as in the others, it is essential that we should be able to obtain and make the fullest possible use of up-to-date scientific knowledge and of modern technical methods. For many materials and methods, that have long been hallowed by tradition, are quite incompetent

to obtain the requisite blessing from finance to-day. D.W. Technical Instructions are published to meet this want.

A very short résumé of some of the more interesting results obtained from experiment may be of interest. It is hoped to give a fuller account of the tests in another issue.

One of the usual causes of the disintegration of external stone and brickwork in this country has been found to be the formation in or immediately below the surface of crystalline calcium sulphate (or crystals of certain other salts) caused by the action of sulphur acids dissolved in rain-water on the lime and lime salts already present. The discovery of this phenomenon has two wide-reaching results and bears an important message for all who are charged with the maintenance of buildings.

When the comparatively soft lime mortar in a joint falls out, it is customary to rake out the joint and repoint it in a hard cement. The efflux of the discharge which caused the trouble is thus diverted to the brick or stone, with the result that the fabric of which the building is constructed is forced to flake away at the side of the joints instead. As long as lime or other salts soluble in rain-water impregnate the material, the pointing should be looked upon as the fuse of an electric circuit, the function of which is to preserve the more valuable part of the installation. Any repointing should rather be done in lime mortar; that is, the fuse must be replaced.

As far as is known at present, the best way to preserve brick or stone is to wash it with the fire hose, twice or three times a year. This can often be arranged in conjunction with the usual fire-alarm tests without further labour or expense. Not till all the deleterious salts have been washed out should building material be covered up with cement.

In the construction of reinforced concrete the cement tends to contract when drying out, while the steel members resist this tendency. The more quickly cement is made to dry, the greater this force of contraction. So that in the case of very rapid hardening cements, the resulting state of unstable equilibrium of the mass is ominous. So much so, that under certain circumstances a shock or concussion might disintegrate it. This might have considerable effect in the case of piles or reinforced concrete work in fortifications in time of war. To reduce the internal stresses, concrete should be allowed to dry slowly and as far as possible in contact with water.

A more detailed account of the activities of the Station are shown below.

Efficiency of Buildings from the standpoint of the User.

1. Acoustics of buildings.

2. (*a*) Solar radiation on thin roofing materials.
   (*b*) Heat insulating properties of materials and construction.
   (*c*) Heating and ventilation.
3. Absorption of moisture by internal wall coverings.
4. Fire-resistant construction.

Weathering.

1. Development of accelerated weathering tests.
2. Movements of materials due to :—
   (*a*) Temperature changes.
   (*b*) Moisture changes.
3. Preservation of stonework.

Materials.

1. Physico-chemical phenomenon of building materials, including study of possible gel structure.
2. Constitution, micro-structure and correlation with physical properties of cements.
   (*a*) High alumina cements.
   (*b*) Portland cements.
   (*c*) High magnesia cements.
   (*d*) Portland blast-furnace cement.
3. Limes and plasters.
   (*a*) Classification.
   (*b*) Physical and chemical properties.
4. Pozzolanic materials.
5. Paints.
6. Bricks and terra-cotta.

Structure and Strength of Materials.

1. Vibrations in buildings.
2. Fatigue in building materials (other than metals).
3. Effect of wind-pressure on structures (in conjunction with Engineering Research Board).
4. Physical changes due to temperature and moisture changes.
5. Reinforced concrete—shear and adhesion.
6. Special structures—domes and special roof trusses.
7. Standardization of test methods.
8. Foundation and earth-pressures.
9. Reinforced concrete slabs.
10. Strength of brickwork and masonry.
11. Reinforced concrete columns.

General Laboratory Work.

Collection of data on the properties of materials and their method of manufacture.

LIST OF PUBLICATIONS ISSUED OR IN PREPARATION.

"Experimental Cottages." A report on the work of the Department at Amesbury, Wiltshire, by W. R. Jaggard, F.R.I.B.A. (1921)

Special Reports:—

No. 1. "Sand-lime and other Concrete Bricks," by H. O. Weller, B.SC., M.INST.C.E. .. .. (1921)
No. 2. "Experiments on Floors." .. .. (1921)
No. 3. "The Stability of Thin Walls." .. .. .. (1921)
No. 4. "The Transmission of Heat and Gases through, and the Condensation of Moisture on, Wall Materials." .. (1921)
No. 5. "Building in Cob and Pisé de Terre." .. .. (1922)
No. 6. "Graphical Cost Analysis of Cottage Building." .. (1922)
No. 7. "Heat Transmission through Walls, Concretes and Plasters." Experiments carried out at the National Physical Laboratory, by Ezer Griffiths, D.SC. .. .. .. (1923)
No. 8. "Fire Resistant Construction," by R. E. Stradling, M.C., D.SC., PH.D., A.M.INST.C.E., and F. L. Brady, M.SC., A.I.C.
No. 9. "Lime and Lime Mortars," by A. D. Cowper, M.SC., A.I.C.
No. 10. "Breeze, Slags and Clinkers as aggregates in Concrete," by F. M. Lea, M.SC.

Bulletins:—

No. 1. "Jointless (Magnesium Oxychloride) Floors," by P. W. Barnett, A.R.I.B.A., and B. Bakewell, M.A. .. .. (1925)

Technical Papers:—

No. 1. "The Stress Analysis of Bow Girders." .. .. (1926)
No. 2. "Primary Stresses in Timber Roofs (with special reference to curved bracing members)," by A. J. Sutton Pippard, M.B.E., D.SC., and W. H. Glanville, B.SC., A.M.INST.C.E.
No. 3. "Permeability of Portland Cement Concrete," by W. H. Glanville, B.SC., A.M.INST.C.E.
No. 4. "The Determination of Free Lime in Hydraulic Cement," by F. L. Brady, M.SC., A.I.C., and F. J. McConnell.
No. 5. "The Consistence of Cement Pastes, Mortars and Concrete," by N. Davey, B.SC., A.M.INST.C.E

THE ORIGIN OF TUNNELLING COMPANIES, R.E.

A Speech by LIEUT.-COL. SIR JOHN NORTON-GRIFFITHS, BART., K.C.B., D.S.O., *at the Tunnellers' Dinner.*

IT gives me very great pleasure, not only to be your guest to-night, but to have an opportunity of thanking my old friend, General Harvey, for the generous terms in which he referred to me at your last Annual Dinner. Owing to my absence abroad it was impossible for me to accept your last year's invitation, but I read of what took place then, with keen interest, from your annual record, and it made me still more disappointed that I had been unable to attend.

It has been suggested that I might give you this evening the very early history and the origin of Tunnelling Companies, R.E., so that this can perhaps be placed on the records of the Association.

During the early days of the War, I was eating my heart out with the Regiment I had been permitted to raise by Lord Kitchener, the 2nd King Edward's Horse, longing to get to France and seeing no prospect of so doing. In thinking over the position that was taken up so early in the war, of the opposing trenches being so near together, as an old miner the idea of undermining and blowing up the enemy occurred to me. As early as November, 1914, I sent in a scheme to the War Office and begged permission to be allowed to take out a handful of men, whom I described as "Moles," and start, but although the scheme was listened to sympathetically, and, indeed, sent out for approval to France, it went no further, until early in February, 1915, I got a telegram to report immediately to Lord Kitchener, and well do I remember that interview. Alone in his room at the War Office, he showed me the urgent despatches which had been coming from Lord French, to the effect that unless some means could be found of checking the mining efforts of the Germans, he (Lord French) would probably have to withdraw certain sectors of the line. Lord Kitchener, to whom I had had the honour of being known, both in the South African campaign and in Egypt, asked me to amplify my suggested mining scheme. Just before this interview the Boche, it will be remembered, had given us a nasty blow at Ypres, had lifted, almost *en bloc*, some of the 16th Lancers in a dug-out near Hill 60, and had buried some 22 or more men at Givenchy, in addition to several minor mines they had sprung on our front trenches.

To his demand I replied, the only thing I could suggest, subject to examination of the ground, would be to use "Moles"; when he

said, "What on earth are 'Moles'?" I said "Clay-kickers, or workers on the cross," using a North Country expression for this class of small tunnel mining. As his patience showed signs of giving way, I then proceeded to demonstrate, with the fire shovel from the War Office grate, and showed him, lying on the floor, what a clay-kicker really was, and what a small hole he could work in, with the result that he turned around and said, "Get 10,000 immediately." I replied that I did not think there were 10,000 in the British Isles, and that it would be necessary to examine the ground before one could ascertain whether this form of mining were possible. The result was, I was off that very night to France, with two of my expert underground tunnellers, who were then employed on important underground works at Manchester for that Corporation. I found, on arrival, that we could at once begin operations to answer the Hill 60 attack, and proceeded, the same day, to Givenchy, where, on hearing a cry of "Hello! there's Empire Jack," I found in the trenches some of my old Wednesbury friends in the Wednesbury Company of the Staffordshire Regiment, many of whom were miners themselves and were accustomed to mining in the narrow seams which exist in some of the Staffordshire coal-fields. The consequence was that I reported to General (now Lord) Horne, Commanding the 2nd Division, to whom I had been sent, that, with the help of the men on the spot, under, I think, Captain Morgan, of the Staffordshire Regiment, also a mining engineer, they could devise a means of defending themselves while I returned to report to Headquarters and the War Office.

I reported back that same night and saw Lord French, explained to him what the position appeared to be, crossed that night, and reported next morning to Lord Kitchener and laid before him what I thought was possible, and that the position was more than serious for the poor devils doing the dirty work in the trenches, for you could not expect Tommy to be shot at from the surface, boofed at from above, and blown to Hell from below. This was on Tuesday, February 15th, and the first bunch of clay-kickers was in the trenches on the following Friday, and in a very short time, you will all remember, we gave them a jolly good answer at Hill 60.

Resulting upon this, almost unlimited powers were given me to rush men out and begin work while the powers-that-be were thinking out the necessary regulations to govern tunnel companies, then described as "Moles" for the purpose of secrecy, which ultimately became part of the Book of Regulations. Well do I remember the early stages, when men were rushed to Chatham, put into kit, and, as under the regulations no man could leave this country without carrying a rifle and 150 rounds of ammunition, we experienced something approaching terror as we wondered whether each man would be shooting the other before we got them to the other side, when we promptly disarmed them—anyhow as far as ammunition went. Well

do we all recollect some of those splendid fellows rushed into the trenches within three or four days from the date it had first been suggested that they should join the Tunnelling Companies;' hurried up in special lorries awaiting them at Boulogne, with no rest, right in the very fiercest part of the battle front, without any training whatsoever, many of them never having held a rifle in their hands before. One old muck-shifter of mine remarked, "The sooner I get underground the safer I shall be." The pick of the British mining industry threw themselves heart and soul into the work, showing, in record time, that for mining progress and speed, no one could touch a Britisher, or even equal him at that game.

At that time there was no question of how many: "Get as many as you can." We started by forming one company after the other as circumstances demanded. But you all know the ultimate result, that in a very few months we had raised 35,000 miners, who were embodied in Tunnelling Companies, beginning at the 170th Tunnelling Company R.E., up to the 215th, I think, to which must be added the Tunnelling Companies later brought over by the Canadians, Australians and New Zealanders, and also the South African unit. To obtain this I corralled the assistance of Sir John Cadman; we searched England, Scotland and Wales, addressed meetings and mine-owners, and called for volunteers at a rate of so many from each mining centre. We then had to search the mine rescue stations for Proto sets, and other life-saving devices. One thing after the other was developed, including listening-schools behind the trenches, and the finding of some explosive somewhere between the local effect of the high explosive and the slower black powder, resulting in our excellent old pal, ammonal, which gave such a good account of itself.

It is amusing now to remember that in this capacity we sought the assistance of the Metropolitan Water Board, and borrowed the listening sticks they used for tracing leaking water-mains. All these different phases we went through, culminating in one of the most efficient and up-to-date units in the British Army, who were able to hear Mr. Boche scratching his head when he was wondering if he was going to bury us alive in our lines.

The records of the first few months of those hurriedly raised units can be taken as a world's record in footage of a necessity of a defensive nature. None of you here will ever forget the heroism of many of our old comrades who were buried in their efforts to counter the German underground attack on our trenches, and the many lone hand-to-hand fights to the death which took place in the dark between tunneller and Boche miner, when occasionally we broke into their tunnels when counter-mining. Many incidents would thrill anyone to the marrow when recalling the extraordinary and unexampled individual bravery and energy which took place in connection with this underground work.

But my desire to-night is more to tell you the history of the Messines Ridge effort, culminating, as it did, in the greatest mining effort in the history of the world. Directly the position our troops occupied under the Ridge was realised, and as soon as we gleaned that the underlying strata was indeed blue London clay, it became obvious that it was a simple, although rather lengthy job, to run a system of deep mines to undermine the whole ridge. You all know the result. But may I tell you of the difficulties we encountered at the inception of the idea? The order came that our tunnelling was to be of a defensive and not offensive nature, and when we had decided that the deep mining was a feasible proposition, it took nearly six months to get the necessary authority to put the work in hand. Both G.H.Q. and the Army Council at that time were averse to adding another spoke to a well-filled wheel if it could possibly be avoided, and, although it was suggested in July, 1915, authority was not obtained until January, 1916, when my old chief, that great man General George Fowke, took me, with the then "Colonel" Harvey, for an interview with the five Army Commanders, upon which interview we considered so many lives depended. At that interview the scheme was unfolded to them, and I do not think it would ever have been undertaken had I not then said we could guarantee that if our mining system were completed—and we saw no reason why it should not be—it would save the lives of at least 10,000 men and that when the day of the attack came the Army could walk to the top, smoking their pipes. I well remember these words being used, for we all knew, from the attack which had already been made, the impossibility of a frontal attack on the Ridge being successful unless we were permitted to co-operate by undertaking this work. It was explained that the intention was, not to "blow out" but to earthquake the whole of the Ridge, which, owing to the fact that the sand hills were virtually one big hill of sand, sitting on blue clay, gave us a splendid opportunity of achieving success in this direction, and we guaranteed not a single German machine-gun, of the thousands that existed on the Ridge at the time, would bark on the day of the attack, if that attack were preceded by our little earthquake.

The answer was still in the negative, but late that night, my chief, General Fowke, informed me that authority had been given and we could proceed with the laying-out of this work. The sites of the two main shafts were selected, ringed in and marked "Water wells—no admittance," and, in this connection, it will be recollected that the season had been a very dry one and that there had been difficulty in getting good water, so it was an appropriate name to hide up our efforts. I well remember this period, because our old friend, General Swinton, was at the same time fighting just as strenuously to get authority to develop the tanks. We used to put our heads together in secret and wonder how we could persuade the Powers-that-be to get

the necessary authority for him to do what he wanted and for us to do what we wanted.

Great anxiety was constantly expressed by the Army Commanders as to what would happen when we let off such a vast quantity of explosives, and so much uncertainty existed in the minds of the higher officials that a consultation took place at the War Office between two or three of the leading members of the Institution of Civil Engineers, with a view to ascertaining how close the troops could be when the mines were ultimately let loose. Owing to my being sent off on another mission to Rumania, I had not the opportunity of seeing the result of this splendid effort, but I was profoundly touched when, on my return from Rumania, I had an invitation extended to me to go and see the result. All we said had come true. There was not the slightest doubt in anyone's mind that the frontal attack without the mines would have been an absolute failure, and would have cost, not 10,000, but 50,000 men, while the attack, preceded by this stupendous artificial earthquake, which shook the Ridge from end to end, and which made the pill-boxes topple over at all angles, supported by the terrific bombardment of our guns, which had been going incessantly, enabled the Army, as we had promised, to walk to the top of the Ridge in comparative safety.

The end of this big mining effort we all know. In the Plugg Street section, in the southern end of the Ridge, a group of mines still in the clay belt were held in reserve as a surprise packet for any counter-attack which it was thought the enemy might make. But the earthquake effect, as far as mining went, was such an indication of goodwill that the contemplated counter-attack never took place, and tons of ammonal had to be de-mined.

The work of Tunnelling Companies, being responsible for the safety underground of the whole British front, became of such stupendous importance that our Engineer-in-Chief, that brilliant soldier General Sir George Fowke, after many conferences decided that it was necessary to have its own General Commanding, with necessary staff at G.H.Q., which resulted in the selection of Colonel Harvey as your G.O.C., with that brilliant mining engineer and born soldier, Captain Stokes, and we all know what magnificent work they did, and the assistance and help they gave to all you good tunnellers who had to do the actual work in the trenches.

Reverting to Messines, it is interesting to recall that this enormous mining undertaking on the Ridge, although only begun in February, was ready for the big offensive intended for July, 1916, but, owing to the developments on the Somme, it had to be postponed for a year. Through the whole of that year this huge system of underground mines lay, fully charged and bottled up, and some of us will remember, when the shafts were boarded up and camouflaged purposely to resemble dug-outs, the Boche raided a portion of our trenches, Plugg Street

end, and actually occupied one of the dug-outs for some days, not knowing that underneath them was the main shaft of one of the most powerfully charged group of mines in the world. However, before they discovered our secret, they were driven out in a counter-attack.

It may not be out of place to recall one of the early incidents near St. Eloi, in what were then well known as the E. and F. trenches. None of them communicated in those days and, when we were trying to pole down through running sand, which sat on top of the clay belt, as silently as we could, in one place, not 70 metres distant, came a German voice, in perfect English, telling us that it was useless to try, as they had done so and failed. One of the best bluffs we put up in the very early stages, when any noise of a tapping nature was taken to be an indication that the Germans were undermining the trenches we were occupying, was to hurriedly sink a little pit, run a heading in, about 20 or 30 feet, wedge up a cross-bar, and hang on it a pick-head or shaft with a bit of string attached to the top, this being pulled from the surface at odd moments against a board jammed in the face, and would cause the Boche to imagine that we were also mining, which resulted in putting the wind up Master Boche and in many of their mines being blown short.

I could give you case after case and story after story of individual bravery and resource, equal to anything in the Service, if time permitted, but I must just remind you of a splendid R.E. officer, of the name of Colonel Griffith, who was C.R.E. of one of the 5th Division units; in answer to an urgent telegram "Send Griffith enemy mining" (meaning me)—he proceeded, with two miners who had just arrived from England, to a dug-out on the front line. It was said they had had, perhaps, a wee drop too much, but after listening very carefully with their ears to the ground, they reported to Colonel Griffith, who was slightly deaf, that the noise must be the result of two male rats quarrelling over a lady rat—*Cherchez la femme!*

Before I sit down, there is one thing I should like to refer to.

I don't know if any of you here to-night have been to Edinburgh and seen the Scottish War Memorial. It is an immensely impressive and moving edifice, but what particularly appealed to me was, that when the suggestion was made that "the humble beasts who also served and died" should be commemorated, a tablet was chosen, depicting our little friends the white mice and the canaries, and has been beautifully carved on one of the pillars of the Chapel, and is entitled "The Tunneller's Friends." That must appeal to all of us, and many, I am sure, will make a special pilgrimage to Edinburgh to pay their tribute of affection to the little beasts who helped you in the early stages of difficulty and danger.

This has been a great evening for me, and recalls one of the happiest periods of my life, when I had the honour of being one of you. Here's to the Tunnellers!

ANTI-TANK MINES.

By Lieut. M. O. Collins, R.E.

In modern warfare there are at present only two defensive weapons against a Mechanized Force:—

The Anti-Tank Guns,
The Anti-Tank Mines.

The latter are at present under R.E. control and so, perhaps, a few theories on their employment may not be out of place.

The employment of Anti-Tank Mines falls naturally into two categories:—

(*a*) Permanent Defences.
(*b*) Mobile Warfare.

(*a*) Permanent Defences.

Under this category fall all forms of field fortification, in the preparation of which reserves of time and material are available. The mines can be laid in two definite ways:—

as a single obstacle, or as tactical fields to force the tanks along definite lines of approach, which will be covered by Anti-Tank Guns.

If it is required to render a large area of ground impassable to tanks it is unnecessary to cover the whole of it with mines. Four rows of mines around the perimeter will be sufficient to neutralize the area.

When the fields have been laid, large-scale maps will have to be produced showing the exact location of the fields.

To prevent the possibility of these maps passing into enemy hands, they should not be distributed to Units. Tracks, which could easily be closed, and changed, should be wired in across the fields.

(*b*) Mobile Warfare.

This category is, perhaps, the more important and certainly presents the more complicated problem of the two.

The more that armies become mechanized, the more unlikely does position warfare become, as the mobility and fighting power of a mechanized force prevents anything like a permanent defensive position being evolved in the face of the enemy.

The problem divides itself naturally into three parts:—

(i) The Organization and Distribution of Anti-Tank Mines.
(ii) The method of laying and the best position for fields.
(iii) The recording of fields and the transmission of their position to units concerned.

(i) *Organization and Distribution.*

The present policy is to carry a number of these mines with the Field Park Company, and these would be laid by the R.E. with the assistance of Infantry working parties. This would be suitable for stabilized warfare, but much too slow for mobile operations; in the latter case mines have to be laid at a moment's notice to block a defile, and a section in a Field Company has to be kept ready for this work, and it is often unable to obtain a working party in sufficient time to provide the necessary labour. Defence against armoured fighting vehicles (A.F.V.) is so important that it is suggested that a separate unit be formed for this work.

For preliminary trials this unit might take the form of an A.T.M. section for each Brigade composed of R.E. and Infantry personnel.

It is assumed that each section would have up to 1,250 mines; then, according to the organization given below, the personnel would consist of 2 officers and 28 other ranks, and the transport would consist of 9 motor-driven vehicles.

ORGANIZATION OF AN A.T.M. SECTION.

Vehicle	Officers	N.C.O.s	Drivers	Men	Mines	Remarks
H.Q. Sub-section—						
1 H.Q. lorry ...	1	1	1	4	50	
1 lorry		1	1	3		For record-
2 lorries		2	2	8	600	ing.
1 motor-cycle ...			1			As D.R.
No. 1 Sub-section—						
2 lorries	1	2	2	8	600	
2 motor-cycles ...			2			As D.R.s.
	2	6	9	23	1250	

The vehicles designated as lorries would be six-wheelers, if possible. The H.Q. car would of necessity have to be a six-wheeler.

The lorry for recording the fields would be provided with tables and large-scale maps, and would be under the charge of the senior N.C.O.

One section would be attached to each Brigade H.Q. and one to each Division H.Q.

The Division Section would have an officer in charge of the recording lorry in addition.

The *modus operandi* of these sections will be described later.

(ii) *Laying the Fields.*

At this stage it is, perhaps, advisable to consider the area a Brigade Section would be able to cover with its mines.

When laid in a single row, they should be 1 ft. apart. Thus 300

mines are required to every 100 yds. of length, or to neutralize an area 100 yds. square, 1,200 mines are required.

This shows that Brigade Sections can only cover a very small area without a further supply of mines from Corps reserve, and the more mobile the operations, the more uncertain and difficult will be the supply of mines from these reserves.

Unless the laying of fields is vitally necessary, a more economical method of laying mines should be adopted.

The number of mines required to block a road or track is between 10 and 20. Thus tracks can be blocked in fairly large numbers, and the Brigade Section can still be left with sufficient mines to deal with an emergency.

The modern A.F.V., although capable of moving across country, is more mobile on roads or tracks, and tends to keep to these forms of approach until its proximity to the enemy forces it to deploy across country. If all important roads or tracks around a moving or stationary Brigade, at some distance from the Brigade, are blocked, it will greatly reduce the attacking speed of any opposing A.F.V.s.

Unlike other forms of road block, mines do not need to be covered by fire, as the less they are brought to the notice of the enemy the more likely are they to perform their *rôle*. This is to disable an A.F.V. in the road and to force the remainder of the enemy either to move across country, or to make a circuit round the block, thus delaying them and allowing the Brigade sufficient warning of their approach.

It is argued that it is wasteful to employ mines on these road blocks, when trees and farm carts could be utilized. A farm cart, however, is not much of a block against a tank, and, to render the road impassable to all forms of A.F.V., trees have to be felled across the road.

To fell trees across the road, time, labour and tools are required, and these tools are only obtainable from Battalion or Brigade reserves.

In order to block the more obvious approaches in this way, large numbers of Sappers would probably have to be detached.

Thus to economize mines by not using them in road blocks would in general be false economy, as it would entail the distribution of Sappers on the outskirts of a Brigade, for whom there is work of more vital necessity.

The method of employing a Brigade Section when the Brigade was either on the move or stationary would be as follows.

No. 1 Sub-section would be sent out to block all obvious tank approaches, and, where possible, to block them in defiles.

The H.Q. Sub-section would remain at Brigade H.Q.

When air report, or other information, of an impending attack by hostile A.F.V. was received, the H.Q. lorry would proceed as fast as possible to the line of approach of the attack, followed more slowly

by one or more of the lorries of the H.Q. Sub-section. When it arrived, it would lay mines to limit the lines of advance of the enemy A.F.V., so as to bring them under the fire of Anti-Tank Guns.

It is quite possible to construct a chute to lay mines from a moving vehicle.

These mines are not buried, but, if the grass or undergrowth is more than six inches high, they are not visible until the tank is actually on them.

If the tank succeeds in stopping before reaching the mines, one of the crew will have to get out to remove them, a difficult and dangerous feat if the field is under fire.

Moreover, mines laid in this way can be quickly collected when they are no longer required.

(iii) *Recording the Fields.*

It is unlikely in future wars that Units will be issued with a map of scale larger than 1 in. to the mile, and although A.T.M. Sections themselves may have larger scale maps, fields should be laid, where possible, at places easily recognizable on a 1 in. map.

The places most easily recognizable on a 1 in. map are defiles or road junctions.

It is impossible to lay a field in a road or track so that it is invisible.

If a Unit requires to move over a field so laid, its position can be indicated within 100 yds. on a 1 in. map, and a few moments' careful search should be sufficient to locate the field.

The usual procedure in recording fields would be as follows:—

The approximate positions of fields to be laid would be given to Sub-sections before they left Brigade H.Q. These approximate positions would be recorded in the recording lorry.

When Sub-sections were laying fields, they would inform local Unit Commanders of their position. If other positions were found suitable for fields, they would be reported to Brigade H.Q. as soon as possible by D.R.

As soon as all fields were laid, Brigade H.Q. would be informed of their exact positions by D.R.

Brigade H.Q. would be responsible for transmitting the positions of all fields, laid or being laid, to Division H.Q.

To prevent delay, Brigade and Division recording lorries will have lists of minefields prepared, giving the exact position of fields laid, and the approximate position of fields being laid, so that when a Unit Commander asked for a position of fields he would be handed a list and he could cross off all fields that would not affect him, in order that he might issue lists to subordinate Commanders.

THE LIFE-WORK OF THE RT. HON. SIR GEORGE TAUBMAN-GOLDIE, K.C.M.G., P.C.

By LT.-COL. P. H. KEALY, R.E. (*retired*).

THERE died on August 20th, 1925, at the age of 79, a great administrator and Empire builder, Sir George Goldie. He was the maker of Nigeria, and, as he started his career in the Royal Engineers, some account of the work he accomplished should be of special interest to the Corps.

George Dashwood Taubman-Goldie was a Manxman, the youngest son of Lieut.-Colonel J. T. Goldie Taubman, Scots Guards, Speaker of the House of Keys, and was born in the Isle of Man on May 20th, 1846. He was intended for the Army, and after passing through the Shop, obtained a commission in the Royal Engineers on 22nd December, 1865, which he resigned on 24th July, 1867.

After some years of African travel, Goldie first visited in 1877 what is now Nigeria, a vast territory of some 500,000 square miles, the bringing of which under civilized rule and its eventual inclusion in the British Empire was to form Sir George Goldie's life-work.

He visited the country with his brother, intending to ascend the Benue (the great eastern tributary of the Niger) to Yola, and thence cross to the valley of the Upper Nile, where they had previously travelled together. Various events prevented the journey being carried through, but it was at this time that Goldie conceived the idea of bringing the region now known as Nigeria under the sway of Great Britain. For the next twenty-three years all his endeavours and foresight were directed to its accomplishment, which was finally brought about in 1900.

During the seventeenth and eighteenth centuries there had been much speculation as to the course of the Niger. Traditions of a great river flowing from west to east had come down from Roman times, and it was generally supposed to discharge into a great lake or to join the waters of the Upper Nile. Or alternatively it was believed to flow westwards from the Nile, and to enter the Atlantic by two mouths, the Senegal and the Gambia.

Many unsuccessful attempts were made in the eighteenth century to reach the Niger by expeditions from the Guinea Coast, from the north across the Sahara, and from the Nile basin. In 1793, the

African Association sent out Mungo Park, who started from Gambia, and reached Sego on the Upper Niger on July 20th, 1796. He was the first recorded European to see the upper reaches of the Niger. After travelling down the river a short way as far as Silla, he made his way back, and reached the Upper Gambia, after incredible hardships, on June 10th, 1797.

