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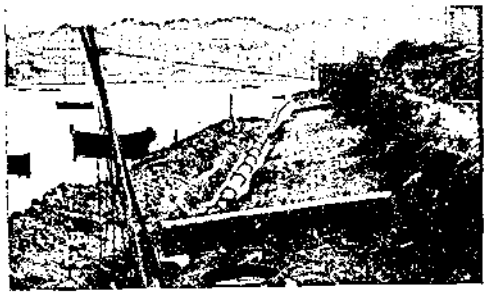
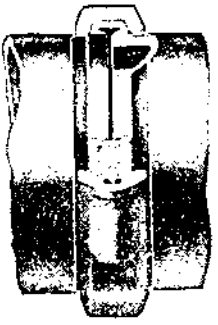


Victaulic joints being assembled in a flooded trench—Weymouth Corporation (Electricity Department).



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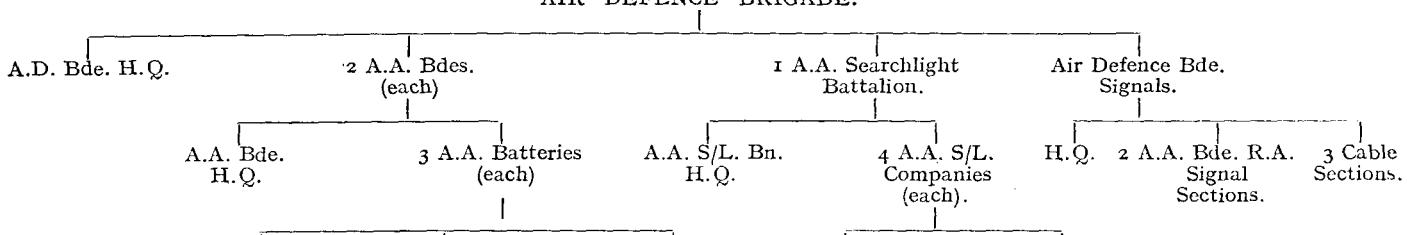
ANTI-AIRCRAFT GUNNERY.

TABLE GIVING COMPOSITION OF AIR DEFENCE BRIGADE.



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3-inch 20-cwt. Guns	48	
A.A. Searchlights	96	
A.A. Sound Locators	96	
A.A. Lewis Guns :		
in A.A. Lewis Gun Sections	48	168
in 3-inch 20-cwt. Sections	24	
in A.A. Searchlight Sections	96	

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CONTENTS.

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MILITARY MINING IN THE GREAT WAR.

A Lecture delivered at the S.M.E., Chatham, on November 14th, 1929, by MAJ.-GEN. R. N. HARVEY, C.B., C.M.G., D.S.O.

I HAVE been asked to tell you something about the mining operations in France during 1915, 1916 and 1917.

In order to meet the requirements of the situation, it was found necessary to create a new and distinct branch of the Staffs at G.H.Q. and Army Headquarters, and to raise a brand new group of companies of R.E. These were known as Inspector of Mines at General Headquarters, Controller of Mines at Army Headquarters, and the tunnelling companies.

Now as I believe that, in any war against a European nation, similar steps will have to be taken, I shall explain why these new Staffs and new units were necessary, so that if any of you are holding important appointments either on the General Staff or as Engineer-in-Chief in those days to come, you may be able to start where we left off, and not have to start from first principles as we did.

The Germans began to mine almost as soon as the line stabilized and blew their first mine about New Year's Day, 1915, at the Brickstacks south of La Bassée Canal.

Immediately there were insistent demands for means to combat this fresh menace. Units called Brigade Mining Sections were hastily improvised by amalgamating a section of a Field Company R.E. with such officers and men who were miners in civil life, and who could be spared by their units in the Formation. This was merely a makeshift, which destroyed the organization of the Field Company and depended upon the popularity or unpopularity of mining in the area as to what support it got from the infantry commanders.

It was recognized almost at once that properly organized companies of officers and men, who made mining their profession in civil life, must be raised to take over mining entirely. I must point out here, that, in my opinion, the training of any R.E. Company can never make it an efficient unit for mining in any but the easiest geological formations. A good deal can be learned in theoretical principles of planning defensive or offensive military mining, but to be an efficient miner, you must have years of experience underground, and miners do not enlist in the R.E.

I will not weary you with the description of how the companies were formed, but the establishment of a tunnelling company was

about 25 officers and 330 men, organized into H.Q. and four sections, each section capable of mining three headings with *continuous* work. To each company were attached, as a permanent fatigue party, 120 infantry.

The commanding officers of these units were at first specially selected officers, who had distinguished themselves with the field companies, but this had to be given up, for the casualties among the field company officers were so heavy that this source of commanding officer was soon exhausted. The tunnelling officers were then called upon to produce their own commanding officers, and they rarely failed to produce any but the best. The tunnelling companies were formed as occasion demanded. Their final numbers were: British 26, Australian 3, Canadian 3, New Zealand 1, total 33.

The units were allotted to armies, but were practically placed at disposal of brigades.

So much for the tunnelling companies. I'll tell you about the Inspector of Mines later on.

MINING IN 1915.

Mining in 1915 was a series of individual efforts by each tunnelling company, to carry out the wishes of the Brigadier to whom it was allotted. It was a sort of underground scramble to get on even terms with an enemy who had always got some weeks' start.

These conditions were almost as trying as any could be, and called for the highest form of courage and self-devotion, and the miners proved that neither quality was lacking in them, at any rate.

There was only one general action in which miners took a prominent part, viz., the capture of Hill 60. Here four mines, of 6,000 lb. each, were used; the mining was carried out under the direction of the C.R.E., Lt.-Col. D. M. Griffiths, D.S.O. The operation was successful, and Hill 60 was held by us for a month, when the troops were driven off by the second gas attack of the War.

Most of the offensive mining of 1915 was devoted to what I call ornamental destruction, which is the demolition of individual snipers' nests, O.P. and M.G. outfits. These were frequently fired to celebrate some day of public rejoicing, Brigadiers' birthdays, and so on, but in no connection with any infantry operation. This sort of mining is perfectly useless for ending a war, it is very unsettling for the occupants of the posts blown up, certainly, but the *straf* which always followed made our trenches most unhealthy.

I consider that 1915 was the year of preparation. Tunnelling companies were being formed and gradually trained in their special work. The equipment was slowly got together, selected from the best of prehistoric ordnance stores, and articles which had been purchased by private effort. The mine rescue apparatus was a relic of the Crimean War; ventilating fans made a noise like a motor-car,

and always drew fire. There were no surveying instruments suitable for use in a gallery, 4 ft. 6 in. x 2 ft. 3 in., the ordinary size we used in France. There was no listening apparatus, and even the explosive ammonal had to be invented, for the navy wanted all the guncotton available. As a matter of fact, ammonal is far better than powder or guncotton. Mining was further handicapped by the fact that for some months of 1915 there were no accurate maps of the trenches, so you can imagine the difficulty of mining from a shaft in an indeterminate position, and to keep direction of the gallery against a point distance unknown, and only to be glanced at in bad light, or when the enemy wasn't looking. Mining attracted a good deal of attention to itself because of the frequent calls for more mining companies, and the complaints of the C.O.s from whom miners were taken to form the companies, so that towards the end of the year, G.H.Q. began to make enquiries as to what had been effected during a year of mining.

There wasn't much to show, except the fact that the infantry were holding the same line which they had taken over in 1914, in spite of the fact that the enemy had been trying to blow them out of it almost continuously.

Underground, there were in nearly every sector and sub-sector of the line, a tangle of galleries running out from *one* shaft, because there had never been a chance of sinking a second one.