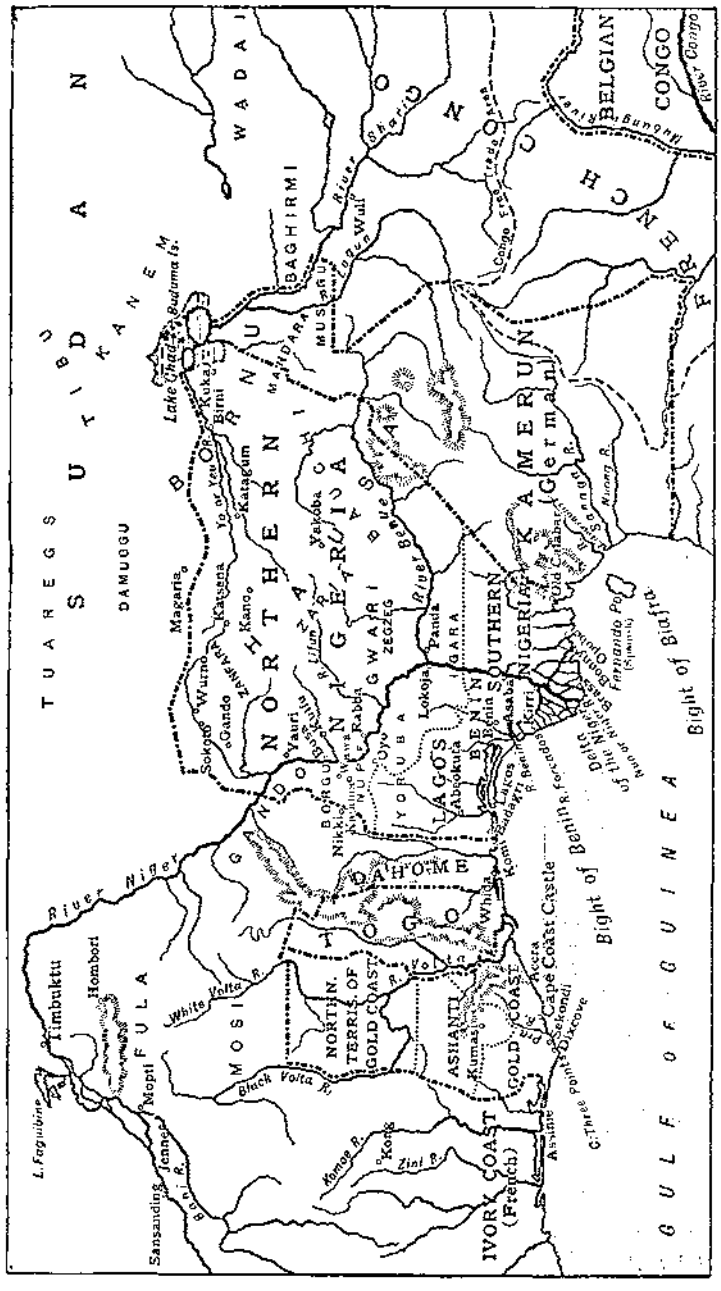
Though the Niger had actually been seen, its further course was still a question of guesswork, and Mungo Park considered the river found its outlet to the sea as the Congo. He was anxious to trace the further course of the Niger, and in 1805 left the Upper Gambia again, with a better-equipped expedition. He eventually reached the Busa rapids on the Lower Niger, at no great distance from the sea, having descended the river from Sansanding in a boat built by himself and other members of the expedition. Here he was attacked by armed natives, and he and the other remaining Europeans were drowned in 1806. The fate of the expedition was not known in England till 1811.

In 1815, the Government sent an expedition under Captain Tuckey to the mouth of the Congo, to sail up the river, and try to reach the Niger or Lake Chad. This expedition only reached 160 miles from the sea, and accomplished nothing.

Owing to our annexation of Malta, and the information gained from our Consuls in Tripoli, the next attempts were made across the Sahara. The first one, in 1818, came to an end with the death of its leader, Mr. Ritchie. In 1822, a second attempt was made by Dr. Oudney, Lieut. Hugh Clapperton, R.N., and Lieut. Dixon Denham, of the British Army. The expedition reached Lake Chad, and did a lot of exploration in Bornu, but failed to clear up the Niger mystery. Clapperton led another expedition in 1825, having as his servant one Richard Lander, who was the man who eventually solved the Niger problem. This expedition did a lot of exploration, but got no further down the Niger than Busa, where Mungo Park had met his death in 1806. In 1830, Richard Lander, "ex-page-boy, valet and footman," aged 25, and his brother John, aged 23, were sent out by the British Government, and landed at Badagri, on the West Coast, near Lagos. From here they made their way northwards till they reached the Niger about Busa. They obtained permission with some difficulty to descend the river in canoes, and after many adventures and dangers reached the sea, and the problem of the Niger had been solved.*

Further exploration was carried on by expeditions sent out by the Government, but in 1865 the British Government of that day had washed its hands of further exploration, and apparently took no

* A popular account of the adventures of these early explorers will be found in *Pioneers in West Africa*, by Sir Harry Johnston.



By courtesy of Messrs. Blackie & Son, Ltd., Glasgow.

more interest in the immense possibilities of the country. The field was thus left open for private enterprise, and in 1877, the date of Goldie's first visit, a number of enterprising firms were trading independently, and in competition with each other, on the Lower Niger.

The first task in his great design accomplished by Goldie was the amalgamation in 1879 of these various trading interests into the United African Co., Ltd. The capital was but £125,000, and was no measure of the great and beneficent schemes in the mind of the organizer. It was a deliberate part of the policy of the Company to extend as far as possible political influence over the numerous tribes of the Lower Niger, and a system of treaty-making with the chiefs was entered into, which formed the basis of the vast authority which the Royal Niger Company eventually exercised.

The appearance of a French company on the Niger introduced a disturbing element, and caused Sir George Goldie to take steps to obtain for the Company a position which would enable it to deal with foreign aggression and interference. In 1881, he started the application for obtaining from the British Government a Royal Charter for the Company, and the negotiations lasted five years. It was a case of determination and perseverance eventually prevailing over official indifference. At his first interview with the Cabinet Minister whose department seemed likely to be most interested in the question, Sir George Goldie was asked what was the capital of the United African Company. When told it was only some £100,000, the Minister said it was unlikely the Government would even consider the granting of powers over so vast a district to such a small concern. Sir George then asked whether a capital of one million would be enough, and the reply was, " When you have a million, come and see me again." Eight months later the National African Company, with a subscribed capital of one million sterling, was successfully launched !

The Charter, however, was not yet granted, but circumstances eventually forced the hands of the Government. The new company publicly included in its aims political as well as commercial objects, and stated its intention of extending to the powerful Mahommedan states of Gando and Sokoto in the interior the same system of treaty-making which had proved so successful with the pagan tribes of the Lower Niger.

The public announcement of this intention had possibly unexpected results. It awakened the interest of other European nations in the country, and brought into the field two French companies, which started to compete with the National African Company, both in trade and in political aims. French policy at that time was believed to be aiming at creating a Franco-African Empire, which would have

extended from the present Congo Free State to the Mediterranean, and would have included the Lower Niger.

The two French companies conducted their affairs with such energy that the position of the National African Company was directly challenged, and the latter found itself forced to take up the challenge or retire from the field. After heavy outlay, the French companies were bought out, and this course was facilitated by the temporary reaction in French Colonial policy brought about by the disaster in Tonkin.

Hardly had this settlement been effected in 1884 than Germany adopted a new and vigorous Colonial policy in Africa, and declared a protectorate over the Cameroons and Togoland.

The ensuing scramble for African possessions brought about the Berlin Conference of October, 1884, when fourteen nations attended to consider the African situation. Sir George Goldie attended the Conference as the Company's representative, and, thanks to the far-seeing policy which had been adopted, he was able to declare that "The whole trade of the Niger Basin is at the present moment exclusively in British hands." The British position was unassailable, and the General Act of the Conference, which was signed on February 26th, 1885, left the territories of the Lower Niger and the lesser streams, known as the oil rivers, exclusively in British hands.

The boundaries of these territories upon the coast were, on the western side, the frontier of the British Colony of Lagos and, on the eastern side, the frontier of the German settlement of the Cameroons. The inland limits were at the time left undetermined, although they, of course included the confluence of the Niger and the Benue. Free navigation of the Niger River was also secured to the merchant shipping of all nations in peace time.

The British Government was now faced with the necessity either of itself undertaking the administration of the country or of granting the Company a Royal Charter, which would make its treaties with native states valid as against another civilized power. The latter course was adopted, and in 1886 the Charter was granted and the National African Company became the Royal Niger Company. Lord Aberdare was the first Chairman and Governor, and Sir George Goldie, Deputy-Governor.

The years that followed witnessed the keenest rivalry amongst the European Powers to obtain possessions in West Africa, and it was well for the Empire that the affairs of the Royal Niger Company were in such strong and capable hands. It will be remembered that the inland boundaries of the Royal Niger Company territories had not been fixed, and that left the question of the great Mahommedan States, of Sokoto, etc., known as the Hausa States, in the air. In

this matter the Royal Niger Company had to face the ambitions of two first-class Powers, France and Germany. The Company had, however, acted with foresight and promptitude, and had dispatched an envoy to Sokoto, who, in 1885, obtained from the Sultan a treaty recognizing the status of the Company, and giving it jurisdiction over his territories on the banks of the Benue and Middle Niger, and certain rights of political influence and commercial privileges over the remainder of his Empire.*

When the Company had gained its Charter all treaties already made were confirmed, and the system of treaty-making was extended, the later treaties containing clauses which recognized the Royal Niger Company as the representative of the "Queen of Great Britain."

In dealing with the international situation, the Company was at all times careful to embarrass the Home Government as little as possible, and, in the case of Germany, conceded to the Cameroons their rights in an outlying province of the Sokoto Empire where the Company was represented and Germany was not. The boundary line between the Company and the Cameroons was not finally agreed upon until 1893, when it was carried as far as Lake Chad.

Similarly on the north there was great activity on the part of the French in their endeavour to reach Lake Chad from Senegambia, and to confine the Company's territories within the narrowest possible limits. But the Royal Niger Company was beforehand, and was able to show cause why the British sphere of influence should be extended to that lake; so that by the Anglo-French agreement of 1890 the northern limit of the territories of the Niger Company was fixed at a line to be drawn from Barrua, on the northern shore of Lake Chad, to Say, a town on the Upper Niger. It was understood that everything to the north of that line was to be French, and everything to the south of it was to be British, but the western boundary line of the Niger Company's territories from Say to the Atlantic coast was still left open. The same course of events then followed on the western boundary as had occurred on the north, and owing to the aggression of French expeditions resort to force was with difficulty avoided. Several French expeditions were disowned by their Government, but by 1896 matters had been amicably settled without a rupture between the two Governments. Thus for the first time the Company found itself free from international complications.

Turning now to internal affairs, the duties of the Company were twofold. It was a trading concern earning dividends for the shareholders, and it was also charged with the administration of a vast territory. Amongst its duties of administration were the putting

* *The Making of Northern Nigeria*, by Capt. C. W. J. Orr, R.A.

down of slave-raiding, and the eventual abolition altogether of slavery, the prevention of the importation of firearms, and also of spirituous liquors. Courts of justice were instituted, and a force of constabulary raised and equipped. This force consisted at first of 400 Hausas under British officers, the numbers later reaching 1,000. A force of civil police also was raised, and jails established.

To meet the cost of administration, the Company was permitted to raise some £90,000 of revenue by taxation. The taxes were levied wholly upon European trade, and as the Company was also the principal trader, it paid also the larger share of the cost of administration.

In 1896, there came a test of the authority of the Company which would have caused its downfall, if it had not been promptly and successfully met. The trouble arose with the Mahommedan Emir of Nupe, who owed allegiance to the Sultan of Sokoto. This Emir refused to desist from slave-raiding expeditions, in spite of protestations and finally threats from the Company, and it became clear that if the obligations as regards stopping slave-raiding were to be carried out, it must in this case be by force. An expedition was accordingly organized by Sir George Goldie, and accompanied by him in person. The army of the Emir was estimated at nearly 30,000 men, of whom about 10,000 were mounted. The utmost force that the Company could bring together was 550 out of the 1,000 Hausa troops in its service. Every possible precaution was taken, and every detail was carefully thought out to avoid the failure which would have proved fatal to the Company. Advantage was taken of half the Nupe army being across the river on a slave-raiding expedition, and in January, 1897, the force of 550 constabulary left Lokoja for the Emir's capital at Bida. The Emir himself at the head of from 10,000 to 15,000 men, mostly mounted, attacked the column outside the walls of his capital. He was quickly defeated, and the town was occupied next morning. The Emir, who had fled, was deposed, and the heir-apparent installed in his place. The southern portion of Nupe which had suffered most from the Emir's slave-raiding was brought under the Company's protection, and the legal status of slavery was abolished throughout the whole of Nupe. Sir George Goldie then visited the Mahommedan Emir of Illorin, who, after a show of resistance, accepted the same terms as had been settled with Nupe. By these brilliant operations it was made clear to all within the Company's sphere of influence that slave-raiding and oppression would not be tolerated.

This expedition brought Sir George Goldie a telegram of hearty congratulations from Lord Salisbury: "The arrangements which brought about the defeat of the Foulahs and capture of Bida appear to have been admirably devised and brilliantly executed." The

native population of the new districts were also overjoyed at their deliverance from the ancient oppression.

Events were now moving quickly to the time when the administrative duties of the Royal Niger Company would be taken over by the British Government. The effect of the expedition to Nupe, coupled with the difficult relations with France on the north-west frontier, was that the Government itself raised an Imperial local military force on the Niger. It consisted of two battalions of infantry, two batteries of artillery, and a company of engineers, and was known as the West African Frontier Force. It was raised and commanded by Colonel Lugard, who left England with a Staff of officers in March, 1898.

In June, 1899, Lord Salisbury addressed a letter from the Foreign Office to the Treasury, in which he stated that he had for some time past had under consideration the question of approaching the Royal Niger Company, with a view to relieving them of their rights and functions of administration on reasonable terms. He had arrived at the opinion, he said, now that the ratifications of the Anglo-French Convention of June 14th, 1898, had been exchanged, and that the frontiers of the two countries had been clearly established, that it was desirable on grounds of national policy that these rights and functions should be taken over by Her Majesty's Government. "The state of affairs created by this Convention," he wrote, "makes it incumbent on Her Majesty's Government to maintain an immediate control over the frontier and fiscal policy of British Nigeria, such as cannot be exercised so long as that policy is dictated and executed by a Company which combines commercial profit with administrative responsibilities." Lord Salisbury therefore requested the Lords of the Treasury to endeavour to come to an early settlement with the Company.*

An agreement was come to between the Treasury and Sir George Goldie on behalf of the Niger Company, and this was set out in a Treasury Minute dated June 30th, 1899, and laid before both Houses of Parliament.

On July 3rd, 1899, the Chancellor of the Exchequer (Sir M. Hicks-Beach) moved in the House of Commons "That it is expedient to authorize the issue out of the Consolidated Fund of sums not exceeding £865,000 . . . for making payments to the Royal Niger Company in consideration of the transfer to the Crown of the administrative powers of the said Company, together with their treaty and other rights, property, and for meeting the expenditure rendered necessary by such transfer." In his review of the history of Nigeria and the

* *The Making of Northern Nigeria.*

work of the Royal Niger Company, Sir M. Hicks-Beach said, "In the work of the administration of the Company, two men, I think, stand out pre-eminent—the late Lord Aberdare and Sir George Goldie. Two Secretaries of State—Lord Salisbury and Lord Kimberley—have borne testimony in the highest terms to the energy, the ability, and the resource displayed by the promoters of the Company, and especially by these I have named, in the work of the administration of these vast territories. Under their guidance, the Company extended its protectorate over an area of something like half a million square miles, with an estimated population of thirty million. It put down slave-raiding and massacres over a great area, it conquered the powerful Emir of Nupe, and the Sultan of Illorin, and took the town of Bida after an expedition with which Sir George Goldie's name will always be honourably connected. Some two or three years ago, it abolished the legal status of slavery within its own jurisdiction; it also did what I think is greatly to its honour, it checked materially that terrible curse of Africa, the trade in spirits with the natives. The Company further established very valuable relations with the great Empires of Sokoto and Gando, Empires which are, as compared with African tribes generally, really civilized countries. Generally speaking, it may finally be said that the Company has founded an empire extending over many thousands of square miles in the most valuable part of Equatorial Africa, and this has been done in sharp contrast with the neglect which successive Governments and Parliaments in this country have shown to British interests in that part of the world."

January 1st, 1900, was fixed as the date from which Government was to assume direct administrative control over the countries which the Royal Niger Company had thus acquired, and from that date the Royal Niger Company reverted to its *rôle* of a trading company pure and simple. Thus was completed the task which Sir George Goldie had set himself twenty-three years before.

At the final meeting of the Royal Niger Company, held on October 27th, 1899, under the presidency of the Right Honourable Sir George Goldie, the Earl of Scarbrough (the Deputy-Governor) made a speech in which he described a visit he had paid to the Niger, and the wonderful organization he found working there. "I had no connection whatever with the Company at that time, but I very quickly found out that the machinery was driven from home, and was controlled by one man; and now that the control is about to pass into the hands of the Imperial Government, we should not forget that what is written on that picture is absolutely and literally true. Nigeria was founded by one man. The organization and its development are the work of one man—with the assistance, it is true, of an admirable and able staff both at home and abroad; and it is now

about to be handed over to the Imperial Government with its half-a-million square miles, with a waterway which is as secure for trade and traffic as the River Thames, after prolonged and most intricate negotiations conducted throughout also by one man—Sir George Goldie. In the making of Nigeria, Sir George Goldie was the master workman, whose vision perceived its possibilities, whose mind conceived the design, and whose hand laid the foundation and raised the main fabric."

Sir George Goldie administered the affairs of Nigeria from an unpretentious office in London, shunning all notoriety, which his soul abhorred. The following extract from a letter, which brings out this point in his character, has not been published before :*

"Twenty years ago, at the Berlin Conference, where I was able to do useful work which has never been made public, some leading journalists asked me to allow my name to be used, on the ground that the public cared more for personalities than for generalities; and they pointed out how I should be helping the cause I had at heart. Between then and 1900, four of our principal publishing firms have written to me or interviewed me repeatedly, urging that the time had come for issuing a biography.

"Although deeply grateful for these delicate compliments, I have throughout refused compliance. I daresay it has been partly due to excessive sensitiveness; and if this were all I should try to conquer it. But, behind that, lies a principle which has remained unaltered ever since I began to *think*, nearly half a century ago. That principle is—

L'œuvre, c'est tout; l'homme, c'est rien.

We (not I) bring our children up to think that fame, position, recognition by the public, are proper objects of ambition. I *loathe* them all. I do not believe that the world will make any great advance until children (generally) are brought up with the idea that real happiness is only to be found in doing good work, in however small (or great) a sphere.

"I felt this as strongly at 18 as I do to-day. If you say 'this is only intense pride,' I shall agree with you. I do not imagine I have a higher sense of duty or philanthropy than my neighbours. I do not assert that my pride is an amiable quality, and I conceal it carefully, except on an urgent occasion such as this, when I am compelled to open my heart freely to a friend.

"Having all my life regarded self-advertisers, from Cæsar to Napoleon, as the worst enemies of human progress, I cannot in my old

* This letter and much other information has been kindly supplied by The Earl of Scarbrough.

age forswear my principles and join the army of notoriety-hunters—poor things.

"When my active work is over, I want (before I die) to write on this subject.

"*Una voce poco fa;* but the sea is made up of drops, and I may be able to do something to help the world to see in which direction true happiness lies."

After severing his connection with the Royal Niger Company, which he did on the revocation of the Royal Charter in 1900, Sir George Goldie travelled in the Far East, and made a particular study of the position in the Upper Yangtsi Valley. Later, he visited Rhodesia on behalf of the Chartered Company, to report on the agitation for self-government in that Dependency.

He was one of the Royal Commissioners who enquired into the preparations for the War in South Africa, and into the operations, and subsequently was similarly employed on a Royal Commission to investigate the disposal of War stores.

He was President of the Royal Geographical Society, from 1905 to 1908, and from that date was chosen an Alderman of the London County Council. He founded the National Defence Association, and was its President prior to the outbreak of the Great War: after that date his health began to fail.

As President of the Royal Geographical Society, an officer writes of him as follows:—"Goldie was an admirable President of the Royal Geographical Society. In addition to presiding over the meetings of the Society with dignity, sympathy and efficiency, he paid particular attention to the financial side of its administration. He was at all times ready to encourage young men to take their part in the work of exploration. He was always accessible and always cheerful, and had the knack of getting the best out of people. His picture, by Herkomer, hangs on the walls of the house of the Society."

Since the taking-over of Nigeria by the Imperial Government the Corps has taken its part in the development of the Protectorate, a short account of which appeared in *The R.E. Journal* for June, 1927, in the article "Some Royal Engineers and their work in Africa."

ORGANIZATION AND TRAINING OF A MECHANICAL TRANSPORT SECTION IN A FIELD COMPANY R.E.

By LIEUT. E. W. H. CLARKE, R.E.

INTRODUCTION.

IN April, 1926, it was decided that the 17th Field Company was to be mechanized and form part of the mechanized force for trials on Salisbury Plain. During the next few months it was settled that the light six-wheel lorry was to be used for this purpose, and that the training of the drivers was to be carried out within the unit. The reasons for the choice of this vehicle and the numbers required at peace and war strength are not discussed in this article; the remarks in this article are confined to the actual training and organization of the transport section.

It was also decided that in this Company the drivers would be Sappers, and would not be organized as a separate branch in the same way as the horse-transport drivers. Whether this will be possible when a more extensive system of mechanization is adopted is debatable, but the system has many advantages. The lorry drivers were Sappers (*i.e.* drivers), and pioneers were selected for training in this work. They belong to the sections and normally parade with them, but on certain days, such as Saturday morning, they parade together for Maintenance and Inspection as an M.T. section, and a Lance-Sergeant who is a fitter-driver takes them in charge. Two of the drivers are Lance-Corporals to assist the Lance-Sergeant i/c M.T. Section. On most days only a few lorries are required for transport, and the remaining drivers work with their sections; on manœuvres, when the company halted to carry out some work such as bridge building, the lorry drivers invariably worked with the other Sappers in the sections, and the additional numbers gained in this way are very useful.

In November, 1926, two Morris six-wheel lorries were sent to the Company for training, but these were taken away a few months later, owing to the crisis in China, and training had to be postponed till May, 1927, when six Morris six-wheelers arrived.

TRAINING.

A course of instruction for training drivers was evolved, through which seven pioneer drivers (I.C.) were taken; at the end of five

weeks' instruction, working in the mornings only, they passed out well on all tests, and could answer simple questions on the theory and working of the lorry. The men seemed to pick up the required knowledge easily, and showed a keen interest in the work. All the instruction was done by two Lance-Corporals, one specializing in the driving instruction and the other in the mechanical instruction, with the exception of a few lectures given by the officer in charge of the M.T. Section

AN OUTLINE OF THE COURSE.

First week.

Daily lectures by the officer :—

(1) High- and low-speed engines—The Otto cycle.
(2) Carburettor (cycle and lorry).
(3) Oiling and cooling systems—Regulations for lubrication.
(4) Magneto.

Practical work—dismantling motor-cycle engine, examining and naming component parts :—

Working and metallic compositions of the parts.
Examination of a carburettor, likely faults shown.
Examination in oiling and cooling systems on the lorry.
Inspection of the transmission, having removed the body.
A talk on the different types of clutches.
Examination of magneto—make-and-break, adjusting and cleaning parts.
Dismantling cycle gear-box—demonstration of working.

At the end of the week, examination questions were set on the week's work.

Second week.

Lectures :—

(1) Maintenance required.
(2) Fire and frost regulations.
(3) Care and repair of tyres.

Practical :—

Decarbonization of a lorry, grinding valves, etc.
Timing an engine—valves and magneto.
General maintenance, go through lubrication chart.
Fitting and tightening bearings.
Fault-finding on a motor-cycle engine.

Third week.

The class was split into two squads of four men each, one squad being on driving instruction, while the other worked on the lorries. Lectures were delivered to the whole class before the day's work started.

Lectures :—

(1) Driving and road sense.
(2) Traffic and mechanized force signals.
(3) Use of gears and clutch while driving.
(4) Economy in petrol consumption (regulations).
(5) Reporting accidents.

Practical :—

One squad always on driving.
The other examining electrical equipment and looking to care of same.
Removing engine from chassis and fitting new clutch.
Re-assembly and re-timing of a lorry engine.
Adjustment and re-lining brakes.

Fourth week.

Lectures :—

(1) Mechanized Force Standing Orders.
(2) Precaution and rules in case of aerial attack.

The squads change over and repeat previous week's work.

Other work :—

Practise fitting tracks.
Test accident case to be reported.

Fifth week.

Revision questions.
Passing out drivers.
Scheme—Work in column as with Mechanized Force.

In addition to this course of instruction, lorry drivers should be taken through a course of map reading, to ensure that they are up to the standard of a Second Class Certificate of Education.

ORGANIZATION OF M.T. SECTION.

Additional lorries are being provided next year for bridging stores, but the present organization is for three lorries per half-company for personnel and one lorry per half-company as a tool cart, and one reconnaissance car for headquarters. There are four motor-cycles, which are used for D.O.s and by officers for reconnaissance purposes.

The lorries for personnel normally accommodate twelve men, the driver and the N.C.O. i/c. lorry in front, with ten men behind, and any stores are carried in the well of the body.

The lorries for tools do not differ from the others; the tools are packed in boxes which lift in and out of the vehicle. The contents of these boxes, plus 26 picks and 27 shovels fitted in the well, are equivalent to those of a double tool-cart. Thus you have a complete set of tools with each half-company, and should a section be sent off on detachment, tools are drawn from the half-company tool-lorry and carried in the section lorries.

Procedure on the breakdown of a personnel-lorry is to distribute the personnel amongst the other lorries and leave the M.T. Section-Sergeant and the driver to remedy the defect and rejoin the column as quickly as possible. Similarly, on the breakdown of a tool-lorry, the boxes are transferred to a personnel-lorry, and the personnel distributed amongst the other lorries, and again the M.T. Section N.C.O. and driver are left to put the trouble right.

Schemes for M.T. Section.

From time to time schemes are held under the supervision of the officer i/c. Section, which were developed on the following lines :—

Phase 1. Lecture on points to observe, such as cover from aircraft, keeping closed up, procedure on road-blockage. Go through route it is intended to follow. See each lorry is supplied with a map.

Phase 2. 30 minutes—this is the normal warning to units to move off, in which time oil, petrol and water-levels are checked, engines are started and vehicles drawn up at the assembly point at 15 yards' interval, ready to move off.

Phase 3. Vehicles move off with the driver and spare driver on each lorry, the Section map-reader rides on the front lorry and is responsible for the route.

Points practised on the route.—Halts.—Mechanical defects, putting them right and rejoining the column.—Road blockages, reconnaissance of route round the obstacle.—Cover from aircraft.—Passage of boggy ground.—Fitting tracks before doing so.—Casualties among the drivers, spare drivers taking their place without crashing.

These schemes can also be done at night, and practise guiding the column to a rendezvous by compass.

A prismatic compass reads correctly if taken 15 yards away from the lorry, and you can steer on prominent objects if visible. If not, the tail-light of a motor-cycle, sent out ahead every 400 to 600 yards and signalled into position, is used for direction For night work, the normal routine is for the leading vehicle to have shaded side-lights and a tail-light. The remaining vehicles show no light, except the tail-light. Each driver steers on the tail-light of the vehicle in front ; these tail-lights are painted over with red paint to dim them.

Motor-cycles only show a dim light, and lamps are cowled with tin, cut out from biscuit boxes and fitted between the lamp glass and the vulcanite holder. The outside of the cowl is painted black. It is essential that no light should shine upwards.

Orders.

The following pamphlets are adhered to :—

1. Standing Orders for Drivers, I.C., and Dispatch Riders.

2. Notes for guidance of Section Officers and N.C.O.s in M.T. Companies, R.A.S.C. Also certain routine orders are worked to :—

(1) All vehicles are washed down and drivers run over nuts and bolts on completion of the day's work.
(2) All levels are checked before starting the day's work.
(3) All vehicles are greased and go over the inspection pit for general maintenance weekly.
(4) Sumps, gear-box and axle are emptied and replenished with fresh oil quarterly.
(5) Body and chassis are painted yearly, and the engine with heat-resisting paint twice yearly.

INSPECTIONS.

Are carried out :—

(1) Weekly by the Section N.C.O.
(2) Fortnightly by the Officer i/c. Section.
(3) Monthly by the Maintenance and Repair Unit.

The results of these inspections are recorded and faults rectified. Vehicle inspection reports (G. 3128) are filed in the A.B. 5s of the vehicle concerned.

BOOKS AND FORMS.

Every driver keeps a log book for his vehicle ; it is divided up into the following columns :—

Date.	Speedometer reading.		Destination and nature of journey.	Stores received Petrol, Oil and Grease.	Remarks.
	In.	Out.			

It is most important that these should be kept accurately and up-to-date, as the entries in these books are the unit's only check against issue-vouchers for petrol and stores received from R.A.S.C. The men take more trouble to keep a neat and accurate book if they are given a decent-looking ruled book with stiff covers.

From personal interest a log is kept, which is compiled monthly when checking the log-books, showing the saving on R A.S.C. Transport by using unit mechanical transport during the past month. This is useful in accounting at the end of the year, to show how the motor-transport is comparing in cost with unit horse-transport.

From these books the vehicles' log-sheets (G. 3519) are compiled monthly by the Section N.C.O. and checked by the Section Officer against issue vouchers received from R.A.S.C. They are then filed in the A.B.5 of each vehicle and stuck in.

The lorries can be used for recreational training purposes at the discretion of the O.C., but if used for the purpose A.C.I. 364 of 1926 must be adhered to.

Stores.

The C.Q.M.S. has charge of all stores and spare parts. They are indented for from the R.A.S.C. depôt, Feltham, and on receipt are entered in a loose-leaf ledger (A.F.G. 3927), which has a separate leaf for every item of equipment of the vehicle. The stores are kept in a locked store, and the C.Q.M.S. is sole possessor of the key; windows are covered with heavy X.P.M. inside. Numbered lockers with bin cards (A.F.G. 3928) show stock on hand. When any part requires replacement the Section Officer signs an A.F.G. 828 for the article, which is issued by the C.Q.M.S. to the driver, who signs for it and hands in the damaged article in lieu. These damaged articles are held on charge until the D.I.M.T.'s inspection, which occurs about twice a year, and on this inspection he gives authority to write off any damaged articles shown to him.

Lorries and their kits are held on ledger charge by C.Q.M.S. The driver signs a A.F.G. 1092 on receipt of lorry and kit, and is responsible for their safe custody; he keeps a copy of the G. 1092 himself. Every lorry's tool-box has a padlock, and the driver is the sole possessor of the key. The key of the garage containing the vehicles is retained by the Section N.C.O., who is responsible that it is locked nightly after the return of the last vehicle. With these regulations few stores are lost.

As can be seen, one C.Q.M.S. cannot possibly compete with the above ledger work in addition to his normal duties, so a mechanized unit requires a trained N.C.O. to assist him with the work.

Conclusion.

The Morris six-wheel lorry was found to be entirely satisfactory for this work. The early models had a weak clutch, but this has now been remedied, and no troubles of any kind were experienced. An average speed of 18 miles an hour can be maintained on most roads, and the lorry has a very good cross-country capacity. Very little maintenance work is required, and even when the lorry is used every day, an hour a week on maintenance is sufficient in addition to the periodical overhauls. As regards training, no difficulty was experienced in teaching the drivers within the unit, though this might not be possible in every case, if an extensive scheme for the mechanization of R.E. units was adopted. The drivers soon became experienced, and the total damage throughout the training in 1927 consisted of one bent mudguard.

THE SCIENCE MUSEUM AT SOUTH KENSINGTON.

By COL. SIR HENRY G. LYONS, F.R.S. (R.E. *retired*).

ON March 20th, 1928, H.M. The King will open the new buildings on the west side of Exhibition Road, which have been constructed to house the collections illustrating Science and Industry in the Science Museum. Provision was made for the Art collections in the Victoria and Albert Museum twenty years ago, but it is only now, after many delays and interruptions, that the Technical Museum has a suitable building in which to display its collections.

The officers and men of the Corps have been closely connected with the development of the Technical collections during the whole of the seventy years that they have been at South Kensington, and the part that they have played in forming them and in determining their aim and scope is now so nearly forgotten that it should be placed on record.

After the Exhibition of 1851 considerable funds remained in the hands of the Royal Commissioners of the Exhibition, as well as certain collections, objects, etc., which had been presented, or which had been acquired by the Commissioners. In their Second Report they proposed that "an institution should be created which should serve to increase the means of Industrial Education, and to extend the influence of Science and Art upon productive industry." The Science and Art Department was formed in 1853 as a result of their recommendations, and Museums of Science and of Art were included in the scheme as essential parts of it.

The collections which had been formed by them were first brought together in Marlborough House, at the offices of the Department, until a building was available for them at South Kensington, where the Royal Commissioners had acquired a considerable extent of ground, and in the south-east corner of it they erected a large iron-roofed building, long known as the Brompton boilers In 1856, a detachment of Sappers was employed in transferring the collections from Marlborough House to South Kensington and arranging them there in the iron building. The detachment was housed in buildings which were already in existence on the site, and remained there to provide the skilled labour which was needed in the Museum, and to furnish a fire picquet for duty when required.

For many years after this, a small R.E. detachment was maintained at South Kensington for duty in the Museum. They worked as skilled artisans in the workshops, provided photographers for the studio, carried out necessary repairs, for some time constructed the Museum furniture, and generally rendered all technical services that were

needed, besides guarding the buildings and their contents against fire. The detachment was withdrawn towards the end of the last century, though a few men stayed on to complete their service. The last member of it retired from military service and took up civil employment on the Museum staff on April 1st, 1900. Several others also had joined the civilian staff from time to time as photographers and in other positions. Not only the Museum but the Solar Physics Observatory at South Kensington gained very largely from the assistance given by R.E. photographers, who also took part in several eclipse expeditions.

In evidence given before a Select Committee of the House of Commons, which reported on the South Kensington Museum in 1860, it is stated that at that time the detachment consisted of about thirty-five or forty men; they are described as "most valuable workmen, and in reference to photography they have been thoroughly instructed and understand the business well." There are now twenty on the staff of the Science Museum who have served in the Corps, and ten more who served with R.E. units during the War.

The first Royal Engineer officer who held an appointment in the South Kensington Museum was Captain Francis Fowke, who, on the termination of his duties in connection with the Exhibition of 1851, was appointed Inspector for Science and Art in 1856, and had charge of the collection illustrating construction and building materials. He designed a series of brick buildings on the north side of the iron buildings, which were used for picture galleries and for the art collections and library. These have been incorporated in the north-east part of the present Victoria and Albert Museum. He also designed a Museum for the Department of Science and Art, which was to face Cromwell Road, and to provide accommodation for the Science and the Art collections. It would have occupied approximately the same site as that of the Victoria and Albert Museum, but it was never built.

The Museum of the Patent Office was also housed in the iron building, but this remained under the Commissioners of Patents until 1884, when this collection of historical objects mainly relating to mechanical engineering was transferred to the Science and Art Department, and was incorporated into the engineering collections.

In 1860, Lieutenant J. F. D. Donnelly was posted for duty with the detachment at South Kensington, and later took up duty with the Science and Art Department, of which he eventually became Secretary.

Among the R.E. officers who have been closely connected with the Museum at South Kensington should be mentioned Major-General E. R. Festing, F.R.S., who was appointed Director of the Science Museum, in 1895, as the officer in responsible charge of the Science and Engineering collections. He was also responsible for the provision of furniture for the whole of the South Kensington Museum and for such repairs and maintenance as had to be carried out.

Sir William Abney, F.R.S., joined the Science and Art Department as a Captain, and was Director for Science in it when General Festing was Director of the Museum. He was, later, Principal Assistant Secretary of the Science and Art Department, when he was largely responsible for the policy followed in the development of the Science Museum.

Colonel H. C. Seddon, too, was a member of a Departmental Committee which reported on the Science Collections in 1881 and 1882, and he also advised on the development of the Building Construction collection. There were, no doubt, many others who from time to time helped the Museum in its earlier years.

The Royal Commission of the Exhibition of 1851, in their Second Report of 1852, had in mind national museums of both Science and Art, but, as years passed by, the Art collections were the more energetically developed. Towards the end of the nineteenth century, the object of the Science collections was definitely laid down as being the teaching collections of the Normal College of Science. It was not until 1907, when the Imperial College of Science and Technology was established at South Kensington by bringing together the Royal College of Science, the Royal School of Mines, and the City and Guilds Engineering College in a single organization, that the Science Museum was once more free to develop as a National Museum. A year or so later, the new buildings of the Victoria and Albert Museum were opened, and in them the Art collections were displayed in a manner worthy of a national collection. The striking disparity between the conditions under which the Art collections and those illustrating Science and Industry were now housed and exhibited led to representations being made by an influential group of the leading men in these branches of national activity, with the result that the President of the Board of Education appointed a Departmental Committee to enquire into and report upon the conditions and the future development of the Science Museum, and the buildings required for it. In their report, which was published in 1912, the national status of the Museum was once more emphasized, and they recommended that the old buildings, in which the collections were housed, should be replaced by new four-storied buildings. It is the first, the eastern, block of these new buildings which is to be opened on March 20th.

The new buildings are situated between the British (Natural History) Museum on the south and the Imperial College of Science and Technology on the north; they will, when complete, extend from Exhibition Road to Queen's Gate, and will then have a total length of 1,130 feet. The main entrances in Exhibition Road and Queen's Gate open direct into entrance halls, from which access is given by broad flights of steps into spacious top-lit lighting halls 120 feet long by 40 feet wide, roofed at the third-floor level. A similar large lighting hall is arranged at the centre of the building.

The intermediate galleries, connecting the galleries surrounding the east, central and west lighting halls, are 72 feet wide, and are arranged so that the structural columns form a central gangway 12 feet wide with 30-feet galleries on either side.

Demonstration rooms, in which lectures can be given to parties of students, are provided.

The approximate areas in the complete scheme are :—

Exhibition galleries	397,000	ft. sup.
Lecture theatre	6,000	,,
Demonstration rooms	16,000	,,
Halls, stairs, etc.	25,000	,,
Basement, workshops	159,000	,,
	603,000	,,

In the eastern section, which alone has been completed up to the present time, the area of exhibition galleries is about 143,000 ft. sup., of basement, workshop, 59,000, and of demonstration rooms, halls, stairs, etc., 27,000. About a quarter of the collection is still housed in the old buildings, originally constructed for the Exhibition of 1862.

The columns, and column foundations, floors, roofs and all constructional units of the building are in reinforced concrete, on the Coignet system. The staircases are formed in reinforced concrete, and finished with 2-in. York stone treads and granolithic risers.

The loadings allowed in calculating the structures are :—Foundations, 3 tons per sq. ft. (on gravel) ; Ground floor, $2\frac{1}{2}$ cwt. per sq. foot ; 1st and 2nd floor, 2 cwt. per sq. ft. ; 3rd floor, $1\frac{3}{4}$ cwt. per sq. ft. ; roof, 65 lb. per sq. ft. ; offices, etc., 100 lb. per sq. ft.

The main east front to Exhibition Road is shown in the photograph. Internally, the walls and ceilings are finished with a simple plaster treatment. The floors are of oak boarding on fir battens. Along all the galleries is an elaborate system of ducts for accommodating the lighting, gas, compressed air and heating mains. The compressed air is used for operating the working models of various types of engines and machines, of which there are about 300 in the Museum. The lighting of the galleries, all of which are side-lit, is particularly satisfactory, the proportion of glass to floor area being 1 to 5, or if the glass roofs of the halls and of a top-lit gallery on the ground floor are included 1 to 4.

The addition of this new block has more than doubled the exhibition space in the Museum, which is now 193,000 ft. super, as compared with 88,000 ft. super in 1913, and it has been possible to develop the collections considerably, and to adopt a definite policy in regard to them. In each group a series of objects is being formed, which is carefully selected so as to illustrate important stages in the development of the group. This historical series is supplemented by a

second series which represents current practice, and which therefore changes frequently. In this way the Museum is both a Museum in the sense that it preserves records of past achievement, and a permanent exhibition of Science in its application to industry as shown by modern examples.

From time to time also, exhibitions are arranged at which Research Associations and Institutions can exhibit the results of their recent discoveries and investigations.

The eastern galleries, which have only just been completed, contain the collection of ship and boat models illustrating the construction of all types of water transport from early times, and from the practice of primitive races down to the present date. It is one of the most comprehensive collections of its kind in existence, and occupies three large galleries, and a reserve collection is available for reference in a basement store.

The ground floor is occupied by stationary engines and locomotives, among which are three engines designed by James Watt and built by Boulton and Watt late in the eighteenth century, also the Puffing Billy, the Rocket, the Agenoria, and the Sans Pareil, some of the earliest locomotives in existence.

In the west gallery is part of the Aeronautical collection, which is probably the most complete that there is. The gliders of Lilienthal and Chanute, the aeroplanes of Cody and Latham, and now, for a while, that flown by the brothers Wright in 1903. A series of about 80 aeroplane models illustrates the development of heavier-than-air aircraft from 1903 to 1928. The Vickers-Vimy aeroplane which Sir John Alcock flew across the Atlantic in 1919 is also here.

On the first floor are the collections of Mining and Metallurgy, a very interesting series of Tools and Machine Tools, and another of Textile Machinery. Part of the collection illustrating Electrical Engineering is on this floor, where automatic telephone exchanges may be seen in operation and are demonstrated daily.

On the second floor Pumping Machinery and Engineering Construction are shown, as well as collections of Mathematical Instruments, Time Measurement, Geographical Instruments, Electrical Instruments and Meteorology.

The rest of the Science Collections, Chemistry, Optical Instruments, Geodesy and Surveying, and Astronomy, are on the third floor.

Since improved accommodation has been available, and it has been possible to display the objects more effectively, the attendance of visitors has increased to a very remarkable extent; in 1927 the number of them was 710,000, and it is increasing steadily. After a long period of slow development the Museum has now reached a truly national status, and its organization and methods have commended themselves to many who are developing similar institutions in other countries.

COLONEL JOHN EDWARD BLACKBURN CB

MEMOIR.

COLONEL J. E. BLACKBURN, C.B.

GENERAL SIR BINDON BLOOD, referring to the subject of the following memoir as " my old friend and comrade in Egypt, 1882–83, and my best man afterwards when I was married," uses words regarding him which those who knew Blackburn best will appreciate most.

" He was one of the best, a right good soldier, a first-rate Sapper, and a good sportsman, and it was good for a man to be his friend."

John Edward Blackburn, the eldest son in a family of six brothers and six sisters, was born at Edinburgh on April 30th, 1851: his father, Robert B. Blackburn, was at that time practising at the Bar in Edinburgh, and subsequently became Sheriff of Stirlingshire. His uncle was the very distinguished lawyer and Lord of Appeal, Lord Blackburn, whilst the legal tradition in his own generation is carried on by his only surviving brother, who is a member of the Scottish Bench with the title of Lord Blackburn. A younger brother, Leslie, in the Scottish Rifles, had a military career of great promise, but was killed at Tuli in the early stages of the South African War. Our Blackburn as a boy was at school for two years at Glenalmond, followed by three years at Eton from 1864 to 1867, when he left to be successfully coached for Woolwich at Mr. Brackenbury's famous Establishment at Wimbledon. His first commission was dated December 12th, 1871, when he was twelfth in a batch of twenty Cadets, of whom the late Sir Henry McCallum was head, then gazetted to the Corps. A contemporary writes, " Blackburn, or ' Bunny,' as " we used to call him, was a great friend of mine both at the ' Shop ' " and afterwards at Chatham. We neither of us played football at " Woolwich, having both been brought up to the dribbling game. " Soon after we joined at Chatham he induced me to play there, and " all the time we were at Chatham, viz., 1872–73 and 1873–74, we " played together in the R.E. team—Blackburn played on the right " wing with Von Donop (in the same batch), and they were a splendid " pair, and never failed to give us centre-forwards chances of scoring " by centring at the proper time."

This period was the hey-day of Association football at Chatham: we were in the final of the Association Cup in 1873–74, and won it in 1874–75, but Blackburn's name does not appear on the latter occasion, probably because he had left Chatham for Aldershot before the match came off. He was, however, a member of the team that made the historic football tour in the North of England early in 1874, beating Sheffield, Nottingham and Derby on their own grounds, and receiving a most enthusiastic welcome from the crowds of spectators.

Blackburn went to Aldershot when his time at the S.M.E. came to an end, and joined the R.E. Train, and served with it for over three years.

The R.E. Train consisted of A or Pontoon Troop, B or Equipment Troop, C or Telegraph Troop, and the Field Depôt, which received and trained all recruits for the Train, mounted and dismounted. The Train was commanded by a Lieut.-Colonel, with an Adjutant, and was kept quite distinct from the R.E. Companies, whilst its officers and men were not employed in the Works. The Train was in a sense the branch *d'élite* of the Corps, the officers joining it getting their "jacket," as did a Gunner on being posted to the R.H.A.: an examination of the names and records of those who served in the Train discloses how great its value was as a means of producing efficient officers.

When Blackburn joined it, the Train included many well known to fame; Sir Howard Elphinstone commanded it, with Lieut. Jelf as Adjutant: Major Micklem commanded A Troop, to be succeeded by Lieut.-Colonel Harrison, now Sir Richard Harrison: whilst the junior subaltern in Major Durnford's C Troop was Lieut. H. H. Kitchener.

The Train as a separate organization came to an end in 1877, (just as Blackburn left it), when B Troop was broken up between the Field Companies then for the first time formed, and the command of all R.E. personnel at Aldershot passed into the hands of one officer, with the title of O.C. Troops and Companies.

At Aldershot, Blackburn, his nickname altered from "Bunny" to "Brush," spent three happy and useful years: he donned the scarlet stable jacket peculiar to the Train, wore spurs on every possible occasion, and, for all we know, may have grown the side whiskers of the period. Popular with all ranks, we may be certain he did not waste his time, and the fact that Blackburn was a first-rate regimental officer was due to the lessons learnt in his early years at Aldershot. Foreign service at Jamaica now claimed him for three years, at the end of which he joined the 26th Field Co., R.E., then commanded by Major, now General, Sir Bindon Blood. In 1882, Blackburn

competed in vain for the Staff College, but the autumn of that year gave him his first experience of active service, in the Egyptian Campaign of 1882, with the battle of Tel-el-Kebir. In the following spring he was ordered home in anticipation of promotion, and commanded the 21st Company at Aldershot until the autumn of 1884, when he returned to Egypt as part of the reinforcements for the approaching effort to save General Gordon.

He rejoined his old Company, the 26th, which in his absence had been fighting under Sir Gerald Graham at El Teb and Tamai, just in time to form part of the detachment which was the first body of troops to ascend the untried cataracts of the Nile in English-built whalers. Blackburn wrote a very interesting account of the Boat Expedition for *The R.E. Journal*, and portions of it will be found incorporated in the second volume of the *History of the Corps*.

When the Expeditionary Force divided at Korti, part going across the Bayuda Desert and part following the Nile, it fell to Blackburn's lot to command the R.E. detachment with the River Column, and he was present with it at the battle of Kirbekan.

It was during these eventful times that the writer first met Blackburn, and the impression remains of one amazingly cheerful under difficulties, who never thought of himself, was everybody's friend, and who always played the game.

Blackburn was mentioned in dispatches at the end of the campaign, but without reward; he stayed on in Egypt with the Frontier Force, saw further fighting with it, and was again mentioned in dispatches. Again the fates were against him in the matter of rewards, and when he finally left Egypt in February, 1886, for peace service at Gibraltar, where he commanded the 18th Co., R.E., he did so without any solid recognition of his services in the three different "shows" in which he had been engaged.

In September, 1887, he took the 18th Co. to Halifax, where he remained until his foreign tour expired in February, 1889. A "Gunner" friend, writing of Blackburn in Halifax, says:

"I have a clear recollection of Blackburn as an ever-sunny presence—as one of those whom one is lucky to find as a brother officer in one's Mess. The R.A. and R.E. Mess at Halifax was a very happy family, but there was always lots of chaff going. Nothing ever ruffled Blackburn: the shrewdest dig at him was met with a cheery smile. He joined in all the many sports that Halifax, in those halcyon days, was famous for providing."

After a year in the London district, when he occupied the little quarter at Kensington Museum which was the home of a succession of R.E. officers, he was given the command of the 7th Field Co.,

which he held for four years, mostly spent at Aldershot. There were changes there, of course, from former days: the attractive old Mess hut with its cluster of officers' quarters, its neat compound and beautifully cared-for flower beds, had gone for ever, and the present Mess had just been built.

The stable jackets were nearing their end, and the side whiskers had long gone, but the "Troop" spirit and tradition were still alive in the Bridging Battalion, with its A and B Troops, and in the 1st Division Telegraph Battalion, which was but C Troop under another name. Most of the senior officers had had "Troop" upbringing, although the C.R.E himself, a keen soldier and a wonderful drill, was new to the place, and did not always see eye to eye with the old Aldershot hands. To mention, among the men of those days, Mackworth, Jelf, Beresford, Rochfort Boyd, Dickinson, Bond and Irvine, is to recall names associated again and again with the "Troops" and Aldershot. The Troops, however, were no longer having it all their own way, for the Field Companies were on the move and coming into their own with great competition to command them.

The Maxwell "stars" were rising above the horizon, and the writer, then at Aldershot, remembers the stories that reached him of what the brothers would have to teach in the way of smartness when they invaded preserves once sacred to the "Troops." Even with such competition, it is safe to say that the 7th Field Company maintained its high traditional reputation under the command of one who knew every move of the game, and possessed all the qualities required for his post. His work as a Field Company Commander ended, Blackburn spent a year at Exeter, and then returned once more to Aldershot to command the Field Depôt for six months, and then for over a year to be Second-in-Command to the O.C. Troops and Companies.

On promotion to Lieut.-Colonel at the end of 1897, he was sent to Gibraltar, where he spent five years as one of the C.R.E.s, and where he made friends with that good friend to so many Royal Engineers—Sir George White.

During these years occurred the Omdurman Campaign and the South African War, and, although he said little, it was a bitter disappointment to Blackburn to miss both at a time when some of his Egyptian comrades were seeing all the fun.

Moreover, Blackburn from his recent experience was eminently suited to command the Engineers of a division, and it is difficult to understand why his services were never utilized during the drawn-out struggle in South Africa.

After six months on half-pay, Blackburn was given the post of Chief Engineer Northern Command, which he held for four years, and on

30th April, 1908, he was placed on retired pay on reaching the age limit.

In the Great War, Blackburn was reappointed Chief Engineer Northern Command in January, 1915, and in difficult circumstances mastered the many Engineer problems which the great expansion of the Army involved. He held the post until relieved by a serving officer in June, 1916.

It was the good fortune of the writer to be again associated with Blackburn in these last days of his military service, and all the qualities that won our hearts on the Nile were still his in unabated strength. Blackburn was mentioned in dispatches for distinguished services rendered in connection with the War, and was made a Companion of the Bath—a well-deserved reward for what he did in the War and in those early unrequited years of active service.

Blackburn never married, but lived with his sisters, to whom he was devotedly attached, and to whom he was the best of brothers.

In his latter years he got attacked by arthritis in the hip, and suffered much, although few could have guessed how much. His cheerfulness and courage in ill-health were as marked as they had been under difficulties of another nature. He was an example to all of how the infirmities of the flesh may be conquered. His closing years were spent in London, where he had a flat with one of his sisters, and, very much crippled, he was to be found most of the day at the United Service Club.

The "Gunner" friend of Halifax days, referring to this period, writes: "Crippled as he was, he was still the same cheery soul as "of old—always ready to give and take chaff with an infectious "laugh and ready even to make fun of his own infirmities. I am "sure that those whom he meets when he has gone will be happier "for his coming."

The writer had a talk with him at midday on the 28th of September last, and "Blackie" was cheerful and apparently quite well. He died suddenly and peacefully early in the following morning, a great shock to his relatives and friends, but for him surely the happiest of endings.

H.M.L.

6th February, 1928.

PROFESSIONAL NOTES.

ACID-PROOFING FOR TABLE TOPS.

(From *The Builder*, December 30th, 1927.)

THE following recipe has been used by the writer (an Assistant Engineer, Madras Public Works Dept.) quite successfully for acid-proofing the surface of teak table tops in the laboratories of the Medical College, Madras: the surfaces, treated three years ago, are still in good condition.

Solution 1.

Ferrous sulphate	.. .. ..	grammes 20
Copper sulphate	.. .. ..	,, 20
Potassium permanganate	.. ..	,, 40
Water to make 500 c.c.		

Solution 2.

Aniline oil	.. ..	c.c. 60
Strong hydrochloric acid	.. .. ..	,, 90
Water to make 500 c.c.		

METHOD.

Apply two coats of Solution 1 with an interval of at least 12 hours. When thoroughly dry, apply two coats of Solution 2.

When the treated surface is thoroughly dry, apply one coat of raw linseed oil with a cloth. When this is dry, wash with very hot soap-suds. The excess of black should be washed off after 48 hours with soap and plenty of water. Occasional washing keeps the surface quite clean.

The surface to be acid-proofed should be quite fresh, or if previously coated with varnish, oil, or paint, it should be thoroughly scraped and cleaned.

VICTAULIC PIPING.

Communicated by the R.E. Board.

AN article on the Victaulic Patent Pipe appeared in *The R.E. Journal* in 1925, Vol. XXXIX, p. 475, but, although this has been the subject

of a D.W. contract for several years, it is thought that its advantages may not have been fully recognized, and that a few further notes on the subject may be of interest.

It is proposed to deal here only with its use for temporary connections: the arguments in respect of permanent work must be considered individually in each case. To test the capabilities of easy and quick laying, certain experiments have recently been carried out under arrangements made by the R.E. Board, and the results of these are shown in Table A. From this Table it will be seen that, speaking generally, Victaulic piping can not only be laid about four times as fast as ordinary screw piping, but that the labour required is less and need only be semi-skilled instead of skilled.

A test was also made on manœuvres; it was found that the use of box spanners very considerably increased the rate of laying, and these were accordingly knocked up out of short lengths of one-inch piping. Using these box spanners, a party of four men actually laid nearly 200 yards in under half-an-hour.

The advantages of these properties for all work of a temporary nature, such as camps or work in the field, need not be dilated upon: the trials prove conclusively that this form of piping is *facile princeps* for such work.

Apart from the enormous advantages of ease and quickness of laying, there are a number of other advantages which make this piping specially suitable for all R.E. work in the field: these can best be summarized as under:—

(1) *Speed of Laying.* Where long lengths have to be laid, work can be done simultaneously at various points in the line; only one pipe has to be cut and grooved at each joint, instead of one pipe and a connector as in the case of screw piping.

(2) *Dismantling.* This can be carried out simultaneously at all parts of the pipe line, whereas with screwed pipe it can only be done from the ends.

(3) No skill is required in laying or making the joints. The use of the grooving tool requires the same care as the use of stocks and dies for screwed piping.

(4) A length of pipe can be removed anywhere without any cutting. This is an enormous advantage in repairing a break or inserting a branch, as it avoids the necessity of long screws and back nuts, etc., which are essential with screwed piping.

(5) No damage can be done to the pipe in transit or by frequent laying and dismantling, whereas with screwed pipe the threads usually suffer.

(6) No materials, such as tow, tallow, etc., are required for the joints.

(7) Fewer kinds of tools are required :—

For Victaulic.	*For Screwed Pipe.*
Two sizes Special Grooving Tool (this is also used for cutting the pipe). Vices, Box Spanners.	Stocks and Dies (sets for each size of pipe used). Vices, Footprints, 3-wheel cutters, Chain-grips.

(8) The pipe is very flexible compared with screwed pipe. This diminishes the number of bent pipes required.

(9) There is no difficulty in joining on to other sorts of piping, as the Victaulic Company makes a comprehensive list of adapters to make joint with screws and flanges.

(10) Weight is approximately equal to that of screwed piping.

The advantages of rapid laying naturally rather disappear with small piping, though there can be no doubt that with anything over 2-inch, Victaulic piping will always have a big advantage.

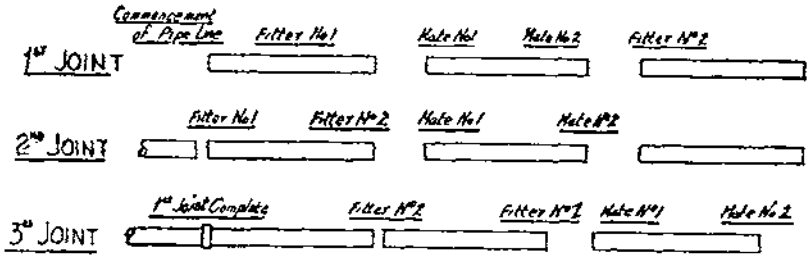
The Victaulic Company recommend a special grease for the washers and ends of pipes : this is merely a preservative and it is unnecessary for temporary work ; the tightness of the joint does not depend on its use in any way.

The following is a drill for pipe-laying which has been tried :—

Party—6 men, divided into :—

A. 2 men lowering pipes into trench.
B. 2 Fitters and 2 Mates connecting pipes.

The suggested organization of Party B. is as follows :—



Fitter No. 1.—

1. Fits rubber ring to end of second pipe.
2. Couples up first and second pipes, assisted by the two mates (who then proceed to assist Fitter No. 2).
3. Tightens up nuts of first joint with spanner.
4. Proceeds to fourth pipe and does the third joint as before.

Fitter No. 2.—

1. Fits rubber ring to rear end of third pipe.
2. As soon as the two mates arrive he couples up second and third pipe.
3. Tightens up nuts of second joint with spanner.
4. Proceeds to fifth pipe and does the fourth joint as before.

Mate No. 1.—Always assists the fitter (1 or 2) until the nuts of the joint are hand-tight: he then joins the fitter at the next joint.

Mate No. 2.—Is responsible for aligning the next pipe to be joined, and is always at the head of the pipe line.

If box spanners are available this drill should be amended so that Mate No. 1 always works with Fitter No. 1, etc.

TABLE A.

COMPARISON BETWEEN SCREWED AND VICTAULIC PIPING.

Pipe Diameter.	W.I. SCREWED.				VICTAULIC.			
	Fitters.	Labourers.	Feet per hour.	Feet per man-hr.	Fitters.	Labourers.	Feet per hour.	Feet per man-hr.
4	2	10	125	10	2	8	600	60
3	2	8	150	15	2	4	600	100
2	2	6	225	28	2	4	600	100

REMARKS.—Fitters for Victaulic need not be as skilled as Fitters for Screwed piping; any Sapper can make the joint with very little training.

BOOKS.

THE ARMY AND SEA POWER.

By MAJOR R. B. PARGITER, R.A., and MAJOR H. G. EADY, M.C., R.E. (Ernest Benn.) Price 10s. 6d.

It is one of the hopeful signs of the times that co-operation between the fighting services is becoming acceptable in theory, if it cannot yet be said to be completely in being. This book is written with the object of making this co-operation more whole-hearted and more real. The Authors could not have chosen a more effective method of demonstrating its necessity than this of gathering together from history the instances when Navy and Army have worked together. Everyone will accept as true the statement that the Army is ineffective without the assistance

of the Navy; not everyone will quickly agree to the converse. The reader of the book will, I think, be convinced that the sailor needs the soldier just as much as the soldier needs the sailor. This conviction is one of the things that are necessary to ensure that in future the services will ungrudgingly and unfailingly work together for the common end.

The story begins with the reasons for the growth of British sea-power, and it traces that growth through the struggles with Spain, Holland, France, and finally Germany. Instance after instance is given, vividly told and critically examined, in which Navy and Army have either succeeded by good co-operation, or have failed through the lack of it. Not only does it provide most interesting reading, but it makes the reader anxious to read more about many of the episodes which are to most people quite unknown.

The book concludes with a summary of the lessons which should be deduced from these operations of the Army and Navy in the past. It defines the *rôle* of the Army with regard to the Navy in the present, and it points to the probability that in the future the development of air power will involve the Army in further defensive commitments. It leaves the reader with much food for thought. War in the future will involve two, if not all three, services; it is all the more important that the conduct of combined operations should be studied by all concerned. To all those who would learn from the past in order to act rightly in the future this book is heartily commended.

N.W.N-C.

FIELD-MARSHAL LORD NAPIER, OF MAGDALA, G.C.B., G.C.S.I.

By LIEUTENANT-COLONEL the HON. H. D. NAPIER, C.M.G.

(Edward Arnold.) Price 21s.

Lord Napier, of Magdala, died in 1890, and in many ways it is unfortunate that no biography of this great man should have appeared until thirty-eight years after his death, chiefly perhaps because present-day conditions have compelled his son to limit the work to a single volume, whereas the account of so important a life, the active portion of which extended over more than sixty years, could hardly have been adequately dealt with in two. Colonel Napier explains in his Preface that the delay was due to the fact that it was originally intended that the biography should be written by Miss A. Yule, daughter of Colonel Sir Henry Yule, but time passed and Miss Yule died, and the duty eventually devolved upon him. The curtailment, he explains, has been made as far as possible in the details of the actual fighting, and for these we must turn to the acknowledged authorities on the various campaigns, as, for instance, Malleson for the Indian Mutiny, and Holland and Hozier for the Abyssinian Campaign. That Colonel Napier has carried out this filial obligation, within the limits which he has imposed upon himself, ably and sympathetically, all readers of this book will allow.

Most of us are familiar with the outstanding incidents in the life of Lord Napier, from the biographical notices in the Corps History or in

Colonel Thackeray's *History of the Royal Bengal Engineers*. Born in 1810, he obtained his commission in the Bengal Engineers in 1826, and went to India in 1828. Not till seventeen years later did he see a shot fired in anger. He distinguished himself in canal work under Cautley, in the development of Darjeeling as a hill station and in laying out the cantonment of Umballa. Then came the First Sikh War, with the battles of Moodkee and Ferozeshah, of which Colonel Napier gives us a most interesting personal narrative. It is curious to read of the share Engineer officers took in the battles of those and earlier times, roaming about the field looking for a job, offering their services to some who do not accept them, riding in cavalry charges, charging with infantry regiments, spiking odd guns, and even as a captain offering advice to the Commander-in-Chief. Napier tells how such advice given by him to Lord Gough may have turned Ferozeshah from a defeat into a victory. He was also present at Sobraon. A year later came the little expedition to Kangra, on which he insisted upon taking eighteen-pounders and made a practicable road for them through country "unequalled in difficulty by anything" the brigadier (Wheeler) had ever seen. "My labour was not useless," he wrote, "for nothing but the arrival of the eighteen-pounders had the effect of bringing the garrison to reason." In the Second Sikh War, Napier was C.R.E. at the first siege of Mooltan. His scheme of attack was too bold for adoption. His schemes always were bold, but when in later days he was in control, he always showed that boldness was successful. For the second siege, Colonel Cheape was C.R.E. and it was mainly Napier's scheme that was adopted—and succeeded. The place fell, and both officers arrived in time to take part in the victory of Gujerat. The Punjab was annexed and for ten years Napier laboured at his great engineering work of developing the province. Surely no great general ever had such engineering experience as Napier: "1,349 miles of road have been cleared and constructed, 858 miles are under construction, 2,487 miles have been traced and 5,272 surveyed, all exclusive of minor cross and branch roads," and exclusive also of canals, public buildings, salt mines, frontier defences, bridges, works too numerous to mention. In this period he took part in two frontier expeditions, the Black Mountain, in 1852, and against the Jowaki Afridis, in 1853, in both commanding columns of all arms, Sir John Cheape only securing the "record" by two months. In 1856, Napier went home on leave, bearing with him a most laudatory letter from Henry Lawrence, which could only be quoted in full. He returned to India to find the Mutiny in full blast, and joined Outram as Chief Staff Officer. Space forbids lingering over the operations at Lucknow, the first Relief, the Defence, and Sir Colin Campbell's second Relief. Then the siege and capture, with Napier as C.R.E. It is one long tale of indefatigable heroism. Colonel Napier gives an extract from a letter, written in 1871, in which Lord Napier wrote: "I do not think any position higher than that of an engineer who, unexcited by the actual strife of battle, amid the unknown dangers of the dark night, or in the face of contending combatants by day, exercises a calm and steady courage under the consciousness that on his skill and judgment depends the fate of thousands or the issue of the campaign." In the

Central Indian campaign of 1858, Napier was in command, and here his wonderful judgment in forecasting the action of the rebels, and his boldness in attacking them, no matter how heavily the numbers were against him, are hardly believable; but they are true and he was always successful. In 1860, he commanded the Second Division in the China War. At Calcutta he superintended the entire equipment and embarkation of the troops, every detail of equipment, food, clothing, ventilation and sanitation for sixty ships, and the security of the powder magazines, coming under his jurisdiction. Much opposition and red tape were brushed aside, and Napier was "enabled to deliver the Bengal portion of the troops in China in excellent condition, and fit for immediate service after a three-month voyage." The account of the success of his division at Sinho, and his advice to attack the North Taku Forts only, which was adopted by Sir Hope Grant in spite of the objections of our allies, the French, are to be found in Greathed's history of the campaign. From 1862 to 1865, Napier was on the Indian Council, first as Military Member and afterwards as President. He was a desperately strong man on the Council, his supreme knowledge of India and the Indians and of all military matters, and his great force of character, enabling him to carry his views against the opposition of the Secretary of State, the Commander-in-Chief, and even of the Governor-General. And yet they all loved and admired him. Even John Lawrence, whom he could never get on with, admired him. He was spoken of as the future Commander-in-Chief in India, as the future Lieutenant-Governor of the Punjab, but he became Commander of the Bombay Army, "strong representations" having removed the objections of H.R.H. The Duke of Cambridge, who could not at first agree to giving the appointment to an Engineer. This appointment led to his commanding the Abyssinian Expedition, almost entirely manned from the Bombay Army, a triumph of organization and fore-thought, carried through by Napier alone, under the eyes of all the civilized world. Perhaps the supreme moment of his life was when he refused to grant peace on the surrender of the European prisoners alone. "If Theodore would bring all the European captives to my camp and submit to the Queen of England, I would promise honourable treatment for himself and his family." The risk to the prisoners was great, but Napier knew his man, and they were surrendered unharmed, though Theodore preferred to die

> ". . . after the high Roman fashion
> And make death proud to take us . . ."

"The brilliant success of the Abyssinian Expedition, together with its strange and romantic setting, seized upon the imagination of the whole of Europe to such an extent that Napier, the most modest and retiring of men, almost 'awoke,' like Lord Byron, 'to find himself famous.'" He went back to India, in 1870, as Commander-in-Chief, having stipulated that the appointment should include a seat on the Viceroy's Council. His activity was unbounded, and so was his influence. "Lord Mayo said that everything conceded was done by him with a pistol at his head." Napier was the enemy of unwise economy, and fought

hard for the well-being of the British soldier, devising great schemes for barrack improvement. But we must not linger over this part of his history. It was a momentous period in India, when Russian activity in Central Asia was threatening the North-West Frontier, and intrigues at Kabul were working up for an Afghan War. The efficiency of the Army was all-important, and Napier initiated Camps of Exercise, the first of which was held at Delhi, in 1871–72. In response to a special appeal from the Duke of Cambridge, Lord Napier remained in office until 1876, and was present at the great review, held at Delhi, in honour of the Prince of Wales, on which occasion he remained mounted throughout with a broken collar-bone, the result of a riding accident—he was a bold and reckless rider, and his son writes that, in his younger days, "there was nothing too foolhardy for him to attempt in feats of horsemanship." When he left India, the *Civil and Military Gazette* praised the "splendid efficiency" of the Army in India, for "which England has to thank Lord Napier and the regimental officers who have carried out his anxious endeavours to keep the regimental system by which the British Army made its fame and brought glory to its colours." In that same year (1876) he became Governor of Gibraltar. In February, 1878, when Lord Beaconsfield's opposition to the occupation of Constantinople brought us within an ace of war with Russia, he "was hastily summoned from Gibraltar . . . and was appointed to command any expeditionary force that might be sent against Russia, with Major-General Sir Garnet Wolseley as his Chief-of-Staff." He was then, as Wolseley was later, "our only general," and after the war scare had passed away was frequently summoned to London for consultation by the Duke of Cambridge. In 1879, he refused to supplant his friend Lord Chelmsford, in Zululand, after the disaster of Isandula. In 1883, he relinquished the command of Gibraltar, where he had carried forward large schemes of improvement in a large way, leading the Colonial Secretary to tell his successor "that such extravagances should not be continued." In December, 1886, he was appointed Constable of the Tower of London, and three years later he died in London, and was buried with great pomp in St. Paul's Cathedral. His statue, by Boehm, originally stood in Waterloo Place, where that of King Edward VII. now stands. In 1923, it was moved to the present beautiful site in Queen's Gate. In a leading article, on 15th January, 1890, *The Times* said of him: "Never was there a career which ascended along more regular and indisputable stages. At every point it was able to bear the minutest inspection. Nothing in it was due to favour. It owed nothing to accident, unless of the sort which offers conspicuous occasion for failure as well as for distinction." His son writes: "Other men have had greater opportunities. Some may have been as intelligent, many as brave, a few as straight, as strict in their morals and conscientious in the execution of every action of their lives, as unselfish and chivalrous, as good a father, as perfect a husband, but no one else I have ever met has appeared to me to combine all these qualities to such a degree." A great man, indeed one of the greatest.

F.E.G.S.

MILITARY OPERATIONS: EGYPT AND PALESTINE.

From the outbreak of War with Germany to June, 1917. Compiled by LIEUTENANT-GENERAL SIR GEORGE MACMUNN, K.C.B., K.C.S.I., D.S.O. (late R.A.), *p.s.c.*, and CAPTAIN CYRIL FALLS, late 11th R.Innis.Fus. and General Staff. (H.M. Stationery Office, 12s. 6d. net; case of maps, 5s. 6d. net.)

War between the Allies and Turkey was not declared till November 5th, 1914. The delay was utilized by the Turks and their German instructors to complete their preparations for war. It was not known at the time that Germany and Turkey had actually signed an offensive and defensive alliance on August 2nd, 1914, two days before war was declared against Germany. In the absence of definite knowledge of this pact, the British and French Governments had a very difficult problem before them at the outbreak of hostilities on August 4th.

The Official Historian, in this case Lieutenant-General Sir George MacMunn, has an intimate knowledge of our military problems in the East and of our Indian Army, and is well qualified to speak on questions affecting the Moslem subjects of the British Empire. He explains the reasons for the delay in the opening chapter. The most important, of course, was the effect that war with Turkey would have on the Moslems in the countries ruled by Great Britain and France and those on their borders. There were other reasons more closely affecting British interests, more especially in Egypt, where the political situation, the position of the Khedive—who was hostile to England and was actually absent in Turkey when war broke out, the large number of Turkish Nationals in Egypt, and the defence of the Suez Canal gave much cause for anxiety. It was not till after the declaration of war with Turkey that the situation was eased by the deposition, on December 18th, 1914, of the Khedive and his replacement by his uncle, Prince Hussein Kamel Pasha, who was raised to the throne with the title of Sultan. On the previous day, Egypt had been proclaimed a British Protectorate. Although there was latent hostility to Great Britain and sympathy with Turkey as a Moslem Power, these drastic constitutional changes were viewed by the people with greater indifference than might have been expected. Expectations of some benefit to Egypt under the new *régime*, and ocular evidence of the great military resources of the British Empire, kept the people quiet.

War with Turkey was declared by both Great Britain and France on November 5th. On November 11th, the Sultan of Turkey, in his position as Khalif, immediately proclaimed a *Jihad* on all those making war on Turkey or her allies. The almost complete failure of that appeal all over the Moslem world was a complete justification of the wise policy, for which Lord Kitchener was largely responsible, pursued in Egypt and in India during the three months before Turkey came into the War.

A great deal has been heard, both during the War and after, about Alexandretta. As early as December, 1914, the importance of Alexandretta as a vital point on the Turkish lines of communications

to Mesopotamia, Arabia and the frontier of Egypt caused a diversion in the direction of the Bay of Iskanderun to be seriously considered. The project was then rejected, for the time being, for the following reasons:—"An organized field army, with modern means of transport "and equipment for the landing of stores, would have been required, "and could ill have been spared, even if it could have been found. "The Navy would have been called upon to make the Bay of "Iskanderun secure against submarines and protect the sea route "thereto. The landing of a British Force for any operations greater "than a raid would certainly have resulted in risings (anti-Turk) of "Armenians and of some of the tribes in the Amanus region, so that, "once having entered upon the enterprise, Britain would have found it "impossible to withdraw, however urgent the reason, and leave her "friends to Turkish vengeance. For these reasons, and especially the "first, Lord Kitchener and the Cabinet decided that in existing circum-"stances the passive defence of the Suez Canal itself, on the banks of "the canal, was the only possible method of protecting Egypt from "attack by land." The question arose again a year later, but will be discussed in its proper sequence.

That the danger of an attack on the canal by land was a real one, was very soon demonstrated.

The Sinai Peninsula has always been a formidable obstacle to invaders of Egypt. In 1916, the War Office estimated that the maximum force which could be brought across this almost waterless desert against the canal could not exceed 5,000 men and 2,000 camels. But on February 3rd, 1915, the Turks, led by a Bavarian Officer of repute, and one whose reputation has been enhanced by his conduct of operations in 1915–16, Oberst Freiherr Kress von Kressenstein, now Chief-of-Staff of the 8th Turkish Corps, crossed the desert by the central route and attacked the centre section of the Canal defences with a force which, according to Kress himself, numbered 20,000 men with nine batteries of field artillery, a 5·9 inch howitzer battery, pontoons, and 10,000 camels carrying supplies and water. Thanks to good intelligence the attack was expected, and was defeated at all points, with a loss to the Turks of nearly 2,000 men, including 716 prisoners. The British loss amounted to only 193. A few of the enemy actually reached the canal and launched the pontoons. The British troops were too immobile and dispersed to assume the offensive and pursue the retreating Turks on the following day. The Official Historian gives the reasons for this:—"In the first "place, though there were 70,000 troops in Egypt, only the Indian "Infantry Brigades, and not all of them, were highly trained, while it "was necessary to retain troops in Cairo and elsewhere. The only "point in the central sector of the canal defences—the sector attacked "in force—at which there were facilities for moving troops quickly to "the East bank was at the floating bridge at Ismailia, the ferries being "very slow and limited in carrying powers for the purpose. The "mounted troops available were the Imperial Service Brigade and "eight Companies of the Bikanir Camel Corps, and of these certain "squadrons and companies were distributed among the three sectors

"of the defence." By the evening of February 3rd, 16 squadrons had actually been collected at the bridge, most of them, particularly the Indian troops, far from advanced in training. There were no water convoys in existence. The force was, therefore, useless in both composition and equipment for a counter-stroke beyond the immediate vicinity of the canal. A reconnaissance eastwards was made on the following day, but the Turks made good their retreat.

Kress, in his book, takes great pride in recording that, in selecting the route across the desert in preference to that along the coast, he disregarded all the precedents of history. He attributes his failure to the defection of the Bedouin and the fact that he was not allowed to use the best Turkish troops available, the 10th Division; but he claims that, although his plan failed in its primary object to inflict permanent damage on the canal, it nevertheless was effective in showing that the Turks could bring strong forces with heavy artillery across the desert, and thereby caused anxiety in England and in Egypt and compelled the British to hold the country strongly. He excuses his failure to renew the attack by saying that, had he done so, the remnants of his force would have run a great chance of being surrounded and destroyed. He omits to mention that there had been abnormally heavy rains at the end of 1914, which had filled the ancient cisterns and wells, and thus facilitated his advance along a route which in normal years is almost waterless. General Sir John Maxwell reported that in Egypt the effect of the British success was excellent, in that Turkish prestige had received a severe blow, and all those whose sympathies were with the British, and above all the Egyptian Government, were relieved of fears regarding the situation and confirmed in the attitude they had taken up.

No serious effort was again made against the Canal. Subsequently a few mines were found in the Red Sea, and a Holt liner struck a mine in the Canal and blocked it for a few hours. The hopes of a Nationalist rising in Egypt consequent on a Turkish success on the Canal, which was undoubtedly the object of the expedition in the minds of the Turkish Government and the Turkish C.-in-C., were definitely, and, as it proved, permanently, shattered. It was not until two years after the War ended that the deep-seated unrest in Egypt broke into flame.

During 1915, the Gallipoli Campaign caused a large number of Turkish troops to be withdrawn from Palestine to that theatre. Before they could be spared to return to Palestine in 1916, the defence of the Canal had been made secure by the development of railways, pipe-lines for water supply, transport, and the improvement of communications generally. Egypt was also crowded with troops evacuated from Gallipoli. It was, perhaps, fortunate for Egypt that the Gallipoli Campaign intervened in 1915. The civil population were enriched by the presence of such large numbers of British troops in the country, for Egypt had become the "Levant Base," and was contented. But there was serious trouble now on the Western Frontier, where, thanks to the activities of numerous German and Turkish agents, the adherents of the Senussi were up in arms. This was followed by a rising in Darfur. To the operations on this frontier, in 1915, three

chapters of the book are devoted. The lesson to be learnt from them is the difference between fighting small wars with fully-trained officers and troops, and fighting them with untrained men unaccustomed to hot climates, with officers unversed in man-and horse-management, and with insufficiency of material and transport. The outstanding feature of these minor operations was the development of the armoured car and of light motor transport, the full value of which experience was reaped afterwards in Mesopotamia and in Palestine.

The proposal to evacuate Gallipoli, towards the close of 1915, was a matter of grave concern to the British authorities in Egypt, for it was certain to set free considerable Turkish forces. That the enemy had not abandoned the idea of another attack on Egypt was shown by his activity in developing the railway system in Palestine during 1915. Sir John Maxwell considered that evacuation would have disastrous results, morally as well as materially, unless Britain struck hard at Turkey elsewhere. It was at his instance that the Alexandretta diversion was once again brought to the fore. The whole problem was referred to the General Staff in London by Lord Kitchener. In Sir George MacMunn's words:—"The General Staff responded "heartily." They took serious objection to the scheme for the following reasons:—

(i) The locality was favourable for the concentration of large Turkish forces (in spite of the fact that the tunnels on the Bagdad Railway were still uncompleted).

(ii) The expedition would have to force its way 25 miles inland; it would then have to hold a perimeter of 50 miles, and for this fortress at least 100,000 infantry would be required.

(iii) Drafts to replace battle casualties and those from exposure would, it was evident, amount to 20 per cent. monthly for the first three months, and 15 per cent. thereafter.

(iv) This expenditure of man-power would not weaken Germany in the main theatre, whereas equal expenditure in France would weaken the Germans to at least an equal degree.

(v) Granting that there was to be a withdrawal *from* Gallipoli and Macedonia, we should nevertheless for a time be engaged in all three ventures at once, which would cause a dangerous dispersion of military and naval force.

(vi) Eventual withdrawal would be difficult, perhaps impossible.

(vii) The scheme offended against a fundamental principle of strategy: to retain the power of concentrating strength for a great offensive in a decisive theatre of War.

To which, Sir George MacMunn adds:—"The Admiralty also was "inclined to be unfavourable to the scheme, for a new transport route "of 400 miles (that is, from Port Said) would be added to its "responsibilities, and if a landing was contemplated before the complete "evacuation of the Gallipoli Peninsula, there would not be sufficient "small vessels and lighters for the new enterprise."

General Sir George Monro was not unfavourable to the scheme, and considered that the General Staff exaggerated the difficulties —particularly as regards casualties and drafts. Lord Kitchener considered that there was no alternative to the Ayas Bay scheme but defence of the Suez Canal. Sir John Maxwell's opinion was that, politically, the defence of Egypt in Egypt was undesirable.

While the discussion was in progress the French intervened and made it known that any plan of operations in Syria must be considered jointly by both Governments, and that if any action was taken it must be essentially a French operation, under French Generals and with mainly French troops.

This ended the discussion, for France was not in a position to conduct such an enterprise.

Great Britain had, therefore, no alternative but to prepare to meet a first-class Turkish offensive directed against Egypt.

With the appointment in January, 1916, of General Sir Archibald Murray to the Command in Egypt, the reorganization of the defence scheme to meet the new conditions was taken in hand at once, on the basis that it must be so organized that no enemy could possibly reach the Canal, and that, if attacked, the defenders must be able to make a counter-stroke. He was not content with a purely passive defence, and recommended an immediate advance to a suitable position east of the Qatiya (Katia) Oasis in the north, and the construction of a railway to Qatiya. By so doing, any attempt of the enemy to concentrate a large force in that comparatively well-watered district within two marches of the Canal, would be frustrated, and any forces directed against Egypt would be compelled to concentrate in positions much further east, whence the attack would have to be delivered with a 40-mile desert zone and with bad roads, on the lines of which the water supply was very indifferent, behind them. He was prepared to carry out this scheme with an Army Corps of three Divisions on the Canal, another Division to hold the Qatiya district, and three Mounted Brigades for all purposes. Recognizing the importance of the El Arish-Kossaima zone as the true strategical base for the defence of Egypt, he asked that, if the occupation of El Arish should eventually be practicable, he should be given two more mobile Divisions and another Mounted Brigade to hold it and enable him to undertake an energetic offensive-defence.

This plan was brought into operation at once, and Mounted troops were pushed out east of the Qatiya Oasis to cover the construction of the railway from Qantara and protect the Sappers employed in developing the existing water supply. The position of the covering detachments at Oghratina and Qatiya invited attack, and the Yeomanry suffered a severe reverse at the hands of a strong force of nearly 4,000 Turks with artillery, under the command of Colonel Kress von Kressenstein himself. Three-and-a-half squadrons and half a company of Engineers were surprised (owing to fog) and overwhelmed in the early morning of April 23rd; but the Turks did not press their advantage. The railway progressed without interference until August 4th, when an attack in force, again under Kress, against the Romani position

was defeated, with a loss of nearly 4,000 prisoners and a mountain battery to the Turks. On this occasion there was no question of surprise, for the Turkish force advanced with great deliberation. The reasons for this were not apparent at the time, but were appreciated when the Mounted troops were launched in pursuit on August 5th and found the Turkish rearguard offering strong resistance. Kress had during his advance taken the precaution to prepare several defensive positions. In the event, these justified the time and labour spent on them, but the delay rendered the element of surprise impossible. The remarkable endurance of the Turks, their marching powers in the deep sand and the great heat of the hot season, their readiness to counter-attack when the opportunity offered, and the rapidity with which they recuperated when they got back to their water and meagre rations, were evidence of the traditional tenacity of the Turk in defence. Romani was a brilliant British success, and marks the end of the campaign against the Canal, but it was disappointing that the enemy should have been able to retire with his force in being and his artillery practically intact, after a complete defeat which had appeared to offer opportunities for his destruction. Sir George MacMunn discusses the causes of his escape at some length, but it boils down to insufficient training of Staffs, Commanders and troops in open warfare. Nevertheless it must not be forgotten that the retreat, especially the withdrawal of the heavy guns, was undoubtedly conducted by Kress and his Staff with great skill.

During the autumn of 1915, the railway and pipe-line for water supply were pushed on with unremitting vigour. Sir Archibald Murray was determined to push on and drive the Turks out of Egyptian territory. His next objective was El Arish, garrisoned by, it was believed, about 1,600 men and well entrenched, and covering all the water in that area. Twenty-five miles south-east of the town, on the banks of the great Wadi El Arish, were further camps at El Magdhaba and Abu Aweigila, protecting the Turkish railhead at El Kossaima.

An advance upon El Arish necessitated the establishment of a very large supply of water at railhead and the concentration of large numbers of camels to carry it forward. Preparations were not complete till the 20th December, 1915, by which date material to carry the railway to Rafah was in sight. On the very day that all was ready for the advance the Turks were reported to be evacuating El Arish. It was occupied by the British on December 21st. Mine-sweeping was at once commenced in the roadstead and the construction of a pier begun. On December 23rd, the first ship from Port Said was landing supplies in boats. The march to El Arish marked the escape from the desert; firm soil was now found in place of the everlasting sand, and patches of cultivation were to be seen. There was, however, to be no halting. The next objectives were Rafah and Magdhaba. The latter was attacked first, on December 23rd, and the position was captured after a brilliant action fought by the Mounted troops under General Chetwode, under whom General Chauvel commanded the Mounted Division, the whole force, including the newly-formed Camel Brigade, being known as the Desert Column.

"Magdhaba will be remembered," writes Sir George MacMunn, "as "a notable instance of the effective employment of Mounted troops "against isolated fortifications in open country. It proved also the "value of the new Camel Brigade. Less mobile than the Light Horse, "now that the shifting sands of the desert, for use in which it had been "organized, had been left behind, and slower in coming into action, "the dismounted strength of its three battalions almost equalled that "of two Light Horse Brigades. When acting, therefore, with other "mounted troops, it greatly increased their offensive power."

The Turks had been dealt a heavy blow at Magdhaba, 1,272 prisoners being captured, together with four mountain guns and a great quantity of ammunition, but it was impossible to follow up the advantage immediately. The force had to wait for rail and pipe, and it was not until January 8th that the advance was resumed from El Arish, to which place most of the troops had been withdrawn to save transport. At 6.15 a.m. on January 9th, the New Zealanders crossed the frontier of Egypt and Palestine. The action that followed was fought in two continents, Asia and Africa.

Rafah was surrounded on all sides, and, before evening, had been captured after a gallant and stubborn defence with its whole garrison, 1,635 officers and men, of whom 162 were wounded—200 having been killed in addition. The British force withdrew with its prisoners at once, before it could be counter-attacked by the Turkish reinforcements sent up from Shellal and Khan Yunis.

Commenting on the capture of Rafah, Sir George MacMunn writes:—

"The enemy had not learned aright the lesson which had befallen his "detachment at Magdhaba. It can only be supposed that he considered "his position at Rafah to be better and capable of being reinforced "more easily in case of need. That his view was not altogether ill-"founded is shown by the fact that, owing to the arrival of enemy "reinforcements and the lack of water—available only within the "enemy's position or many miles to the rear—the British Commander "(General Chetwode) at one moment proposed to retire before the "fight was won. The margin between success and failure had been "slight." Kress states that his advice (after Romani presumably) was to evacuate Sinai completely, but that the Turkish C.-in-C. (Djemal) for political reasons would not agree to this course. He points out the great advantage possessed in country of this sort by a combatant very strong in mounted troops over an enemy almost without that arm. He exaggerates, however, when he describes the three mounted brigades at Magdhaba as "two English cavalry divisions."

"Sinai was now won. Its occupation may be said to have begun in "early April, 1916. It had been extended by bounds, followed by "steady consolidation and preparation for the next move, except for "the one serious check administered by the enemy at Qatiya. This "method of progress was to continue, its speed always dependent on "that of the railway, and, in rather a less degree, of the pipe-line. But "now the necessity of waiting for the rail and pipe was not the sole bar "to progress. The British Government, in January, 1917, had decided

" that the necessary reinforcements were not available for a further " advance into Palestine and that the prosecution of operations on " a large scale must be deferred till the autumn of 1917. The general " policy during the summer was to prepare for such a campaign, but " meanwhile—here was the rub—to be ready to release for service in " France one or two Divisions." As a matter of fact, the 42nd Division was ordered to France on January 17th. The enemy in the meanwhile fell back to Gaza and Tell esh Sheria, 14 miles north and north-east of Shellal respectively, thus necessitating a further pause, during which the railway and pipe-line were pressed forward and the troops reorganized into the Eastern Force and Desert Column, the Mounted troops being reorganized into two Divisions, and the infantry provided with wheeled transport in place of camels. Kress states that he would have liked to fight on his strong position at Shellal, but found himself too weak to hold it and at the same time secure the defence of Gaza. Though reinforcements had been promised him by Enver, most of them did not reach him till after the first Battle of Gaza, and he had to order the evacuation of Shellal and all the stores and ammunition collected there. This was completed by the 5th of March.

Before advancing on Gaza, the British had to wait till railhead reached Rafah, which it did on 21st March, followed closely by the pipe-line. The total enemy forces at Gaza, or in a position to intervene, were estimated by G.O.C. Eastern Force, General Dobell, to be two-and-a-half weak Divisions. As a result of the advance along the coast, the British line of communication now overlapped the Turkish. To quote the Official History:—" The question whether the Force should follow the coast-" line, or turn inland towards Auja on the Turkish railway, had already " been discussed and the former alternative had been chosen. Now " that Rafah and (later) Khan Yunis, from which tracks left the coast " route towards Beersheba, had been reached, the problem required " reconsideration. Sir A. Murray, however, again came to the con-" clusion that to turn inland was inadvisable, since by so doing he " would be drawing his L. of C. parallel to the enemy's front, and there " was no technical advantage to be gained by linking up the military " railway with the (Turkish) Central Palestine Railway, either at Beer-" sheba or at Tell esh Sheria. The true line of advance (he decided) was " still along the coast, since the enemy was no less effectually threatened " thereby, while his own L. of C. was more easily protected and railway " construction was more rapid, owing to the absence of gradients. Both " the C.-in-C. and Sir Charles Dobell were concerned lest the enemy " should evacuate Gaza and withdraw out of reach before a blow could " be struck at him. It was, therefore, necessary to act swiftly, and the " only effective action within the immediate power of the British " appeared to be a repetition on a larger scale of the operations which " had proved so successful at Magdhaba and Rafah: that is to say, " a cutting-out expedition against Gaza, after which it might be " necessary temporarily to withdraw the whole force or a part of it to " railhead. Sir A. Murray set three objects before Sir C. Dobell, to " whom the operation was entrusted: to gain the line of the Wadi " Ghazze in order to cover the advance of the railway, to prevent the

" enemy from withdrawing unmolested, to capture Gaza and its garrison " by a *coup de main*."

Gaza was attacked on the 26th March, 1917. Two chapters are devoted to the narrative, which is excellent in every way. The battle was within an ace of being as brilliant a victory as Rafah, and had there not been a delay, caused by fog at dawn on 26th March, which hindered reconnaissance and thereby the advance of the infantry, it is probable that the town would have been captured and the force withdrawn before dawn on the 27th, that is to say, before the Turkish reinforcements, two Divisions, which were very slow in coming up and failed to arrive on the 26th, could intervene. As at Rafah, it was a case of " touch and go," but Dame Fortune did not, this time, decide in favour of the British. In the evening, General Chetwode, commanding the Desert Column east and north-east of the town, came to the conclusion that the infantry attack would not succeed on his left, and fearing that his Mounted troops—already in touch with the belated Turkish reinforcements—could not be withdrawn to water their horses without interference, gave the order to General Chauvel to commence a general withdrawal. This was at 6.10 p.m. and the order was given with the concurrence of the G.O.C. Eastern Force, Sir Charles Dobell, whose headquarters were alongside of his at In Seirat, south-east of Gaza. If only Sir Charles Dobell had known the desperate straits of the garrison at that hour, it is probable that the order would not have been given. The tragedy was that the state of the garrison was known not only at Sir A. Murray's forward headquarters on the railway at El Arish, but even at Cairo! Wireless messages exchanged between the Turkish Commander (Major Tiller) in Gaza, and Kress at Sheria, had been deciphered in Cairo but were delayed in transmission and did not reach General Dobell till between 10 and 11 p.m.

The private diary of Major H. P. T. Lefroy, R.E., Wireless Officer attached to Intelligence (E) at Cairo, is quoted in the " Official History." Major Lefroy had the key of the Turkish cipher, picked up all the enemy's messages during the day and telephoned them on, within a quarter-of-an-hour of their being deciphered, to Eastern Force Exchange at Rafah, which was in direct communication with the Battle headquarters of both General Dobell and General Chetwode at In Seirat.

Again to quote the " History " :—" Why these messages did not reach " General Dobell earlier cannot now be determined, as their originals " are not now to be found. The only obvious explanation is that the " advanced headquarters were far from Eastern Force Exchange at " Rafah, that there was heavy pressure on the line forward, that proper " discretion as to the priority of messages was not exercised. The " times of the messages are not known, but there were at least four " which reached Rafah before 6.30 p.m., all of which would have been " of immense value to General Dobell, had they been earlier in his " hands."

The wireless station in Gaza was actually blown up by the Turks, after exchanging farewells with G.H.Q. at Sheria, and receiving orders to destroy all papers and blow up the installation, at 5.40 a.m., on March

27th, which confirms the information in one of the messages that the Turkish officers had refused on the previous evening to face combat at dawn.

That mistakes were made by subordinate commanders is obvious. The causes of the failure are discussed by Sir George MacMunn on pp. 315–317, but some insight into them is gleaned from a paragraph on p. 289, which anticipates the failure and endeavours to find the cause in the smallness of the Staffs for the number of troops employed. There is also a significant paragraph on the previous page, also anticipatory, in which the Official Historian comments on the advantages of the battle headquarters of the G.O.C. Eastern Force and the G.O.C. Desert Column being alongside of each other, but adds:—"In this there was "advantage, but it was, perhaps, counter-balanced by the fact that the "subordinate of two commanders inevitably feels himself cramped in "his conduct of an action if his superior is 'on top' of him."

After the First Battle of Gaza, the policy of the Government was completely changed, and Sir A. Murray was now urged to advance and capture Jerusalem as soon as possible. This was partly due to the news of British successes in Mesopotamia, but must be in part attributed to the somewhat optimistic tone of Sir A. Murray's first dispatch reporting the action, which apparently led the Government to believe that a victory had been won.

Accordingly, steps were at once taken to hurry forward the railway and provide additional water supplies further north, while the 74th Division was brought up, and with it eight tanks just arrived from England.

Gaza was again attacked on April 17th. Surprise was now out of the question, and it was a case of a frontal attack, for in the three weeks that had elapsed since First Gaza the enemy had reinforced the garrison and constructed a line of redoubts which rendered the outflanking of the left of their position practically impossible, with the troops at Sir A. Murray's disposal. The main effort was made on April 18th, and the battle continued on the 19th, but by the afternoon of that day it was apparent that there was no prospect of success on any part of the front. General Dobell issued orders for the attack to be renewed on the 20th, but was forced by circumstances to abandon the idea, and the ground won was consolidated.

Sir George MacMunn summarizes his comments in the following words:—"Thus ended the second attempt to capture Gaza, and the "most considerable battle yet fought in this theatre. It has none of "the interest of the first attempt, which was practically an encounter "battle with constantly changing situation and ever-unfolding oppor-"tunities on both sides. This was a dogged advance against "imperfectly located entrenchments and in face of fire from heavy "artillery, without adequate support from that arm on the side of the "attackers, an advance which finally lost impetus owing to the lack of "the necessary mechanical support. It needs no comment, save that "it illustrates once more the high quality of Turkish troops in prepared "positions and emphasizes the advantages of defence in areas as opposed

" to linear defence, at least by day and in clear weather. There were " wide gaps in the Turkish position, but the redoubts were well-sited " for mutual support and permitted the retention of resources for " counter-attack outside the danger zone. Since the Turkish infantry " did not flinch from counter-attack, the result was never in doubt."

The question whether Sir A. Murray was justified in attacking Gaza at all a second time is not discussed. He must have been aware that the enemy had been considerably reinforced after First Gaza, whereas the only addition to his own troops was the 74th Division and eight tanks. Troops have to be trained to work with tanks. The point is whether the C.-in-C. ought not to have resisted the urgent demand of the Government to push on, in the hopes of capturing Jerusalem, without waiting to be reinforced himself. It was probably the eight tanks that turned the balance and induced him to do what he could with what he had got. The only compensation for the failure is, perhaps, that the effort so loyally made diverted Turkish reinforcements from other fronts. To decide that point we have to wait for the second volume.

Space does not allow of much reference to the Arab Revolt against Turkey. It is, however, intimately connected with the advance of Sir A. Murray into Palestine, and its importance was recognized by him. Sir George MacMunn's chapter on the relations of Islam, Arabia and Turkey, and those between Great Britain and the Sherif of Mecca, is a valuable one, and ably summarizes the situation which led to the Arab Revolt. It is satisfactory that the Official Historian recognizes the services of Lieutenant-Colonel—then Captain—T. E. Lawrence (now Aircraftsman Shaw of the R.A.F. in India) to whom, he writes, " much " of the final success of their (Arabs) campaign was due." The " problem " of Rabegh is fully discussed. " The wisdom of the decision " —not to send a British Brigade to Rabegh—can now scarcely be " doubted, strong as were the arguments of those who advocated the " dispatch of troops ; for the presence of a brigade on this unhealthy, " ill-watered shore might have involved the E.E.F. in a serious commit- " ment "—is the comment of the Official Historian, so that Sir William Robertson's opinion is confirmed.

The operations near Aden, in 1915, are lightly touched upon, but, for a general account of affairs in that corner of Arabia during the War, the reader is referred to *The Empire at War*, edited by Sir Charles Lucas, pp. 135–148.

Speaking generally, the form of this volume of the *Official History of the War* follows that adopted in those relating to the Western Front. The Maps and Sketches by Major A. F. Becke, attain the same high standard. The inclusion of panoramic sketches of the country are very helpful in enabling one to realize its nature, although in the case of a comparatively level plain the features are somewhat difficult to discern. In some of them, the impression given is that there could hardly have been any cover at all in the advance.

There is a somewhat different style of comment on the operations in these volumes, which gives the reader the impression that the Editors have been somewhat lenient in accepting amendments and explanations

to the advanced proofs, which it is customary to circulate confidentially to officers who took part in the operations. Page 200 is a case in point. It is to be hoped that in the matter of criticism the second volume will adhere more closely to the example set by the more experienced Editor of the *Official History of the Operations in France and Flanders*.

H.B-W.

THE PALESTINE CAMPAIGNS.

By Colonel A. P. Wavell.

(Constable, 12s. 6d. net.)

This addition to the series of volumes on *Campaigns and Their Lessons*, edited by Major-General Sir Charles Callwell, K.C.B., following that by Colonel H. de Watteville on *The Waziristan Campaign*, can be confidently recommended to the general reader. It has appeared very opportunely, anticipating Volume I of the "Official History" by a few days. The student has now three good books with which to commence his study, that by Major-General Sir M. G. E. Bowman-Manifold being the third.

In Colonel Wavell's Volume we have, as in General Manifold's, an account of the whole Campaign in Egypt and Palestine by an officer who has had access to the official information on the subject. The book is well written and affords easy reading. It is a relief to re-read it after delving into the detail of the "Official History," for it often summarizes in a page or less the information which must be extracted from perhaps a chapter of the official version. At the same time, sufficient detail is generally given to enable the reader to quote chapter and verse for the statements made.

After reading both Colonel Wavell's Volume and the "Official History," the officer who intends to take up the Campaign for special study, with possibly a view to an examination, will in the last instance do well to refer to the former volume for condensed—and well condensed—epitomes of the political, strategical, or other questions which come up for discussion.

The Volume concludes with a short chapter on "The Lessons of the Campaigns," the subjects discussed being the Value of Mobility, Mechanized Forces, Training and Surprise. This chapter might well be considerably enlarged in a future edition. For instance, to take only one phase of the Campaign—the advance from Qantara to Gaza—lessons that may be drawn include the following:—

(1) Danger of using Cavalry dismounted unless it is absolutely necessary—Romani and Gaza.

(2) Value of close co-operation of R.A.F. and Cavalry. Magdhaba and Rafah.

(3) Value of Mounted troops for long-distance independent missions, especially in a country with no roads. Magdhaba and Rafah.

(4) Unsoundness of giving the Commander of one formation a call on the troops of another. First Battle of Gaza.
(5) More than one task should not be given to one body of Mounted troops. First Battle of Gaza.
(6) Impossibility of commanding Mounted troops at a distance. First Battle of Gaza.
(7) Raid on Auja-Beersheba Railway justified because the Mounted troops were not thereby kept away from any important operation.

If the title of the Series *Campaigns and Their Lessons*, is correct, and the object is to help officers to dispense with crammers, the consideration of questions such as these is of the greatest value. It entails a thicker volume, some sketches perhaps, and a little greater cost (less than a crammer), but so much has been successfully achieved by Colonel Wavell in the condensing of the mass of material at his disposal that the results of expansion in this direction would probably popularize the book. As it is, the volume does not quite fit the title "Campaigns *and Their Lessons*," and the reviewer has to agree with the verdict of a young officer who has had to study the Campaign—"Rather light!"

The absence of an Index is to be regretted, although there is a good "Table of Contents." The Maps are sufficient, and, for a publication which is not subsidized by public funds, the price, 12s. 6d. net complete with maps, is very moderate. The book is well worth getting, whether one has to study the Campaign or not.

H.B-W.

THE STAFF AND THE STAFF COLLEGE.

By BREVET-MAJOR A. R. GODWIN-AUSTEN, O.B.E., M.C., The South Wales Borderers.

(Constable & Co.) Price 21s.

To many non-unionists "the world's most exclusive trade-union" is from time to time a subject of mild derision or embittered criticism. Others, turning a deaf ear to the pessimists, are struggling in the tide which they hope may wash them up, weary but rejoicing, at the gate marked "In" on the London Road at Camberley.

If the former read, as I trust they will, Major Godwin-Austen's excellent book, they will learn that, after all, the Staff College graduate is a very human person, brought up, at an age when it might be thought that life would be beginning to move with a more dignified and measured tread, in a school in which hard work, hard riding and hard play are sauced with a *joie de vivre* worthy of the junior school next door.

The other class will surely be stirred to greater efforts in order that they may join in the good days awaiting them: incidentally they will absorb much good meat against examination day.

It is hardly too much to say that every officer should read this book as an essential part of his military education, for in it the author has

traced clearly and in the most attractive manner the growth of the organization which was not only responsible for the outstanding efficiency of our small Expeditionary Force in 1914, for its secret and rapid dispatch overseas, but, in spite of the heavy losses of trained personnel, was yet capable of forming the foundations of the tremendously expanded staff required by the great armies of later years, firm foundations to which the success of the fine operations of the summer of 1918 bore witness.

Major Godwin-Austen has told his tale in a quite admirable manner, for although he has included all the *Army Orders* which form the main milestones on the road of progress for the last 120 years, he has sandwiched the dry bread of official memoranda so cunningly with the juiciest meat of anecdote, and infused the whole story so well with that rare good spirit of *camaraderie* and humour in work and play, the best quality of the two best years of one's life, that there is never a dull page in the book.

What will strike the reader most, perhaps, is the way in which he has made, with a wealth of apt stories, all these historical characters stand out alive, vivid, human, natural as if one knew them in person. Le Marchant, founder of the Staff College, or Senior Department of the R.M.C., as it was at first, "student and fighting soldier, teacher and administrator; an upright gentleman; a man of the world, of high moral character." General Jarry, kindly, courteous old Frenchman, educated and thoughtful soldier, an enthusiastic exponent of military sketching: Hamley, humorous writer, eminent military historian, combining "exceptional ability with a love of every kind of sport, fine horsemanship and reputation for bravery in the field," but not one to encourage students to differ from him in opinion!

Many more sidelights we are given on great men of the past: Wellington, inveighing against "educated" soldiers, yet surrounding himself with the men of High Wycombe; the Prince Consort, strong friend to the Staff College, for which it may be said he gave his life: the old Duke, first energetically supporting reforms in Staff and Staff College, and then, in later years, the devil he had raised pushing him faster and faster towards uncharted shoals, unable to stem the tide, thanks to the energies and wider outlook of Wolseley and his men; all these the author brings to life for us.

Finally, he recaptures the high spirit of the Drag, best of all institutions, breeding-ground of many a lifelong friendship, rare training and test of soldierly qualities, humour, grit, patience, a good heart.

As "teacher" might say: "Good work."

R.L.B.

"THE MECHANIZATION OF WAR."

By VICTOR WALLACE GERMAINS ("A Rifleman").

(Sifton Praed.) Price 8s. 6d.

This book, which includes an instructive "Foreword" by Major-General Sir Frederick Maurice, is a useful contribution to the ever-

increasing volume of post-war literature on the subject of tanks and of the mechanization of the Army in general, and should be read by those who have studied recent works on these matters by Colonel Fuller and Captain Liddell Hart.

Mr. Germains deals firstly with the use of tanks and the problem of their design, and then makes a vigorous onslaught on those who seek to establish a new "Science of War." He next passes to the problem of how to escape from trench warfare, and concludes with a chapter on the policy that should be adopted for the future organization of our Army.

Supporting his arguments by the opinions of many well-known authorities, the author contends that the popular theory, that the "deadlock" on the Western Front in the late War was only finally solved by the use of tanks, has little foundation in fact. This deadlock, he asserts, was due to a general balance in military resources and a general standardization in methods, training, and equipment, *not* to a breakdown in military technique, and he points out that where such a general standardization did not exist there was no stalemate, *e.g.*, the battles of Tannenberg, the Masurian Lakes, and the break-through at Gorlice.

What really solved the deadlock on the Western Front was, in Mr. Germains' opinion, the arrival of vast numbers of American troops, which had great effect on the morale of the German Army, besides freeing considerable numbers of French and British troops from quiet sections of the line.

The chapters dealing with the value of tanks during the War are, on the whole, very convincing, although occasionally Mr. Germains appears to have slightly over-reached himself in the search for facts to suit his opinions.

It cannot be denied that, as he says, some German attacks made *without* tanks were as successful as Allied attacks with them, and that our successful tank attacks owed much to the co-operation of all the other arms and to surprise being possible.

Mr. Germains is, however, inclined to underestimate the moral effect of tanks, and it seems probable that his opinion on this point would be different if he had had the mischance to be charged by one in the open, with nothing but a rifle in his hand and a pair of 8 m.p.h. legs to move him out of the way. He suggests that it should be no more difficult for infantry with a rifle firing armour-piercing bullets to stand up to a tank attack, than for a big game hunter to face a charging elephant. One is inclined to wonder whether he would maintain this argument if the elephant's trunk, instead of merely emitting hot air, were belching forth machine-gun bullets at the rate of 300 to the minute.

In dealing with tank design, the author shows that we have entered on the phase which began in sea warfare with the development of the "ironclad," the struggle between armour and projectile, in which the tank, having *all* its surface exposed to view and attack, is at a disadvantage as compared with the warship.

The conclusion at which Mr. Germains appears to arrive is that all Governments will be equally alert against surprise by new forms of tanks, and that, since it is infinitely cheaper and simpler to build anti-tank weapons than to build tanks, the chance of bringing off tank "surprises"

are by no means favourable. Later on in the book he admits, however, that tanks in limited numbers and for certain purposes are necessary.

As Sir Frederick Maurice points out in the "Foreword," the history of war shows clearly that no one weapon is for long supreme: the reply to it is soon found. This, then, renders it all the more necessary, while making every endeavour to equip troops with the best possible weapons, to rely upon correct principles rather than particular methods.

With regard to the so-called "Science of War," the author maintains that there is no such thing, and that what is often popularly given this name is in reality a "Technique of War." It is absurd, he suggests, to postulate "Laws of War," and he points out that victory can often be gained by deliberately disregarding so-called "Laws." A "Military Pelmanism," Mr. Germains remarks, is a sure road to disaster.

The majority of military students will no doubt agree in the main with the author's somewhat drastic criticisms of the would-be creators of a Science of War. As Sir Frederick Maurice points out, "there is nothing new in this attempt; the military pedants of the eighteenth century were more skilled in it than are their imitators of this year of grace. The *artist* Napoleon swept aside their theories as an autumn gale sweeps away the leaves that fall. Belief in a Science of War took Mack to Ulm."

In the chapter on "How to Escape from Trench Warfare," it is pointed out that, however swift a mechanized force may be, however rapidly it may manœuvre, it has to have lines of supply, and cannot live on the country (a point often slurred over by ardent protagonists of the tank), and it has no smashing power. Mr. Germains writes—"It has no heavy artillery, it cannot charge forts. Thus it is necessary for us to bring, or threaten to bring, *smashing power* against the enemy's great railway centres. By this means we shall fix him to his ground, and afford to the mechanized column the chance to "drive" at his flank and rear. The issue of such fighting will depend on questions of leadership, numbers and power. If the enemy is equal or superior to us in such elements, it is hopeless to think of decisive victory. But given superiority on our side, the combination of *weight* and *pace* affords the only real prospect of making a break with trench warfare."

It is doubtless true that no war can be won without fighting, and that to hope to win a battle by manœuvre without fighting would be futile. At the same time, to lay down that a mechanized column can have no *smashing* power seems open to argument. Mr. Germains evidently visualizes such a column as composed solely of vehicles like the Vickers tank, whereas most readers when picturing a mechanized column will include mechanized artillery, mechanically transported "infantry," supply vehicles, etc., which will undoubtedly be necessary in some form or other to enable a mechanized column to fulfil its functions.

In the last chapter the author outlines our military commitments, and exposes fairly accurately our military unpreparedness as compared with pre-war days. He lays down somewhat arbitrarily that an Expeditionary Force of 12 Divisions, plus ancillary troops, represents the minimum necessary to fulfil our obligations under the Locarno Treaty, and that we must be prepared to support this by a further 12 at very short notice,

otherwise it would mean stalemate, and a war which might last for years.

The conclusion that Mr. Germains arrives at is that mechanization of a large national army is not a practical proposition, and that, therefore, while we are active in experimental work, and while we may be justified in producing a small mechanized army, the latter must be supported by a great national army in time of war if it is to do anything really useful. He therefore suggests that greater efforts should be made to build up military reserves. The problem of training and expanding the Territorial Army should be tackled by making the Regular Army work closer with the Territorial Army—the former acting, in fact, as an educational agency for the latter. He suggests that short-service men should be taken into the Regular Army to qualify as instructors in drill, musketry, etc., and that on expiry of their colour service they should be given non-commissioned rank and posted to Territorial battalions instead of to the Army Reserve.

Mr. Germains also attacks the Cardwell system, alleging that it is wasteful and illogical in time of peace. He suggests (without referring to the hardships and administrative difficulties it would involve) a system in threes, whereby only half a battalion would be maintained at home for every battalion abroad. It is maintained that by this system the other half-battalion would be available for training short-service recruits and building up a reserve.

The author appears to overlook the fact that the battalions now stationed at home on the Cardwell system enable us to provide only an Expeditionary Force of 5 Divisions. If the home battalions were, as he suggests, cut down to half-battalions, it is difficult to see how any Expeditionary Force at all could be organized, or even how provision could be made for situations such as that which now exists in China. Mr. Germains rightly considers that a European war is our biggest commitment, but he appears to ignore the fact that, whereas only perhaps twice in a century are we faced with a European war, small wars and disturbances occur at far more frequent intervals, and have to be dealt with by a standing army.

It seems doubtful whether Mr. Germains' solution is the correct one, although it will be generally agreed that, as Sir Frederick Maurice points out, our little Regular Army has not solved all or even most of our probable military problems. It is but the advanced guard of our national army. "Let us make the advanced guard as mobile as may be, but in doing so we must not neglect the main body."

G.N.M.

PSYCHOLOGY AND THE SOLDIER.

By F. C. BARTLETT, M.A.

(Cambridge University Press.) 7s. 6d.

This book is a selection from lectures delivered at Cambridge by the author, who is Reader in Experimental Psychology and Director of the Psychological Laboratory of the University of Cambridge. The Preface

acknowledges the help of Brig.-Gen. E. W. Costello, V.C., C.M.G., C.V.O., D.S.O., Director of Military Studies at the University of Cambridge.

With the progress of material science, the burdens laid upon the officer increase daily—but at the root of all things lies the *man;* he is the one fundamental factor which does not change, or changes very slowly. It is curious, therefore, that in the multiplicity of text-books an officer has to study but little direct assistance is given him in this study of the "fundamental factor." Not every officer is a born leader of men, and surely a wise study of psychology would prove of assistance to most. The following quotation from the General Introduction to the books puts the case clearly: "If the Duke of Wellington had been accused of being a psychologist, his reply would probably have been brief but very emphatic. On one occasion, however, he was trying to state the qualities of a great Captain. 'One must understand,' he remarked, 'the mechanism and power of the individual soldier, then that of a company, or battalion, or brigade, and so on, before one can venture to group divisions or move an army.' Personal courage is necessary and valuable, but is by itself utterly inadequate. In discussing Sir John Moore, Wellington said: 'He was as brave as his own sword, but he did not know what men could do, or could not do.'"

There, in a nutshell, is the case for the application of psychological study to the problems of building and training an army. For it is the psychologist's business to try to understand "the mechanism and power" of the individual, to know "what men can do and what they cannot do, and to learn how human conduct is governed."

Part one of the book deals with "Choosing and Training the Recruit," and the chapter headings will give the scope: "Testing the Special Senses," "Testing Intelligence," "Tests of Special Abilities," "Training bodily skill," "Practice and Motives in training bodily skill," "The Study of Fatigue."

Part two deals with "Leadership, Discipline and *Morale*," and it is this part which is likely, perhaps, to make the most immediate appeal on first reading.

Incidentally it is a pity that the word "morale" is not treated as an English word and so written, instead of as "*morale*" or "*moral*." Surely, as laid down in *Modern English Usage*, the time has arrived to adopt a standard and straightforward way of writing this ill-treated word.

Discipline is defined as "enforced obedience to external authority," morale as "obedience to an authority which comes from inside the man himself." This is a restricted use of the word morale, which in its wider sense means "the mental state of a group of men," such as an army. The whole discussion is interesting and helpful.

Leaders also are classified under three different types, and their characteristics and limitations and different methods of leading are illuminating. A further chapter deals with "morale with special reference to group games."

Part three is on "Mental Health and Disease in Warfare." The normal reactions, of the individual and the group, to war conditions are discussed. Then follow chapters on the hysterias produced by the late War, which were sometimes classed under the general name of "shell-shock."

Altogether, this book may be recommended to the reading of all officers, with the hope that it may lead to further individual study of this important subject. As the author puts it, "it is most desirable that any person who takes up a professional career should have some lively interest, outside of the mere routine work of his profession, but if possible bearing upon it, which he can prosecute throughout his life. Such an interest, though it be no more than what is called a hobby, is in most cases just what is needed to keep a man keen and alert, to prevent him from stagnating, from falling into hopeless ruts." Such an interest, he suggests, is given by the study of the problems dealt with in this book, and by the study generally of the men with whom the officer deals in his daily work.

P.H.K.

WASHINGTON: AN ESSAY IN THE REMOVAL OF WHITEWASH.

PIOUS LIBELS.

Reviewed by E. B. OSBORN.

GEORGE WASHINGTON, THE IMAGE AND THE MAN. By W. E. Woodward. (Jonathan Cape.) 15s. net.

(Reprinted from *The Morning Post.*)

The Mayor of Chicago and all the other hundred-per-cent. American patriots will surely detect the "snoot" of George the Third on every page of Mr. Woodward's vivid biography. Indeed, we should not be surprised if the book were burnt alive on the lake-front of their midway metropolis, that huge paradise of boodlers and bootleggers! Not only does Mr. Woodward scrape off the various coats of whitewash from the historic effigy of the first President (an executive officer, by the way, created in the image of George the Third), but he also does his best to destroy the popular myth of a righteous Revolution carried out by pious whole-hearted patriots. Let us, first of all, consider the new background he paints into his portrait of the Father of his Country.

"The revolutionary movement," he points out, "was started by the merchants and the lawyers. It was purely a commercial dispute which had nothing to do with personal liberty. To make their grievances more alarming to the British Government, the aggrieved merchants organized the common people—the voteless and the landless—into mobs which made it impossible for the British to carry on the peaceful administration of affairs or to protect life and property."

The American working classes were in a perpetual state of impoverish-

ment. Nothing had been done to alleviate their hard lot, and in the Courts a working man had practically no standing when he was opposed to his employer or any other person of property or social position. There was a time when the oppressed common people threatened to capture the whole revolutionary movement, and they would certainly have done so but for the powerful opposition of Washington and other leaders of the colonial aristocracy, who were able to thrust them down and keep them down. When the British rule came to an end, the working classes were worse off than they had ever been.

American history is now being re-written by American scholars, who seek the truth in a spirit of scientific disinterestedness, and nothing "Big Bill Thompson" and men like him can say or do will prevent the completion of this task. The popular conception of the "Boston Tea-Party" is one of the many myths which have been swept away by truth-seeking historians. The East India Company had decided to ship tea direct to America in its own vessels, to establish its own warehouses there, and to sell direct to the retailers. This plan, if carried out, would have eliminated the tea smugglers and other middlemen, and have provided the working classes with a necessity of life—they then drank hot tea at all three meals, if and when they could afford it—at a much reduced price. There was nothing patriotic in the successful campaign at Boston, and elsewhere, against cheap tea. The tea smugglers, who occupied a position similar to the liquor smugglers of to-day, were responsible for its success. What happened was just what would happen if the Anti-Prohibition movement were to become so strong that Prohibition would be really in danger. "Does any sensible person," asks Mr. Woodward, "think that the bootleggers of America would stand by in idle indifference, and see their trade swept away, and their families brought to ruin? Dollars by the million would pour into the Prohibition treasury, lobbies would besiege Congress, the Ku Klux would be set to work, and in the remote districts the more aggressive opponents of Prohibition would probably be decorated with tar and feathers."

The American Revolution was a squalid business from first to last. The picturesque legends of "Embattled Farmers" at Bunker Hill vanish as we read of the efforts to suppress mutiny in the revolutionary armies—in particular, as we contemplate the fate of the Pennsylvanian soldiers, who refused to march south unless they were paid "in real, not ideal, money." The twelve ringleaders were shot by their particular friends and messmates. Washington himself had little belief in patriots and patriotism. "I know patriotism exists," he wrote, "but I will venture to assert that a great and lasting war can never be supported on this principle alone. It must be aided by a prospect of interest or some reward."

Mr. Woodward ruthlessly destroys all the Washington legends invented to give a moral tone to the Revolution, which have been taught to generation after generation of American school children. The story of the axe and the cherry-tree has long been abandoned by historians, and the myth of exceptional vitality which shows us Washington engaged in solitary prayer in the woods at Valley Forge, making it very clear that he wanted God's help in giving the British a

good hiding, is proved to be a preposterous fabrication. "In direct opposition to the pious Valley Forge legend," writes his biographer, "is the fact that Washington was never known to pray in church; that his own pastor said he never knelt when there were prayers; that he never took Communion, even in the church of which he was a member." And there is no historical authority for the literary composition known as "Washington's Prayer," which has appeared in innumerable papers on the anniversary of his birthday, and will, no doubt, continue to appear.

But the removal of the several thick coats of whitewash leaves a character, strong and sufficient to itself and scornful of picturesque illusions, which stands head-and-shoulders above his contemporaries. Even when we know his weaknesses, we must needs respect this strange combination of an aristocrat and a backwoodsman. Among the corrupt wire-pullers and war profiteers and noisy demagogues of his period his figure is splendid, almost heroical, by contrast. He was not a great soldier; his conception of an army for his purpose was unsuited to the colonial character, and he missed the opportunity of creating a mobile force of marksmen, which would have anticipated the methods of the Boers. But, despite constant ill-health and the haunting obsession that he came of a short-lived race, he finished the work he took up and earned the "tranquil enjoyments" (a typical Washington phrase) of his later life at Mount Vernon. Perhaps Mr. Woodward is right in summing him up as "the American common denominator, the average man deified and raised to the *n*th power."

(CHEMICAL WARFARE) DER CHEMISCHE KRIEG.

By DR. RUDOLF HANSLIAN; 2nd revised and essentially enlarged Edition. Large 8vo, 411 pages and an Appendix of 31 plates; 3 coloured maps and 111 photographs and sketches. (E. S. Mittler und Sohn, Berlin, S.W.68, Kochstrasse, 1927.)

Favourable reception of this work at home and abroad caused the first edition to be exhausted in a few months. So much new material had meanwhile become available that the author, instead of acceding to the many demands for an immediate re-issue, felt himself constrained to re-write the book. It has now become an encyclopædia on gas-warfare, which should be in the hands of everyone who, like the author, is convinced that gas-warfare, having arrived, has come to stay, and of anyone, if such there be, who has yet to come to this conclusion.

As motto of the book might well have been chosen Admiral Mahan's dictum that every new weapon of war has invariably been first called barbaric, and finally universally adopted. Its object is stated in the Preface—to lead the reader to a recognition of the future possibilities of gas and its presumable influence on war. The method chosen of attaining this object is "the collection of valuable material out of the fullness

of the existing and continually increasing gas-literature of foreign countries." To this end the author has compiled a bibliography of close on 300 books, pamphlets and articles, to most of which he refers and from some of which he makes extracts, often of considerable length.

The works most frequently referred to or quoted from are :—

Fries and West, "Chemical Warfare." (McGraw Hill, New York.)
British official "Manual on the Use of Smoke."
Vedder, Lt.-Col., "Medical Aspects of Chemical Warfare." (Wilkins, Baltimore.)
Bloch, Chef d'escadron; "La Guerre Chimique." (Berger-Levrault, Paris.)
British official "History of the Great War: Medical Services."
Kerschbaum: "Die Gaskampfmittel." (Mittler und Sohn, Berlin.)
"Chemical Warfare" (Magazine of the C.W. School, Edgewood, U.S.A.).
Fischmann: "Gasowaja Woina." (Soviet Govt. publication, Moscow.)
Lefebore, Major: "The Riddle of the Rhine." (New York.)
Heigl, Major: "Die künstliche Vernebelung." (Vienna.)
Haber: "Die Chemie im Kriege." (Julius Springer, Berlin.)
French official, "Instruction pour la protection contre les gaz de combat."
Dopter: "Lectures at the Ecole Supérieure de Guerre." (Paris.)
Farrow: "Gas Warfare." (Dutton, New York.)
Worrall, Lt.-Col.: "Smoke Tactics." (Gale & Polden.)

The foregoing provide together about one-half the total number of references in the text, which amount to nearly 600 in all. There are, in addition to these, 300 cross-references, over fifty other footnotes, and no less than three separate indexes—one technical, one geographical and one of proper names. Indications are thus not lacking of considerable pains having been taken in compiling the book. Further, the author in his Foreword complains of the trouble caused in gas-literature by incorrect examples due to misprints, or more often, to mistranslations. It is the more surprising, therefore, to find that very little care has been expended in getting English titles of books and articles correct. Altogether, over thirty such mistakes have been counted, and English readers are liable, in consequence, to judge unfavourably of the general accuracy of the work. "Wielemans," on p. 89, can hardly be passed as the name of a British general, while "Wilougsby," although recognizable, is too strange to be true. On p. 139 reference is made to our "6th" Army, while on p. 90, Hill 60, of undying memory, is helped towards oblivion by being called Hill "160."

Figures and formulæ are not always happy. The metre and yard vary in relationship within limits as wide as 450 : 550 (on p. 349), and 210 : 200 (on p. 343). On p. 61, both the formulæ given for the Chlorarsines, Lewisite B and Lewisite C, appear to be wrong, as they do not check with Lewisite A, Chlorvinyl Dichlorarsine, Cl. CH : CH. As Cl2.

As regards the correctness of translation, Sir P. Chetwode, speaking at the R.U.S.I. on Air Attacks on London, comes in for particularly bad treatment in this respect, two of his remarks having obviously been made into "pie."

There must be so many Germans who know English well that there can be very little excuse for such mistranslations, especially in a book where forty per cent. of all the references are to English and American works.

These are blemishes on an otherwise excellent compilation.

F.A.I.

TASCHENBUCH DER TANKS, ERGÄNZUNGSBAND, 1927.

By MAJOR HEIGL.

(J. F. Lehmann's Verlag, Munich.) Price 8 marks.

The mass of new material which Major Heigl has gathered since his *Taschenbuch der Tanks* appeared last year has forced him to bring out a supplementary volume. No more convincing evidence could be offered of the importance attributed to the tank by the military powers, and of its immense possibilities in future warfare. The book contains:

Part 1.—Technical Progress, Tracks (steel and rubber), Semi-Track, Wheel-cum-Track; 40 pages, 16 photos and 4 plates.

Part 2.—New Tanks; England, 28 pp.; Morris-Martel (photos and plates); Carden-Loyd (photos of two types—caterpillar and wheel-cum-tracks; also of 2-man tank); Vickers W.C.T.; Light Vickers Mk. I (photos and plates); Light Vickers Mk. IA (photo); Light Vickers Mk. II (photo); Heavy Vickers (photos and plates); France, 9 pp.: the Char 2c (photo and silhouette); the new light tank (photos). Besides England and France, many other countries receive notice, and in addition to photos of the U.S.A. Medium M 21 and Medium M 22, and of the Italian Light Fiats, there are full descriptions, photos, silhouettes and elevations of the Russian Fiat Half-tank, the Swedish M 21, the new Spanish light tank and the famous Czecho-Slovakian K.H. 50.

Part 3.—Modern tank-tactics. This part starts with tank-tactics of 1918, illustrated by extracts from reports of the battle of Cambrai, and of the battle of the 8th August, and gives an account of the arrangements for the Hush-operation at Middelkerke. It deals with tanks in defence and tank patrols, gives French manœuvre examples of combined attack by the largest break-through tanks and light tanks, examples of tank-action in Morocco and in Syria; Rapid tanks; tanks used independently; English manœuvre examples (chiefly from Capt. Liddell-Hart); anti-tank weapons; the battle of the future; the R.R. Vickers; strategic mobility.

There follow two useful lists, a bibliography of tank literature in various languages, and the tabulated principal details of over one hundred of the latest tanks of all nations.

This book, like the *Taschenbuch der Tanks*, to which it is a supplement, is more than a revelation of what has already been achieved. It is also an earnest of wonders to come. The next volume will be eagerly awaited.

F.A.I.

NOTES ON THE VARIOUS ARMS OF THE SERVICE.

By CAPTAIN A. M. BARRETT, M.C., Essex Regiment.

(Gale & Polden, Ltd.) Price 1s.

This is an attempt to condense down to thirty-two pages the information given in various text-books on the characteristics of the various arms of the service and their employment "in the five principal tactical operations of war." A Foreword says that these Notes should be of much assistance to those officers and N.C.O.s of the Territorial Army who are unable to find time to study all our numerous official text-books and memoranda from cover to cover; but the amount of study and the number of books required to obtain such information as is contained in the pamphlet are not really great. The elementary details and *rôles* of the various arms are adequately covered, but as is so often the case in this form of "cramming notes," the pamphlet suffers severely from slipshod phrasing, which, at times, renders passages difficult to understand. This is particularly the case in the Artillery paragraphs. One cannot help feeling that a diet of fresh meat is more healthy and pleasant than one of meat lozenges, however they are shaped and flavoured, even if meals do take longer to consume.

H.G.E.

PHYSICS IN INDUSTRY.

Lectures delivered before the Institute of Physics. Vol. V. By H. E. WIMPERIS, O.B.E., M.A., F.R.AE.S. (Director of Physical Research to the Air Ministry), and F. E. SMITH, C.B., C.B.E., D.SC., F.R.S. (Director of Scientific Research to the Admiralty).

(Oxford University Press, London: Humphrey Milford.) Price 2s. 6d.

This book comprises Lectures X and XI of the series.

Lecture X, by Mr. H. E. Wimperis, is upon the relationship of Physics to Aeronautics.

It appears that experiments made hitherto have had as their object the ascertainment of the lift and drag coefficients of aero-foils: they are usually carried out in wind channels upon models; the reader is left to imagine the details of the experiments and the precise nature of the apparatus.

Many points are touched upon, but so superficially, and so many

technical aeronautic terms are used that the Lecture can scarcely be of use or interest to the average physicist. Probably it has been devised for those directly concerned with aviation experiments.

Lecture XI, by Dr. F. E. Smith, is upon the relationship of Physics to Navigation.

An introduction describes the evolution of the various instruments used in navigation, ending with a description of the gyroscopic compass.

Then follows an account of the various methods of navigation in foggy weather near land, the approximate position of the ship being supposed known.

An accurate chart being available, the taking of soundings appears one of the most reliable ways of finding the ship's position. Soundings can quickly and accurately be made by the Admiralty echo sounder, of which a description is given. This instrument is fixed near the keel, and enables the interval of time between the emission of a sound and the reception of the echo from the sea bottom to be measured, thus giving the depth.

For navigation in a narrow channel, when landmarks are invisible, the leader cable is a device of interest. This is an insulated cable, laid along the bottom of the channel, through which is passed an alternating current. The vessel to be navigated is provided with electro-magnetic apparatus, on either beam, of such sensitivity as to record unequal effects unless the ship is symmetrically over the cable.

This device seems open to the objection that a pair of ships following the cable might very easily collide.

Consideration for the amount of space available forbids description of other interesting methods.

The Lecture concludes with a summary of the methods employed for determining the distance of icebergs in foggy weather, but, in the opinion of the lecturer, sufficiently reliable apparatus is still lacking.

The printing and diagrams are admirably clear and reflect credit upon Messrs. Humphrey Milford, the publishers to the Oxford University.

J.M.W.

NEW GEODETIC TABLES.—R.G.S. TECHNICAL SERIES No. 4.

Could that celebrated warrior, Brigadier Gérard, revisit the scenes of his exploits, he would, so one may think, be not a little astonished to discover that there existed soldiers to whom the exact figure of the earth was a material consideration.

Face to face indeed with the complexities of modern war, one can imagine even his stout heart failing, and see him making all haste to regain once more the security of the grave.

It is possible that not a few R.E. officers, if called upon to deal at short notice with some of those Geodetic problems, with which the military surveyor has occasionally to grapple, would fully appreciate his sentiments.

Chief, perhaps, among these problems, are those which arise from the practice, by surveyors of different lands, of assigning varying dimensions to the earth on which we live.

In order to compute his triangulation, the surveyor must assume some values for the shape and size of the body on which his measures are made. These values always require subsequent amendment, but, once adopted, correction is troublesome and is seldom urgent enough to justify the expense involved.

It thus happens that the surveys of the world are projected on a great variety of figures of the Spheroid, and the hapless British military surveyor may find himself constrained to use any one of them—a necessity which, until the production of the present pamphlet, might have involved him in severe computation.

Geodetic Tables are given in the *Text Book of Topographical Surveying* for Clarke's 1858 figure, which the recently published book on Survey Computations repeats in slightly different form.

The Ordnance Survey uses Airy's figure, and the Survey of India Everest's, each with its own set of Tables, but there are, of course, many others in current use in other parts of the world.

The Tables under review are for Clarke's 1880 figure, and for that adopted by the International Geodetic Union in 1924.

They contain some novel features, the most interesting of which is the device by which comparison can be made of these with other figures.

The preparation of Tables for any new figure is by this means very greatly simplified.

The Tables themselves are preceded by a preface and introduction giving full particulars of the method of use, and of the circumstances which led to their preparation.

Bound in the form of a handy pamphlet, and admirably printed in excellent clear type (there are unfortunately one or two misprints in the Introduction), the work is one for which the authors may well receive the grateful thanks of all whose duties deal with Survey and Geodesy in the Field.

M.N.M.

QUANTITIES OF MATERIALS AND COSTS PER SQUARE FOOT OF FLOOR FOR HIGHWAY AND ELECTRIC-RAILWAY LONG-SPAN SUSPENSION BRIDGES.

Paper No. 1649 of the American Society of Civil Engineers.

By J. A. L. WADDELL, M.AM.SOC.C.E.

The author claims that this paper will "Enable any engineer of good, "general experience to compute, in two or three hours, when full pre- "liminary data are furnished, the total cost of any projected highway "or electric-railway or combined highway and electric-railway suspen- "sion bridge and its approaches."

All calculations have been reduced to simple curves for bridges from 00 to 5000 ft. span.

Although Royal Engineers are unlikely to be called upon to build permanent bridges of such dimensions, there is much matter of interest in the assumptions and method of working out costs and design.

There are also interesting discussions by eminent American Civil Engineers on such subjects as light-weight floor design, the "elastic" and "deflection" theories for calculations and effect of these in design, of stiffening trusses, and the theory of anchorages.

These discussions and the author's summing-up are well worthy of study.

H.A.B.

THE ELECTRICAL EQUIPMENT OF AUTOMOBILES.

By STANLEY PARKER SMITH, D.SC., M.I.E.E., A.M.INST., C.E.

(Published by Chapman & Hall, Ltd.) Price 5s. net.

This small book embodies the material given in a course of lectures intended to furnish essentially practical information required by those engaged in the manufacture, maintenance, repair and running of automobiles.

A knowledge of the fundamental laws of Electricity and Magnetism is assumed, and the book is an attempt to give in plain terms a technical description of the action of essential parts of the electrical equipment of automobiles. Complications involving no fundamental principle are not discussed, as the author considers that a sound understanding of basic parts will enable the reader to follow the working of more complicated systems. Throughout, consideration has been given to proper maintenance, and stress is laid upon the methodical location of faults.

The book deals, in order, with storage batteries, the action of electric motors and generators, the starting motor, the three-brush generator, ignition systems, and wiring systems, and is illustrated with sketches and diagrams to explain the principles set out.

With the assistance of this handbook and makers' diagrams and instructions, there should be no difficulty in keeping the electrical equipment of automobiles in good order, and in finding out what is wrong in case of trouble.

R.M.

ELEMENTARY ELECTRICAL ENGINEERING.

By ALBERT E. CLAYTON and HERBERT J. SHELLEY.

(Longmans, Green & Co., Ltd.) Price 7s. 6d.

There is nothing particularly new in this book, but it is written very clearly, the subject matter on D.C. Machinery and A.C. Theory being particularly well explained.

A useful Table of the properties of insulating materials is given in Chapter XV.

Well worth the price—7s. 6d.

R.M.

THE ELEMENTS OF TELEPHONE TRANSMISSION.

By H. H. HARRISON.

(Longmans, Green & Co.) Price 5s.

Although written primarily for telephone engineers, a large portion of the book will be found very useful by power engineers. The book is divided into four chapters: the first giving a résumé of elementary mathematical theory required by electrical engineers, and the second an elementary theory of alternating currents. The whole of these two chapters, which comprise about half the book, are directly applicable to the transmission of electrical energy for power purposes. The third chapter deals with wave transmission and will assist the power engineer when studying transient phenomena due to faults and switching. The last chapter deals with practical telephone circuit conditions.

A few printer's errors are noticed, but considering the large amount of mathematics in the book, the errors are insignificant.

The treatment of "skin effect," given on pp. 56–58, is interesting and helpful, but not very conclusive. If a conductor is divided up into a large number of strands, it will be clear, from page 56, that the inductance of individual strands increases from a minimum at the circumference to a maximum at the centre. This causes a non-uniform current distribution in the conductor and, therefore, an increase in its effective resistance. The effect becomes more important as the frequency increases, owing to the increase of the ratio of reactance to resistance, the latter being relatively large compared with the reactance at the lower frequencies.

To secure approximate uniform current distribution it is not sufficient simply to strand the conductor. The strands must be insulated individually, and, further, they must be plaited so that each strand has the same mean distance from the centre as all the other strands.

The last two lines on page 58 are liable to mislead the beginner. Iron wire has been used extensively for telephone lines and is quite satisfactory up to, say, 20–30 miles for ordinary military purposes.

Lines 10, 11 and 12 on page 67 are correct, but the treatment given does not constitute adequate proof.

In the practical example given on page 79, para. 10, the spacing of the wires should have been given.

The treatment of the subject is, on the whole, quite clear, but it is unfortunate that the same notation has not been adhered to throughout, *e.g.*, V is used indifferently for velocity of propagation and for voltage. Capacity is denoted sometimes by K and sometimes by C, Impedence sometimes by Z and at others by I, thus confusing it with current. It is surely time that writers accustomed themselves to the symbols recommended by the International Electro-technical Commission.

The book can be recommended to anyone intending to take up the study of Electrical Engineering seriously, whether for power or signal purposes. It is good value for money.

W.M.

ELEMENTS OF MACHINE DESIGN.

By W. C. UNWIN, LL.D., F.R.S., and P. L. MELLANBY, D.SC. (Longmans, Green & Co., Ltd.) PART I, New Edition. Price 15s.

This book is an introduction to machine design, and is intended to supply students with the necessary principles and formulæ which are afterwards to be used in the actual design work. The book opens with a chapter on ferrous and non-ferrous metals used in machine construction with Tables of tensile strength and elongations. This is followed by a summary of the straining action experienced in machines, and a comprehensive survey of the resistance of structures to these strains. Much of this chapter, *e.g.*, bending moments of beams under load, is old ground to all R.E. officers, but the calculations for Boiler Shells and Leaf Springs are interesting. The author then deals with the calculations for strength of various machine details, in each case discussing the problem and arriving at a logical or, in some cases, an empirical formula as a basis of design. Riveted joints, screw threads, bolts and keys are fully discussed. The chapter on journals contains a summary of the principles of lubrication and figures of recent tests and experiments. A large number of sketches or drawings are given of various types of bearings, and recommended proportions are stated. Finally, one hundred and seventy pages are devoted to power transmission by friction gearing, geared wheels, belts, ropes and chains. The theory of geared teeth is worked out, and sample calculations for strength and wear are given. There is a very full consideration of driving by belts; the results obtained show that the usual Army practice as laid down in *M.E., Vol. 1*, is on the safe side.

The book has a wider scope than is normally required from R.E. officers, but can be recommended for all E. and M. officers as a book of reference. No more knowledge of the general principles of mechanics is needed from the reader than all R.E. officers possess.

A.P.A.L.

SIMPLE METHODS OF SURVEYING FROM AIR PHOTOGRAPHS.

By Lieutenant M. Hotine, R.E. (H.M.S.O. 1927. Price 3s. 6d.)

This little book will be welcomed by all who are interested in Air Survey, for it is the first of its kind which deals clearly and simply with a practical method of making a medium-scale map from overlapping air photos. The theory of the principles involved is confined to an Appendix, and there may be many who will leave this Appendix unread and thankfully say "We accept the radial assumption—let us confine ourselves to the body of the book and see how to get on with the job." Others, on the other hand, may think that this "radial assumption" is open to criticism, but it must be remembered that the practical results of surveys based on the methods described are extraordinarily good, and that the "proof of the pudding is in the eating."

Roughly, the underlying principle of the method is that directions from the "principal point" of any photo are all true directions, provided that there has been no excessive tilt. With photos overlapping 60% it is

possible to pick up points of detail which appear on three successive photos, and by intersection and resection the " minor control plot " as it is called is carried through the whole strip of overlapping photos.

This plot is then brought to correct scale by reference to two control points whose distance apart is known, having been fixed by ground methods.

Contouring is done on the actual photos by means of the topographical stereoscope, spot heights being provided by ground methods as a control.

There is no question that the book would be easier to follow if it were possible to have a strip of overlapping air photos and a stereoscope in front of one, and actually to carry out the various processes of orienting the principal point bases, plotting the minor control, and contouring, etc., step by step. Without following each excellently written description of what to do in practice in this way, one suffers from the same difficulty as would occur if one was to read a text-book on how to play chess without having a board and chess men with which to carry out the moves described.

Chapter II, pages 17–29, makes most interesting reading, and describes how " height traverses " with batteries of aneroid barometers can be carried out. Such aneroid traverses are, of course, perfectly applicable to surveys made wholly by ground methods, and all surveyors will be interested.

Chapter V describes a most ingenious method of " carrying on " with the minor control plot should any pair of photographs fall short of a 50% overlap. It is based on sound principles, but there is, of course, a limit to this makeshift, and it cannot be too strongly emphasized that over 50% is the overlap required. One hopes that this knowledge will be widely disseminated, especially amongst pilots who undertake the flying for such photography. To fly level, to fly straight, and to be certain that your photos are really overlapping 50% or more is what is required of you. The days when your skill was judged by the fewness of the photos that you found it necessary to take to cover a given area are gone.

P.K.B.

MAGAZINES.

COAST ARTILLERY JOURNAL.

The Military Notes of the Journal for September have an interesting account of the great importance attached to bayonet training in the Japanese Army, comparing it to the apparent lack of the bayonet spirit in the American Forces.

The Japanese Regulations stress this spirit in the most stirring terms :—

" No machine will ever be invented that can withstand the bayonet
" courageously and intelligently directed by the human brain and the
" human hand. Handle it as your fathers did their swords, and rely

" on it as they relied on their swords. . . . the final issue will be met " man to man. Then the bayonet will be supreme and the spirit of " the bayonet will be the spirit of the winner . . . the Field-Marshal " will count his bayonets and measure the strength of his forces by that " count. . . . The enemy cannot overthrow our plans until he has " overthrown our infantry and their bayonets, and we can only over- " throw the enemy by the fearless use of the same bayonets. . . . " The most brilliant exploits of the artillery, cavalry, air service and " all the other arms cannot save the day if the man with the bayonet " fails. . . . The cold steel has, from time immemorial, been the weapon " of the Japanese soldier; with it, and with it alone, he has preserved " his country and made his glorious record as a fighting man. . . . " The abdomen of the enemy is the first objective, and it is the place " easiest to hit and easiest pierced with the exception of the throat. " To the throat, however, is hard to get home; the throat is the part " of the enemy's body which he can most easily remove from the line " of the bayonet thrust. The soldier will do well, therefore, to run at " his foe at top speed, shouting his battle cry, in order to weaken the " spirit of the enemy, and thrust home to the stomach with all his " might and with the full strength of his weapon and his arm. Usually " the first thrust will be successful. If not, a second thrust should be " made from either side of the foe, and at once, as no time should be " lost in fencing. The man who thrusts the surest and the quickest, " and thrusts repeatedly, is the man who wins the bayonet fight."

An observer relates that the long thrust is used to the exclusion of all other forms of attack, and the butt is seldom if ever brought into play. This is probably to make up for the short stature of the average Japanese infantryman. No time is lost in fencing. The attack is made in pairs as far as possible, efforts being made to gain the enemy's left side and aim at the lower abdomen.

A large part of the time of instruction in bayonet training is devoted to personal combat; the winner of each combat meets man after man until he himself is defeated. The skilled bayonet man is looked up to with something akin to awe by his fellow soldiers, and is frequently excused various duties.

Night-manœuvres are always carried out with fixed bayonets, in order to accustom men to handling their rifles in the darkness under these conditions.

The Japanese bayonet course has several unique features. A trench about twelve feet deep and eight feet wide has to be crossed at the charge: to climb on the far side, one man bends over while his companion climbs upon his back and scrambles over the top with his rifle still in his hand.

To assault an unbroken fifty-foot belt of barbed wire, the first men up to it throw themselves flat on to it face downwards and lay their rifles over it in front of them; their fellows jump on their backs and in turn throw themselves as far as possible into the wire with rifle extended so as to elongate the slender bridge as much as possible, and enable their comrades to pass across as soon and as quickly as they can, with the pur-

pose of making a lodgement. Meanwhile, others begin cutting the wire out from the bottom so as to form a free passage.

Men who are ready to do this in cold blood, even though plain wire is used for training instead of barbed wire, must indeed be animated by the burning patriotism and religion which is said to be the base of the Japanese cult of Bushido.

When the infantry recruit first joins, and when the reservist rejoins the colours, his rifle, with bayonet fixed, is personally delivered to him by the Regimental Commander with his own hands, with the admonition to guard it and keep it unsullied as his own soul. To say that the bayonet is venerated by the Japanese infantry soldier is not considered too bold a statement.

D.M.F.H.

REVUE MILITAIRE SUISSE.

(1927. Nos. 1 to 6 inclusive.)

L'armée espagnole dans sa dernière campagne riffaine. Colonel de Diesbach gives an interesting account of a visit paid by him to Melilla, in May, 1926, on the termination of the successful operations carried out by General San Jurio against the Riff tribes; the African troops of the Spanish Army created an extremely favourable impression on his mind, and he was apparently somewhat surprised to find that their equipment was quite up-to-date.

Défense économique et nationale. Under this title, Lieutenant E. Naef deals with the question of motor spirits. He points out that the production of petrol is no longer merely an industrial problem, but one which, in view of the rapid mechanization of modern armies, is also a matter closely affecting national defence; in consequence, an attempt should be made to discover a "carburant national," suitable for all types of engines propelled by motor spirits, which is not derived from petroleum oils. A brief review is given of some of the recent researches carried out with this object in view.

Autour des leçons de la guerre. The article is a contribution from General J. Rouquerol; in it he indicates some of the errors to be avoided by those who attempt to deduce lessons from past campaigns for application in future wars.

A l'est ou à l'ouest. Colonel Feyler makes instructive comments on an article by the Austrian General Goiginger, published in the fourth part of the 1927 issue of the *Schweizerische Monatschrift für Offiziere aller Waffen*, wherein the latter discusses the problem which confronted the Great General Staff when, in 1914, Germany found herself committed to a "war on two fronts." General Goiginger approves, on military grounds, with the plan of campaign adopted in August, 1914, by the Germans. Colonel Feyler investigates the situation and shows that, in reaching his conclusions, General Goiginger has assumed without any justification whatever that Great Britain and Belgium would necessarily

in any case have been participants in August, 1914, in a war between Germany, and France and Russia fighting as Allies. Colonel Feyler points out that, had there been no invasion of Belgium, the problem before the Great General Staff would, on the immediate outbreak of the war, have been a very different one and might well have been solved in a different way. With only the French and Russian Armies to contend with on the Western Front, the line of contact between the opposing forces would have been reduced from the 400 km., involved by bringing Belgium into the war, to 250 km., and the Germans would have had 70 divisions to deal with instead of 80. In these circumstances, a defensive war on her Western Frontier and an offensive war on her Eastern Frontier at the opening of hostilities might, in all probability, have crowned Germany's effort with success.

W.A.J.O'M.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1927. TOME II. NOS. 1 to 3 INCLUSIVE.)

Les opérations de l'armée belge. Events of October 20th, 21st and 22nd, 1914, are dealt with in these numbers of the *Bulletin*. The contents of an Intelligence Report, issued from the Belgian G.Q.G. at 7 p.m., on October 20th, are set out in No. 1; it shows that by this time the Belgian High Command had ascertained generally the composition of the German Fourth Army and had an accurate knowledge of the enemy force operating against the Belgian Front. An account is given in No. 1 of the strong attacks directed by the Germans against Nieuport and Dixmude on October 20th: a sketch map, inserted in the text, shows the dispositions of the Belgian Army on this date and also the Fronts held by the formations of the British and French Armies operating in Flanders—the line held at the beginning of the day, as well as that to which they had fallen back by the evening, are both marked; the various formations of the German Army in contact with the Allies in this region are also shown on the map.

The opening phase of the Battle of the Yser is dealt with in No. 2, and the text of the instructions issued by the O.C., 2nd Bn. Belgian Engineers, for carrying out the inundation of the region east of Nieuport, between the Nieuport and Yser canals, is given. Action was taken on these instructions on the evening of October 21st, and a sketch map, inserted in the text, has marked on it the limits of the inundation actually carried out. Another sketch map shows the Fronts held by the Belgian Army, the French troops on its right, and the B.E.F., on the morning of October 21st, and the changes which had taken place before nightfall on the portion of this line south of Dixmude. The text of the Operation Order, issued at 6 p.m., on October 21st, from the Belgian G.Q.G., then at Furnes, is set out in No. 2: on this date the Germans directed a violent bombardment against the Belgians, and carried out a strong offensive against the central portion of their Front. The situation on the Belgian Front, as known at the G.Q.G. (Furnes) at

6.30 p.m. on the 21st, is given; it was causing the Belgian High Command much concern. Reinforcements, in the shape of the French 42nd Division, arrived during the day in the region of Ghyvelde, Bray Dunes, Coxyde and La Panne, and its commander, General Grosetti, proceeded to Furnes, where he arrived at 7.20 p.m. Differences arose at once as to how the 42nd Division should be employed; the French General intimated his intention to move his troops to the region of Nieuport, whereas the Belgian High Command desired that the French troops should be available for utilization on that part of the Belgian Front which the needs of the moment might dictate. The situation became somewhat more embarrassing when it was learnt that in the orders, issued by General Foch on the 21st, in relation to the constitution of the "Détachement d'Armée de Belgique," under General D'Urbal, directions were given for the following troops to be placed in the groups under General Bidon—this group linked up the left of the B.E.F. with the right of the Belgian Army—viz., the Fusilier Marine Brigade, 42nd Division and the 9th Corps (this Corps was then being transferred from the Aisne to Flanders). General Joffre had visited the Belgian G.Q.G. at Furnes during the day and had discussed the situation with King Albert; the latter apparently was not put in possession of information as to the intentions of the French G.Q.G. as to the manner in which the 42nd Division should be utilized, and neither the French generalissimo nor King Albert raised any question as to any fresh plans in connection with the employment of the Belgian Army.

The events of October 22nd are dealt with in No. 3 of the *Bulletin*. The situations north of Nieuport and at Dixmude, at about 8 a.m. on the 22nd, are shown on sketch maps; the line, from Nieuport to the French Frontier, held on the evening of the 22nd, is marked on a third sketch map. The Germans on this day surprised the Belgian troops near Tervaete and forced a passage across the Yser, inflicting serious losses on the defenders; a grave situation was thus created on the Belgian Front. The Germans on this day also launched an offensive against the French right; the French gained a small success at one point, but had eventually to fall back, and at the end of the day were holding the western bank of the canal between Knocke and Steenstraat. The German attack against the French right involved the British left; the 1st Division had to give ground and for a short time a critical situation existed, owing to the penetration by the enemy of the Allied Front at the point of junction of the British and French troops. The timely arrival of support enabled the situation to be restored. The French 17th Division (9th Corps) had detrained at Cassel on the previous day, and was moved up to Ypres by motor transport during the 22nd. A German radio message had been tapped by the B.E.F. on the previous day; it contained information as to the objectives of the German Fourth Army. The contents of this message were communicated to the Belgian High Command, and are set out in the *Bulletin*. The text of the Operation Orders, issued by the Commander of the "Détachement d'Armée de Belgique," at 7 p.m., on the 22nd, and by the Belgian G.Q.G. at 2.15 a.m., on the 23rd, are also given in No. 3.

Problème de la Sûreté. The sixth of a series of articles under the above title, by Major Barthelemi, of the Belgian General Staff, is published in No. 1. The original article contains interesting comments on projects prepared by von Moltke in 1867 and 1870 for the invasion of France, and a comparison of the arrangements actually made in August, 1870, by the belligerents at the outbreak of the Franco-German War to cover their respective Armies during the mobilization and concentration periods. The opening phase of the 1870 War is also briefly described.

Le Principe de la Bataille. The two concluding parts (XI and XII) of the article under this title, by Major Jobe, are published in Nos. 1 and 2. Part XI deals with the 1918 Campaign of the Great War; the general situation at the beginning of 1918 is briefly sketched out; Ludendorff's plan of campaign is discussed; the German offensives in Picardy, on the Lys, on the Aisne, on the Oise and in the Champagne region, are described in outline and commented upon. An outline map is provided on which are shown the line held by the Entente troops on March 21st, 1918, and the territory gained by the Germans during their offensives.

Part XII deals with the final phases of the Great War, beginning with the counter-offensive launched by the Western Allies on July 18th, and ending with the general advance from the Sea to the Meuse which compelled the Germans to seek terms of peace. The lessons of the campaign are discussed, and, in conclusion, Major Jobe points out that the study of campaigns from the date of the Battle of Cannæ to the present time demonstrates that the aim of the stragetist has throughout the ages remained unchanged, but the methods employed by him to attain his aim have continued to vary from century to century, and, as there is no finality in inventions which affect the equipment and the other matters bearing on the mobility of armies, novel methods will still have to be devised in the future by the strategist to meet the changing conditions of the time. The eventual objective of every skilful commander still consists in the complete encirclement of the forces opposed to him. However, the Great War has shown that a new factor has been introduced into the problem in the future; strongly entrenched fronts with inaccessible flanks are likely to be met with in big wars. In these circumstances, strategic flanks cannot be turned by manœuvre alone, and it has, therefore, become necessary to fight costly battles in order to break through the enemy's front, as a preliminary to cutting him off from his line of communications, for the purpose of attaining the ultimate strategic aim of the High Command.

W.A.J.O'M.

REVUE DU GÉNIE MILITAIRE.

(*August.*)—This number contains the first part of an article of considerable interest, by Colonel Clément Grandcourt, entitled, "Fortress Warfare on the Russian Front." It gives a short history of the Russian

system of fortification in Poland and a detailed account of the attack and capture of Novo Georgievsk. The importance of this place, known to the Poles as Modlin, which lies at the junction of the Vistula and Narev, was realized by Napoleon, in 1807, who made there a quadruple *tête de pont*. The works sketched out by the French were amplified twenty-four years later by Nicholas I. After 1870, the place was strengthened by Todleben. Plans for modernizing the fortress were drawn up in 1911, but were far from complete in 1914. Novo Georgievsk stands on the railway between Danzig and Warsaw; its fall was essential to the Germans for the prosecution of their great offensive in the summer of 1915.

(*September.*)—The above article is completed in this number. By August 10th, 1915, the place had been invested. The north-east sector only was subjected to heavy artillery fire. One fort surrendered on the morning of the 17th, and, during the following night, the whole of the forts in the principal line in the north-east sector were abandoned. By an order of the Governor, on the afternoon of the 19th, the permanent works in the north-west sector were also abandoned, and, on the 20th, the fortress capitulated. Amongst other material, 1,200 guns and 200 tons of copper fell into the hands of the Germans. Thirty Generals and more than 85,000 officers and men were taken prisoners. The fall of the fortress was due far more to the pusillanimity of the Governor than to any other cause. Of 33 forts, three were taken by assault, one surrendered, and the remainder were abandoned. From the strategical point of view, the defence of Novo Georgievsk had served to deny the use of the Danzig-Warsaw Railway to the Germans for some twelve days, and had prevented 50,000 Germans from taking part in the pursuit of the Russian Field Armies during one month; a small result for a fortress as strong as Verdun.

An article on raft bridges, by General Normand, gives examples of bridges made from rafts, starting with the passage of the Rhine by Hannibal and ending with bridges made during the Great War.

Chef de Bataillon Chambaud describes a bridge of boats for heavy loads made over the Rhine by the 12th Engineer Regiment, between the 5th and 16th October, 1925. The bridge was 88 metres long, of which 52 metres were floating. The boats took up practically the whole of the waterway.

The *October* number contains an article by General Caloni, entitled, "The Preparation of the Field of Battle of April 16th, 1917," in which he describes the preparations, from an engineering point of view, carried out in the area in rear of the line Hurtebise—Beaumont-sur-Vesle occupied by the 5th Army.

The preparations started with a reorganization of the Engineer Command. Experience gained in the battles on the Somme had shown the necessity of the Engineer Command taking a more active part in the supply of material and transportation in the advanced zone. On January 4th, 1917, G.H.Q. ordered the suppression of the "Directions

des étapes et services" (D.E.S.), their functions being allotted to a fourth branch in each army staff so far as supply of material and transportation was concerned, and to a "Direction des étapes" (D.E.), forming part of the staff of the Commander of the group of Armies, so far as the organization of the L. of C. and exploitation of local resources were concerned.

The D.E.S. was abolished on January 16th in the 5th Army, and the services of water and roads from the technical point of view; the Engineer park of the Army and the exploitation of forestry were handed over to the Engineer branch of the Army. At the same time all Engineer units came under the command of the Engineer-in-Chief.

The article describes the Engineer work under the following heads:—

R.E. Parks and Depôts.
Works.
Preparation of the Area of the Attacks.
Communications.
Water Supply.
Electrical Services.

In spite of difficulties, due to the weather, all preparations were completed by April 16th.

An article called "Engineering in the Levant," by Lieutenant-Colonel Vergnon, describes certain works carried out by the French Engineers in Syria, namely:—

(1) The narrow-gauge railway (60 cm.) from Ghazalé on the Hedjaz Railway to Sonéida, constructed in order to facilitate the conduct of operations in the Djebel Druze.
(2) The reconstruction of the citadel of Sonéida, which had been burnt down after its evacuation in September, 1925.

There are several photographs and plans.

In the *November* number there is an article, "Notes on Construction in the Western Sahara," by Captain Ricard. In it he gives a brief account of the communications, inhabitants and natural resources of the country. It is interesting to note that the subterranean canal called "foggara," which is a common feature of the country, appears to be identical with the "karez" of Central Asia. The staple building-material is round brick, and the only tree from which timber for building purposes can be obtained is the palm tree. The method of construction with these materials is described in detail.

A.H.B.

REVUE MILITAIRE FRANÇAISE.

(*October*, 1927).—In the second instalment of *Douaumont pendant l'occupation allemande*, General Rouquerol describes, firstly, the relief of the 5th Brandenburg Division by the 2nd Bavarian Division on 23rd May, 1916, and, secondly, the measures taken to improve the defences of the fort. The Bavarians had to attack almost as they carried out their

relief, and were successful in regaining the forward trenches lost a day or two earlier, but suffered very heavily in the process. The conditions about this time must have been almost indescribable ; but by continuous labour, especially by pioneer units formed for the purpose, the sector was improved till a reasonable degree of comfort was reached before the autumn. Unfortunately for the Germans, the defensive work outside the fort received less attention than the work inside.

Colonel Lucas begins an article entitled *Des qualités du chef* in this number. He points out that, according to the regulations, the duties of a commander are to " conceive, prepare and conduct " operations in his own formation. It is quite clear that conception is mainly the duty of the higher, conducting that of the lower, commander ; and the writer goes on to discuss in detail the various qualities which different commanders should possess, those commanding divisions and lower formations being regarded as the lower commanders, as it is impossible for the commander of a formation higher than a division to be actually known to his own troops. In this instalment, qualities which are essential to both types of commander are considered.

Cheval et moteur is an interesting and important article by Commandant Janssen, on the subject of mechanization. He discusses the advantages and disadvantages of H.T. and M.T., and comes to the conclusion that the horse is still the most important means of draught within fighting units, whereas the introduction of M.T. for supply services would produce a saving of personnel equal to three divisions in the French Army. He points out, however, that the introduction of mechanization is useless unless the nation can supply its own fuel ; but apparently successful experiments in this direction have been carried out. Actual armoured fighting vehicles are not considered in this article, which refers mainly to types of M.T. which exist in peace-time.

The second instalment of Commandants Desmazes' and Naoumovitch's article, *Les victoires serbes en* 1914, describes the crossing of the Drina by the Austrians, and the concentration of the Serbian Third and Second Armies on the battle front before the Austrians had made real headway. Part of the Second Army covered one hundred kilometres in two days, and the mobility of the Serbs, compared with the slowness of movement of the Austrians, compensated for the advantage which the latter held in possessing superior forces and the initiative.

Capitaine Andrieux' *La répression des fautes militaires dans les armées romaines* is of historical interest. He points out how the Romans, like ourselves, realized the need for military law, and describes briefly the main crimes and penalties. Where the Roman system failed, as compared with our own, was in the combination of prosecutor and judge, as represented by the tribune.

(*November*, 1927).—The third instalment of General Rouquerol's *Douaumont pendant l'occupation allemande* describes the French attack of October 22nd, 1916, and the succeeding days. Apparently the Germans were short of ammunition at this time, and the French artillery practically won the victory before a single infantryman moved forward. To follow the narrative, reference to the map given in the preceding number is necessary.

Commandants Desmazes and Naoumovitch, in the third instalment of *Les victoires serbes en* 1914, describe the defeat of the Austrian Fifth Army during the period August 16th–19th and its retreat over the Drina. Although the Austrians were really in superior numbers, they allowed a whole Army, the Sixth, to be masked by a small Serbian force. The Serbs were, therefore, able to concentrate superior numbers against the Austrian Fifth Army, which was heavily defeated. The operations are illustrated by a useful sketch map.

Colonel Lucas completes his article, *Des qualités du chef*, in this number. After discussing the application of intellectual, professional and moral qualities, first to higher, then to lower, commanders, he concludes by pointing out how the responsibility of the highest commanders tends to increase, rather than decrease, and how a sense of proportion between the various qualities is required. We all know Napoleon's maxim on the study of the campaigns of the great commanders of history, but to command successfully we must know also how to apply this study.

Pour apprendre l'art de la guerre, by General Camon, is an article which should be of value to Staff College candidates. The writer considers three phases of the operations of war, viz. (a) the effect of the political situation on the plan of campaign; (b) the preparation of a plan which takes into consideration the counter-moves which may be expected from the enemy; and (c) the distribution of troops in the theatre of war. These are illustrated by examples from Napoleon's campaigns and amplified from the Emperor's own writings.

Les troupes de montagne dans l'armée allemande, by X . . ., describes the present organization of "mountain" troops in the German Army. Before the Great War, no troops were specially trained for fighting in mountainous districts, but, by 1917, six Divisions had been given special, instruction, and it was these who were instrumental in the Italian disaster at Caporetto. Full details are given of the present organization and the type of training is indicated. It is, of course, quite clear that these troops form part of the nucleus of a national army, not part of the internal security army which was laid down at the Treaty of Versailles.

General Rouquerol completes *Douaumont pendant l'occupation allemande* in this number. Apparently, the fort was evacuated by the Germans on account of the general withdrawal of the line on this part of the front. It was the French bombardment which really achieved the success; although the fort had resisted the deluge of shell so far, on October 23rd terrible havoc was caused by 400 millimetre projectiles, used for the first time at Douaumont. The evacuation of the fort was begun on the next day. In his comments, the writer draws attention to the jealousy between the Bavarians and the Prussians, which began in 1870 and was still apparent during the Great War.

Etude sur nos procédés défensifs, by Général Brossé, is an important article on the present-day trend of thought with regard to defensive positions. The writer considers that the brilliant success of General Gourand's Army in July, 1918, has given the impression that his method is necessarily the correct one for the defence to adopt. In practice, as is pointed out, General Gourand's success was due to the factor of surprise

which he employed so effectively. If all defensive positions are occupied on the same lines, the surprise factor vanishes, and the dice are loaded on the side of the attack. The writer considers, and with reason, that there is no golden rule for the adoption of a defensive position, but that the first, second, third or fourth line of defence should be the one selected for protracted resistance, according to circumstances.

La garde prussienne les 21 et 22 août 1914, by Commandant Maury, begins in this number. The account is of the operations of the 2nd Division of the Guard Corps at the passage of the Sambre. The operations are described in considerable detail, but the most interesting feature is the appearance of Ludendorff as Quartermaster-General of the Second German Army. Although von Bülow, the Army Commander, had ordered his Corps to halt on 21st August, owing to the Armies on the flanks not being up, Ludendorff, who was sent forward on a reconnaissance, had no hesitation in ordering the Guard Corps to attack when it appeared that the crossing of the river might be forced.

Infanterie et chars de combat, by Colonel Velpry, is a discussion of the employment of tanks in conjunction with infantry. He demonstrates what is accepted in our own Army, that if tanks are used they should be employed in considerable numbers and not in little packets. From certain examples from 1918, he concludes that about a company of tanks is required on a battalion front of attack, or one battalion to a division, a proportion corresponding to that which is aimed at in our own Army.

Au Maroc français en 1925, by Capitaines Lacau and Montjean, begins in this number. This instalment deals with the special conditions (climate, terrain, etc.) which apply to war in Morocco, and the situation when Abdul Krim's power was at its height. These are described in considerable detail and illustrated by sketch maps. The instalment concludes with the arrival of Marshal Pétain in August, 1925, to take charge of the operations.

In *Le salon de l'automobile en* 1927, Lieutenant-Colonel Doumenc criticizes the tendency of French manufacturers to concentrate on luxury and six-cylinder cars of various designs, instead of turning to the American methods of mass production and provision of cars for the majority of the people. The value of mass production in war and the need for home-made fuel are emphasized by the writer.

La centenaire de la bataille de Navarin, by Colonel de Nerciat, is a short historical sketch of the liberation of Greece at Navarino, a hundred years ago.

H.A.J.P.

MILITÄRWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(MAY–JUNE, 1927, CONTINUED.)

Technical Weapons and Services, by Lt.-Col. Paschek. War technics were too little appreciated before the World-War in favour of ruthlessly mobile tactics. The numerically few technical troops in the Austrian Field Army in 1914 included, for constructional and destructional work,

Pioneers (comprising Engineers, Sappers, Bridgers, etc.) and for communication services, the following:—railway troops, inland waterway personnel, and the signal service.

During the Great War, troops for chemical warfare were added to the first group; while separate branches were formed for road-making, and for heavy bridging. Other branches were generalized (building services) or separated (camouflage, H.T. electricity, etc.). In position-warfare, both formations and equipment increased enormously. As regards transport, the chief increase took place in motor transport, while an air transport service was also got under way.

It is peculiar to technical troops that, more than any other, they are dependent upon equipment and materials. Many tool-columns, depôts and dumps are the visible signs of this dependence.

Unlike the case of military railways, where engineers are responsible for traffic as well as for construction and maintenance, there is the case of the roads which the engineers construct and maintain, while the traffic is in the hands of the transport service. Thus various interactions result. The connection with the fighting arms has become more and more intimate, as evidenced by battalion pioneers, technical services in close fighting, chemical warfare, motor transport, tactical transport by lorry and aeroplane, and, finally, the signal service in the battle area. We should in future say not "The Combined Arms," but the "Combined Arms and Services." There is much work to be done in organization. Finally, close co-operation with science is indispensable, and with national and private technical organizations.

The Engineers. The demand for an organization as simple and uniform as possible, and easily administered, is sound. Against such an organization work technical demands of every kind. The controversial question as to whether there shall be one kind of engineers or several tends, among the nations with unlimited equipment, to be answered in the latter sense. Otherwise, training and organization of employment prove altogether too difficult. One naturally tries to keep the Universal Engineer as far as possible, and, indeed, upon the conquered nations he has been directly forced by the limitation of numbers. A good deal has been taken off the shoulders of the Engineers by permanently adding regimental pioneers to the different arms.

Regimental Pioneers should resemble army pioneers as much as possible. In the infantry and cyclists, their allotment should be on a unit basis, *e.g.*, to each infantry regiment (English, brigade) there is a company of pioneers, which, however, is only detached when occasion demands. It carries long- and short-handled tools, wire-cutters, explosives, small flame-projectors, gas and smoke-bombs, camouflage material, inflatable sacks, collapsible boats, material for obstacles, lighting equipment and signal stores. The proportion of portable equipment to equipment conveyable in first-line transport is carefully tried out, so as to relieve the man of as much weight as possible. In case of necessity the company has allotted to it some of the divisional transport which is usually earmarked for the regimental pioneers. The Cyclist Battalion could include a section, and the Divisional Squadron a group of pioneers, principally

with demolition and bridging material. It is worth considering whether the G.O.C., R.A. should not have a section for building O.P.s and light bridges. Technical cares are removed from the Cavalry by their own pioneer squadrons, or, in the case of Light Mounted Brigades, (or Divisions), by their cyclist companies. Here and there it is better to give the much-overburdened infantry regiment (English, brigade) a company of pioneers to itself, but the closer the different arms are accustomed to work together, the less important this becomes.

Army Pioneers. Engineer units are both included in the higher formations, and reserved for allotment by A.H.Q. and G.H.Q. They differ according to the nature of their technical work and in organization and distribution.

(*A*) *General.*

(*a*) The Pioneer is essentially the earth, stone, concrete and explosive worker for fortifications and communications ; also carpenter and smith for military bridges and fortifications.

(*b*) The work of the Sappers and Miners is what their name indicates.

(*c*) The Bridger is chiefly a waterman for crossings, for military and temporary bridges. Even if the first two services (*a*) and (*b*) are combined, this service should be kept separate.

Besides the above, in countries where motor transport is highly developed, there is likely to be :—

(*d*) A road-construction service, which, if necessary, will serve for railway construction.

For this work it is no longer necessary to have, as for the services (*a*) to (*c*), only fully trained and physically fit ; on the contrary, apart from the foreman and other leaders, men under instruction, physically defective and of old categories will do. This is even more the case in :—

(*e*) The general construction (auxiliary) service ;

so that Army pioneers and Bridgers, who are few in numbers and difficult to train, should be relieved and set free for other work. The good pioneer, and especially the pioneer N.C.O., is becoming rarer and more precious. In the highly-industrialized state, skilled workmen fall off considerably. In addition to this, military engineers are, to a great extent, trained by drills and exercises for which short service becomes less and less sufficient. The number of completely-trained engineer units is cut down, equipment is simplified, one tries for better methods of working, for less-trained men with foremen and leaders, and strives, finally, as far as possible, to replace the man by the machine. Hence the necessity for organized auxiliary services.

The labour of the fighting troops themselves can also be reckoned under this head, especially that of reserve infantry formations.

(*B*) *Special.*

(1) With the fighting arms (*a*) chemical warfare, gas and smoke, (*b*) technical close-quarter fighting, flame-throwers and mining, (*c*) search-lights, (*d*) camouflage, (*e*) river warfare, navigation and mining.

(2) Other services (*a*) Electrical and power machinery and the service of workshops (loads, boring, sawing, cutting, sweating, ramming, etc.), lighting, cooking and heating, H.T. obstacles, ventilators, pumps, arrangements for drinking-water, photography, (*b*) construction and running of light railways and telferage, construction of broad-gauge railways, (*c*) heavy iron bridges.

(*C*) *Replacements.*

(1) Reserve depôts for personnel.

(2) Tool and equipment columns, and store depôts, with personnel.

(*To be continued.*)

Permanent Fortification, by Colonel Schneck. The development of permanent fortification is traced from the abandonment of the bastioned trace for the system of girdle-fortresses consequent on the introduction of rifled ordnance, and the parts played by Brialmont, Tilschkert and Vogel, von Brunner, von Leithner, Sauer, von Schumann and Mougin are shown. The Author says that, generally speaking, permanent fortification has suffered from two main evils, (1) that its objects have been very expensive of attainment, (2) that progress in armaments has been only to a limited extent capable of anticipation or met by reconstruction. Consequently, at the beginning of the Great War, not a single state was in possession of a system of permanent fortification which consistently met requirements. The position of Austro-Hungary, with about 3,500 miles of frontier, nearly three-quarters of which bordered on presumptive enemies, was particularly unfavourable.

An examination is then undertaken of the *rôle* played by permanent fortification during the Great War in each of the nations, starting with Austro-Hungary, which is dealt with under four headings (*a*) Galicia, (*b*) the mountain front (Carinthia and Tyrol), (*c*) the Balkan front, (*d*) the coast.

The conclusion reached is that the permanent fortifications of the country, in spite of their being not up-to-date in many respects, completely fulfilled their essential task of gaining time.

(*To be continued.*)

The Crossing of Rivers under Cover of Smoke. General Mischek, of the Czecho-Slovakian Army, has written a book dealing with fights for rivers (*Boj o Reky*), which the Austrian reviewer considers should become a standard work on the subject. He gives the following extract :—

"The already extremely difficult undertaking of a river crossing becomes, against an enemy strong in artillery, so much more difficult that the cover afforded by smoke is essential. Smoke is equally necessary if

attacks by hostile aeroplanes are to be expected, against which it affords, often, the only protection. A smoke-screen is required for the place of preparation as well as for the place of crossing, and great care is necessary in selecting the positions for the smoke-forming materials. The production of smoke on a large scale must be carried out under tactical leadership in order to guarantee success and to avoid anything prejudicial to one's own troops. In order to deceive the enemy, neighbouring sectors must also have smoke-screens put down. Since smoke discharged from the bank will often not be able to cover the river in its entire breadth, smoke will also have to be produced on islands, sandbanks and in small boats. As under ordinary circumstances smoke will hardly persist for longer than half an hour, further supplies of smoke-producer must be arranged for whenever a screen is required for more than that time."

The Author gives three examples of smoke-screened crossings :—The crossing of the Dwina, near Riga, by the Germans in October, 1917 ; a crossing by the Austrians in June, 1918, and one by the Italians in October, 1918.

Anti-tank Defence. Extracts from the *Army and Navy Journal*, of the U.S.A., giving the effects of explosives against Renault tanks.

Tank-crossings. Extracts from the *R.T.C. Journal*, for February, describing Major Martel's demonstration before the Colonial Premiers at Sandhurst.

(*July-August*, 1927.)—*An Example of an Opposed River-Crossing*, by Major Rendulic.

As the river concerned is the Piave, and as the crossing here described took place within five miles of where the British crossed four months later, it is impossible to avoid comparisons. The negotiating of the same large and difficult river is common to both cases, also that the enemy held a strong position on the opposite bank. Here the resemblance ceases. In October, 1918, the tide of victory was flowing, and our troops, full of determination, crossed the Piave against an enemy in a state of approaching demoralization. In June, as this article relates, Austrian troops fought their way over, in a carefully-planned and executed attack, against a stout resistance, which included a superiority both in aircraft and in heavy artillery. Of these two crossings of the Piave, that by the Austrians is, therefore, likely to furnish more instructive lessons than that by the British, both to Engineers and to the other arms.

Extracts from the orders of the Corps concerned are given, and from those of one of the three divisions engaged. These the Author considers " masterpieces of clear and appropriate orders, possessing permanent instructional value." The object of the enterprise was the capture of the Montello, a hill on the right bank, 600 feet high, as a necessary preliminary to the advance of the Isonzo Army, to the south, on Treviso.

The preparations were systematic and thorough. Fourteen Sapper Companies, ten Bridging-trains and 384 boats were distributed amongst the divisions as special allotments. The total number of guns per division was brought up to 200. The number of A.A. batteries was

increased from three to eight, and a large number of machine-guns was allotted for the A.A. defence of the crossings. The necessary bridging material was brought up by train and lorry and parked under camouflage three to eight km. from the front. Careful reconnaissances were made of all approaches and of the river-bed, including the profiling of every likely crossing-place. Places of concealment for the bridging material nearer the front were selected and prepared, and, since at most 16 half-pontoons could be brought forward *per* division *per* night, the moving forward of the bridging material started 17 days before the assault. In nearly every case, man-handling was necessary for the last mile up to the place of concealment. Training in back areas of both Engineers and infantry took place. The former were put through pontooning courses on the Tagliamento and the Livenza, and all of the latter, who were to be shipped across before the bridges were built, practised embarkation and disembarkation.

On the 15th June, shelling of the enemy's batteries in the form of gas-surprise started at 3 a.m. This was followed by one hour's gas-shelling of the same targets, and then 3½-hours' bombardment of the front line and batteries. During this and from 5.30 a.m., foremost brigades to be shipped over; at 7.40 a.m., storming of edge of the Montello: bridges to commence as soon as capture complete: by midday, one bridge to be finished in each divisional sector, the crossing by pontoons to continue meanwhile: on completion of bridges, the rear brigades and artillery to cross; under protection of barrage, the attack to be continued on enemy second and third lines. Thus far the orders; what happened was as follows: The left division had all its pontoons and most of its boats destroyed by 11.30 and transhipping was stopped after 1½-battalions had been got across with 530 casualties, while the Sapper Company lost 70%; no bridge was possible, and a new place was chosen one kilometre up-stream for both transhipping and bridge; on the other hand, the storming-troops had suffered so much from m.g.-fire that they stormed the river bank at 7.15, twenty-five minutes ahead of schedule. The centre division had one bridge, over 100 metres long, across the north arm of the river by 8.30 a.m., and a second over the south arm by 12.45. The right division, like the left, could get no bridge built. Here, too, the infantry would not wait, and had stormed the river bank by 6.15. Subsequent progress from this line was: the left division had captured the Italian third line by 9.40 a.m., but could not get any further all day. The centre division (the only one having bridges) had all its infantry and two mountain-batteries over by 2.40 p.m., and got forward to a line 4½-km. from the river. The right division, partly by transhipping and partly by using the centre division's bridges, was able to get forward the same distance.

In the next few days, the situation elsewhere had altered to such an extent that orders for the withdrawal from Montello were given. These were sadly obeyed, the evacuation being faultlessly carried out on the nights of the 21st and 22nd June. The Engineers were prominent to the end, a last worthy effort being when, having seen that the enemy had reached the river bank, a party set out in two pontoons to bring away possible stragglers, and lost seven killed out of ten in the attempt.

Co-operation of Fleet and Army in the Great War, by Colonel von Suhay. The Author deplores that public opinion, accustomed to expect the decision from the Army, and following its operations with feverish attention, attributed too little importance to the Navy and was inclined to look upon fleets as more or less necessary but inactive spectators. No conclusion could be less justified. While millions opposed each other on land and the Great War appeared as if it must end in a draw, it suddenly came to an inglorious end owing to the internal collapse of the Central Powers. This fateful event was a consequence of the blockade, which, by cutting off the Central Powers from the world's resources, starved them physically and morally. Success was thus the achievement of superior naval force: it was the fleets of the Entente Powers which decided the War. While armies struggled vainly for a decision, that decision was found by sea forces, and that even without having to fight a great battle to obtain it. The Author then proceeds, in order to stimulate an understanding of how Army and Navy can co-operate, to investigate broadly:—

(1) The *rôle* played by the Navy in the plans of campaign of the land forces.
(2) To what extent the Navy participated in those operations of the land forces in which the sea played a part.
(3) The nature of the co-operation in cases where Army and Navy worked together for a definite war purpose.

As regards (1), in Germany and in Austria, in 1914, the navies were under the respective G.H.Q.'s, but this single control was only nominal. Since it did exist, however, the C.G.S. should have given the navy, in peace, such directions as would ensure unity of action with the army in war, but the G.S. left all naval preparations for war to the navy. Excepting England, most nations agreed that the war must be decided on land. General Staffs laid their plans accordingly, and the method of using the fleet, being considered of subsidiary importance, was left to the naval authorities. Thus it happened, when war came, that armies assumed the offensive while their fleets remained on the defensive.

For example, the German Navy was not informed of the plan of campaign of the German Army to attack France by outflanking it through Belgium. Moltke, the C.G.S., attached no importance to the Navy making their plans fit in with this scheme. In 1908, however, the Admiral C.-in-C. intended, in a war with England, to use the fleet offensively. His more cautious successor, in 1914, used a relatively stronger fleet on the defensive; and yet the German plan of campaign on land was the same in both cases. The C.G.S. had no influence on either of the naval C.-in-C.'s, regarding the fleet as a sort of strategic reserve, a protector of the coast, and a weapon to be held in hand for the eventual peace negotiations. This idea of saving the fleets had some foundation in a peculiarity of naval warfare, viz., that a great sea-fight is a life-and-death struggle, *e.g.*, Santiago, Tsuschima, Coronel and the Falkland Islands, where the fleets defeated—Spanish, Russian, British and German—were wiped out. "Who knows," the author asks, "how Skager Rack would have ended but for night breaking it

off?" His implication is clear, that the Germans should have fought it to a finish.

In the case of other nations, he admits that there was a closer relationship between army and navy in England's war-plans, and to some extent in those of France, but such co-operation was not strategical, but a necessity arising from the geographical position of the probable theatre of war, since naval co-operation had to be arranged beforehand for the transport by sea of the British Expeditionary Force and of the French contingents from Algiers and Morocco. A study of the course of the war, however, reveals that war plans might have been entirely based upon a strategic use of fleets. This is specially true of Germany, where the weak points of the otherwise ingenious Schlieffen plan demanded a strategical *rôle* for the German High Sea Fleet, since a German naval offensive alone could have brought about the desired prevention of English sea-transport. It could not have been a matter of indifference to German G.H.Q. that Britain brought "its excellent army," 120,000 strong, to the Western Front, especially since Germany no longer possessed a numerical superiority there, owing to Italy's secession from the Triple Alliance.

After the fronts had stabilized, it was England that first recognized that a decision could no longer be hoped for on land, and transferred the gaining of a decision to the Fleet. As soon as Germany began to realize whither the blockade would lead, it also decided to use its Navy for strategical purposes, viz., to raise the blockade; but too late.

(2) describes in detail the chief incidents of the Austrian naval history of the war, from which it appears that co-operation between navy and army was very close throughout.

Under heading (3) the first place in undertakings where army and navy worked together with a definite war-purpose is awarded to the Navies of the Entente Powers, not only for their transport work mentioned in (1) above, but also for bringing 1,200,000 Americans, together with an enormous quantity of war material, 3,000 miles to France without loss of any kind. Colonel von Suhay does not like to admit that this success was due to radio-compass work directed against the German submarines, but without that aid the performance would be more wonderful still. He classes the achievement as "worthy of admiration as one of the greatest performances in the war." Two examples are then given of army and navy co-operating, apart from purely transport purposes, viz., the German seizure of the Baltic Islands and the attempt on the Dardanelles, "the greatest combined war-undertaking by army and fleet that ever took place and which cost defender and attacker each a quarter of a million men."

Railways in War. General Ratzenhofer continues his article. He shows how, before the Great War, the popular idea of the shortness of a modern war, and hence of the importance of early successes, was held by the military staff concerned with railways in Austro-Hungary, and that upon this idea their schemes were based, all things being so arranged and ordered as to assist in the mobilization of army and fleet being

carried out as rapidly and as accurately as possible. These preparations envisaged war on four-fifths of the Austro-Hungarian frontier, *i.e.*, omitting only the frontiers of Germany and Switzerland, and included for all possible cases of war and war situations the preparations of lines of communication on the main lines of traffic, and guarding against hostile undertakings and sabotage.

When war came, all this fell far below what was required. The change from mobile to stationary warfare with its undreamt-of mass and variety of requirements, the provision of light military railways in every theatre, the restoration and running of many thousand kilometres of enemy railways in the East, South-east, South and South-west, the endeavour to compensate for numerical inferiority on whatever happened at the time to be the more important front by increase of transport-activity —all these were new factors, to which later were added difficulties arising from lack of raw material, lack of personnel, failure of other means of transport, and finally passive resistance and strikes, due to exhaustion and dwindling will to victory.

The remainder of the article, which is to be continued, deals with the description of the railway system in peace, the duties of the military railway authorities (*i.e.*, the railway branch of the General Staff) in peace, and their general provisions for war.

The Development of Artillery Material in and since the War (continued). Describes this month with eight photographs and seven drawings :—

A. Infantry guns, the French M16, the Beardmore, the new Polish infantry gun (Pocisk system) and the new American experimental gun M25 E.

B. Field guns, improvements in the French C97, the English 18-pr. Mark IV, " a very pretty gun," and Mark V carriage, new guns by Schneider, St. Chamond, Skoda and Bofors. The palm is awarded to the American experimental guns constructed according to the Directors of the Westervelt Board.

C. Medium artillery. No essential development during the war, but since then progress has been made by the Americans and by Schneider.

F.A.I.

(*To be continued.*)

HEERESTECHNIK.

(*January*, 1927.)—With this number the magazine changes its publishers to the well-known firm of E. S. Mittler and Son, Berlin, S.W.68.

Modern Internal Ballistics, by Dr. Becker. The second volume of Cranz's masterpiece on ballistics has just been published by Springer. It deals with internal Ballistics, contains 450 pages, and has been eagerly awaited for years both in Germany and abroad. This volume contains not only Cranz's own experiences, lasting over many years as

instructor and principal of the Ballistic Laboratory at the Military Technical Academy, but also introductory articles on the thermodynamic and thermochemical principles of internal Ballistics and on explosive-constants by Professor Poppenberg, and an article on external Ballistics by Professor Eberhard, of Krupp's.

The Tars and their Products. The first instalment of this article is devoted to pit-coal tar and contains, in addition to plan and elevation of a distiller, a useful "genealogical" tree showing the principal products of the pitch and of the distillate under the usual headings Gas-liquor, Light, Medium, Heavy and Anthracene oils.

The Dispersion of Projectiles, by E. Wedemeyer. The chief causes of the dispersion of shells and bullets, whether under the head of internal or of external ballistics, are enumerated, and the Author then shows by simple examples how even a minute deviation of its centre of gravity from the longitudinal axis may be the greatest disturbing element in the flight of a projectile, and further that, even when the centre of gravity of the shell lies truly in the axis of rotation, it may happen that the centres of gravity of the forward and after portions of the projectile lie outside that axis and form a disturbing couple.

The Present Position and Prospects of Photographic Survey. This article by Lieutenant-Colonel Boelcke, who in the Great War was the head of the War Survey Service in Germany, makes its appearance in order to mark the occasion of the second Congress of the International Association for Photographic Survey, held at Charlottenburg in November, 1926.

The Association was founded, in 1907, in Vienna, as an Austrian Society; was extended, in 1909, to include Germany and has now, after a lapse of thirteen years, held its second General Meeting. On this occasion the following States were represented: Austria, Germany, Switzerland, Sweden, Norway, Greece, Italy, Poland, Russia, Czecho-Slovakia, the Ukraine and Colombia.

The art of photographic survey, although necessarily confined at its inception to mountainous country, has now, owing to the success achieved by photography from aeroplanes, received so great an extension of its sphere of utility as to be able to replace former topographic methods.

The Author mentions the apparatus installed on the tops of the survey-ship *Meteor*, which, on Atlantic voyages, photographs the waves and measures their heights accurately to one centimetre. Also Lieut. von Orell's Stereo-Autograph, which was used with great success during the war in mapping the mountainous districts of Macedonia, of which the existing maps were quite inaccurate. Also Hugershoff-Heyde's Aerokartograph, a portable instrument, invented by Professor Hugershoff and constructed by the firm of G. Heyde in Dresden, which draws accurately contoured maps from stereoscopic photographs. A photograph of this wonder-work is shown.

(*February*, 1927.)—*The Czecho-Slovakian Light Machine-Gun* /24. A machine-gun can only be judged properly by its battle performances, but this weapon is worthy of consideration owing to its having been the winner of the international competition which took place at Milovice,

in 1924, since when it has been introduced into the Czecho-Slovakian Army.

The shape adopted is that of the ordinary infantry rifle; weight, including supporting fork, 20 lb.; gas-pressure loading; magazine, fitted above the barrel, contains 30 rounds; theoretical rate of fire, 540 to 640 rounds a minute.

The article gives every detail, with photographs and diagrams.

The Motor Vehicle in Snow. Two cases occur: the use of special vehicles and the use of special devices on ordinary vehicles. The use of special motor vehicles during the winter does not need to be considered in countries where firm snow lasts only a short time. It is then only a question of adding an equipment to ordinary motor vehicles, such that they can change easily from one system to the other.

The answer to the general problem of how to keep motor vehicles from digging themselves into the snow is to use the lightest possible vehicles, to increase the number of axles, to use large low-pressure tyres, and to put on anti-skidding chains, not as rings but as an endless screw. These chains must be made fast so that the wheel cannot turn inside them.

Photographs are shown of:—

(i) A motor-cycle with runners which can be lowered and raised as required.
(ii) The Austrian Aquillon system for lorries, viz., front wheels on runners, hind wheels replaced by runners, between which is a chain-driven track, which the driver can raise or lower.
(iii) The Swedish Nyberg system, viz., front wheels on runners, hind wheels replaced by tracks.

The latter system has been adopted by the Swiss postal authorities for their post-omnibuses, and with certain improvements, including rubber tracks, is used in the Upper Engadine.

The Tars and their Products. Deals with the successive fractions in the destructive distillation of coal, viz., light oil, medium oil, heavy oil, anthracene oil and pitch; how each is obtained, of what it consists, its uses, and the details of all washing-processes.

The Creation of a British World Network of Air Routes. It is considered that the projected air routes London–Capetown, London–Singapore–Australia, London–Kenya, with extensions to important centres in S. Africa, will not only form a basis for trade and travel purposes, but will be an important foundation for the development of Imperial Defence. These routes are still only to be regarded as a small beginning of what the British Government intends to carry out.

German War Gas. The *Revue d'Artillerie* (*December*, 1926) is quoted as authority for two statements about German progress in war gas, which are startling enough to be unconvincing without authentification. Some pains have been taken to track down this Report, and the trail leads back from Paris to Rome (*Rivista di Artigleria e Genio*), from Rome to Vienna (*Militärwissenschaftliche Mitteilungen*), from Vienna to the United States (*Chemical Warfare*), and thence, completing the vicious circle, back to France again (*La Croix*). It would thus have been

simpler for the *Revue d'Artillerie* to draw on *La Croix* in the first place, but in that case the report would not have been able to attain its full snowball-growth. Science and propaganda make an ill-assorted pair.

(*March*, 1927.)—*Artillery Draught.* Consists mainly of extracts from an article in *The Field Artillery Journal*, by Captain Winton, who, after experience of a horsed battery in war and of a mechanized battery in peace, sums up the pros and cons from a battery-commander's point of view. The German reviewer agrees in general with the soundness of Captain Winton's deduction in favour of the dragon.

The Tars and their Products. This third (and last) instalment deals with brown-coal tar and its products, with distillation and washing processes.

The chief product, although only amounting to 10 to 12 per cent. of the whole, is paraffin, and this is almost entirely used for candles; next comes, 5 to 6 per cent. only, brown-coal petrol, which is chiefly used for cleaning the paraffin; then Solar oil, cleaning oil, yellow oil and red oil, used for Diesel engines; gas oil, formerly used for making oil gas and latterly for making carburetted water gas; asphalt and creosote.

Construction and Effect of Aerial Bombs, by Major Justrow. The Author shows how the war caught aviation quite unprepared for aerial bombing, and that, although, during the war, there was a development in the shape of the bomb from sphere to cylinder and torpedo, the best shape was never decided, let alone such questions as the best distribution of the weight, the number, size, and best position of the steering-vanes and their correct curvature for ensuring regular rotation and thus stability of flight. As regards types of bomb other than mere explosive, the gas bomb received no attention in the war, being useless against troops in the small concentrations which alone were possible, while no nation was willing to incur the odium of being the first to use it against towns. With incendiary bombs a certain amount of success was achieved against French and English towns, but Major Justrow considers them inferior both in destructive and in demoralizing effect to the ordinary explosive bomb. He looks, however, to a development of both incendiary bomb and gas bomb as certain.

(*To be continued.*)

Present-Day War Technics. The review of a book by the editor of the magazine, Lieutenant-General Schwarte, which has been written to inform Germans of the technical progress of the armies of other countries, and thus to bridge over the time until Germany has the same right as other nations to develop its war technics. The book's object will have been achieved if at some future date Germany may be found equipped and well prepared—at any rate in mind!

Russian Views of the Structural Measures to be taken for the Protection of Town Dwellers from Air Attack. Modern war being a matter of nations, and not of armies, the great development of aviation and of air fleets since 1918, and the zeal expended in finding out and perfecting war gases, make it certain that these new weapons will be used in the fullest measure against national sources of strength.

In Russia, at any rate—to judge by reported utterances in Russian military literature—there are no illusions in this respect.

The following are characteristic of the point of view of military (and civil) circles in the Soviet Union :—

(1) No Hague Tribunal has been able to prevent wars in the past ; no Locarno will in future be able to stop their breaking out, so long as the political economic and social causes of wars persist.
(2) Future war will be a war of armed peoples to the death, in which all means are "good" and "permissible." The possibility of distinguishing between means which are permitted and means which are forbidden is a fiction and self-deception.
(3) Reliance on the effect of international treaties (which at the first shot are changed into "scraps of paper") or international agreements, which forbid "barbaric methods of conducting war," is vain.
(4) The most extended use of all methods and means of destruction from the air—by bombs and poison gas—is to be awaited with certainty.
(5) Owing to aviation, the ideas of "front" and "line of communication" have changed their significance.
(6) Even the existence of a powerful air fleet and strong anti-aircraft artillery cannot guarantee the safety of large towns, administrative, industrial and trade centres, in the interior of the country.
(7) Hence, every citizen—even living hundreds of kilometres from the frontier—may find himself exposed a few minutes after the declaration of war to hostile explosive or gas air-bombs.

The result of the warnings issued by the Soviet Union was the formation of two large organizations, the *Dobroljot*, or league for the voluntary creation of a strong air fleet, and the *Dobrochim*, or society for the promotion of the chemical industry and preparation of the chemical defence of the country. These two organizations, of which the latter had already in the year of its foundation 12,000 groups, comprising 1½-million members, became united in May, 1925, under the name of the *Aviachim*, having the same purposes as the parent societies and also the instruction of the population on the importance and properties of the two methods of warfare. The *Aviachim* works in the closest touch with the People's Commissaries for National Defence, Internal Affairs, Economics, Communications and Health.

The following, though written by "A Civil Engineer," is believed to represent Soviet Government ideas :—

"The development of aviation, which has made national frontiers illusory, at the same time does away with the hitherto sharply-drawn boundary between military and civil building. When every civil building is at any time in war threatened with destruction by bombs, civilian architects are forced to concern themselves with the effects of these changes and to build accordingly. As in the Middle Ages nearly every town was a fortress, and many buildings were of the nature of castles, and as in the time of the Renaissance every architect was to a certain extent a designer of fortresses, so nowadays the ever-

present danger of war demands that the civil architect should adapt himself to the requirements of war in solving the problem of the protection of the people's dwelling-places. And indeed the study and knowledge of the modern methods of conducting war will not only necessitate another standpoint for the designing of single houses, but probably for the planning of whole towns."

F.A.I.

(To be continued.)

CORRESPONDENCE.

THE EDITOR, *The R.E. Journal.*

SIR,

The Journals of our great technical Institutions teem with "Discussions," "Communications" and "Correspondences." In fact, these are often as illuminating as the original papers to which they are appended. Half-an-hour's study of the *Proceedings of the Institution of Civil Engineers* will convince anyone of the value of such appendages.

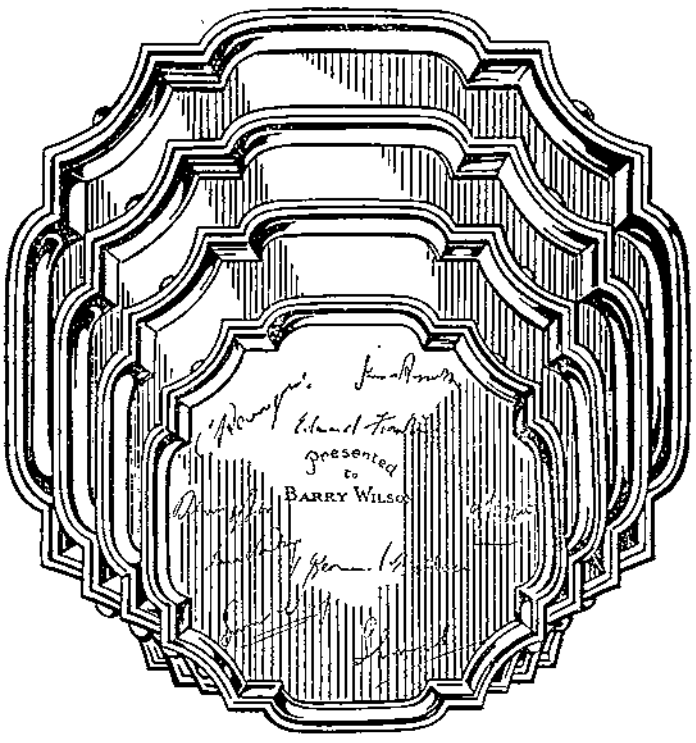
But it is rare for an article in our *Journal* to evoke any form of reply. One wonders whether it is that we are too modest. Or is it that we are too uninterested? Or are we too busy? Surely not. Perhaps it is not realized how discussion can enliven the dullest subject, how the liveliest can be enriched by keen comment. I cannot believe that the articles are tedious beyond hope of enlivening, nor that they are so perfect that to add one jot or tittle would be to gild refined gold.

Having said this much, may I be exempted, this time at least, from putting into practice what I have preached, and merely remain, Sir,

Yours, etc.,

C. A. DE LINDE.

Ecole du Génie, Versailles,
21*st January*, 1928.



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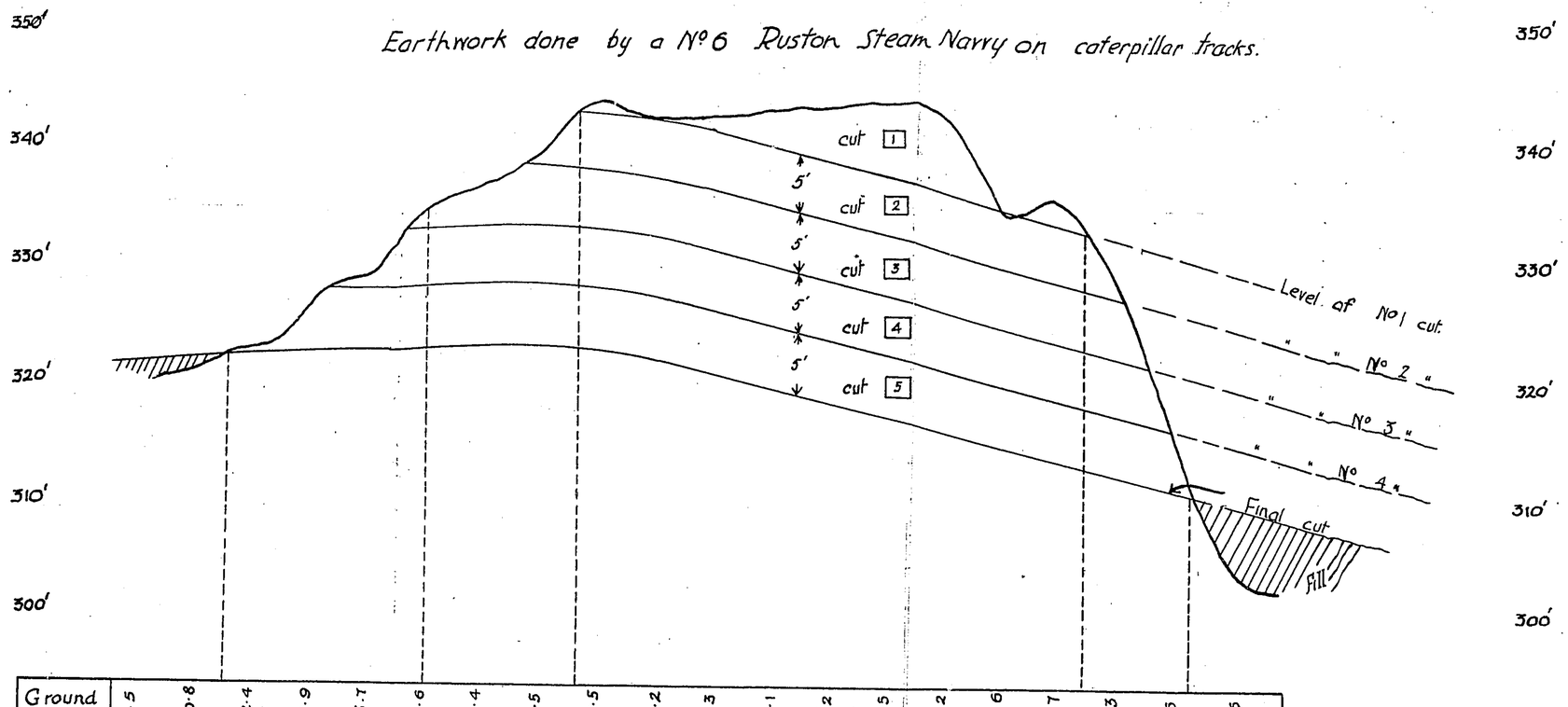
LAYER METHOD of TAKING OUT DEEP CUTTINGS

AN ACTUAL EXAMPLE FROM LONGMOOR - LISS RAILWAY EXTENSION AT THE RAILWAY TRAINING CENTRE LONGMOOR CAMP

Earthwork done by a No 6 Ruston Steam Navvy on caterpillar tracks.

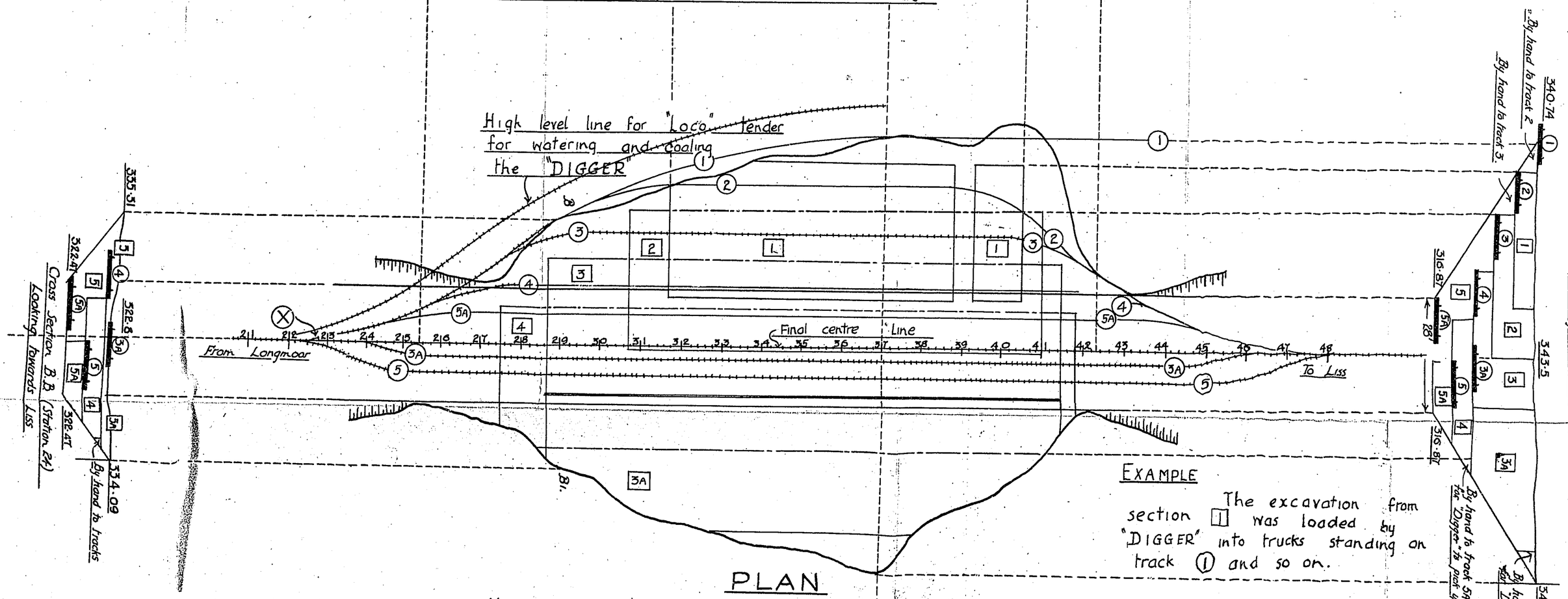


Ground Levels.	517·5	320·8	322·4	326·9	326·7	334·6	336·4	339·5	343·5	342·2	342·3	343·1	343·2	343·5	342·2	334·6	335·7	327·3	313·6	302·6
Formation Levels.	321·95	322·15	322·55	322·57	322·77	322·97	323·17	323·17	322·87	322·07	320·77	319·47	318·17	316·87	315·57	314·59	313·21	312·03	310·25	309·67
Cuttings.	—	—	·05	3·83	5·93	11·63	13·23	16·33	20·63	20·13	22·53	23·63	25·03	26·63	26·63	19·61	22·49	15·27	8·7	—
Distance in Stations.	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43

Successive positions of railway tracks are shown in circles — thus 3A

Successive "slices" or cuttings are shown in squares thus — 3

Extract from Longitudinal Section of Railway



PLAN

EXAMPLE

The excavation from section 1 was loaded by "DIGGER" into trucks standing on track (1) and so on.

NOTE :- Track (1) is slewed into track (2) track (2) into track (3) etc.
No turnout is required at the junction of the tracks.
At X only one turnout is required for the high level tender line
Nos. 5 and 5A layers are not shown on Plan for the sake of clearness.