G.H.Q. had, up to this time, no accurate knowledge of what had been done; the reports which should have been rendered weekly on a properly ruled form, never got as far as G.H.Q., or if they did, they were hopelessly out of date. So it was decided that there must be closer touch between the G.S. at G.H.Q. and the mining operations; and the E.-in-C. was asked to nominate an officer to be styled Inspector of Mines at G.H.Q., and one officer in each army called Controller of Mines.

That is how the appointments of Inspector of Mines and Controllers of Mines came about.

I was in the E.-in-C.'s office at the time, and I was told to draw up the duties of Inspector of Mines. Knowing well the difficulties we had had in getting up-to-date information from the front, I drew up a charter for the I. of M. which would enable him to visit any mine, anywhere, and at any time, without any reference to the Headquarters of any formation, except to tell them he was going into their areas, and added the ordinary duties of an inspector.

To my surprise, the G.S. at G.H.Q. accepted it, for it gave the I. of M. more freedom of movement than anyone else in France, except the C.-in-C. himself.

After this job had been refused by one R.E. officer, I asked the E.-in-C. to nominate me, and to my great satisfaction, he did so.

And that is how the Inspector of Mines and the Controllers of Mines came into existence.

The first step taken by the G.S. was to lay down the principles on which mining in future was to be conducted. They were :—

1. No offensive mining, unless it formed part of a definite military operation on the surface.
2. Defensive mining in all sectors to be confined to the offensive —defensive.

The C.-in-C. authorized at this time the use of deep mines as part of the operations against Messines.

Under the new organization began a new era for the tunnelling companies. They were removed at once from the control of the Brigadiers, and came directly under the Controller of Mines of the army who represented the G.S. for mining work.

The principal duties of the Inspector of Mines were :—

1. To see that the directions of the G.S. as regards offensive mining were strictly carried out.
2. To ensure that the mining defences in each sector were designed on a definite plan.
3. To keep the G.S. constantly informed of the progress made with such mining as was intended to form part of a general operation.
4. To report the result of such mining after the operations.
5. To advise the G.S. on the question of transfer of tunnelling companies from one army front to another.
6. To watch the interests of the officers and men of the tunnelling companies as regards appointments, reinforcements, supply of stores and equipment.

The duties of the Controllers of Mines were somewhat similar as regards the G.S. of their armies.

The staff of the I. of M. was as follows :—

2 staff officers.
1 geologist (a necessity on all mining staffs).
1 medical officer (specially versed in diseases of miners).
1 mechanical engineer.
Clerks and draughtsmen.

Reports went straight from the Controller to the Inspector of Mines, and thus direct touch was established, which became more and more close as the I. of M. began to inspect the front and learnt his job.

In the office of the I. of M. were kept all the mining records, and from it was issued propaganda of all sorts to the companies. All experiences which came to notice and were of general value were broadcast; everything was done to do away with watertight compartments; the achievements of one company were published and sent to all companies and produced the keenest rivalry.

Every effort was made to standardize the articles of equipment, and to ensure that what was available should be fairly distributed. Standardizing equipment was more difficult than you may suppose. The tunnelling officers were all mining engineers, from any part of the world, and they had enormously strong prejudices in favour of the things they had used themselves. However, we managed compromises in most things that had to come from England, but where the army workshops could make any pattern at all without check standardization was impossible.

Each army started its own mine school. At this, instruction was given in listening, mine rescue work, life-saving and mine tactics. These schools were essential for training officers in their work before they went up to the trenches, so that they would not have to learn it under fire. Our mine rescue apparatus now was the same as is used in the mines at home, and was the means of saving many lives. Listening was the science which was developed to the highest extent at the schools, and we got surprising results from the careful training of selected men.

When we started mining in 1915, we thought that ten feet of clay, or thirty of chalk, was sound-proof. In 1917, our listeners were so skilful, that they could correctly estimate distances up to 80 feet in clay or chalk, and differentiate between the sounds they heard, shovelling, picking, talking, laughing, etc.

We eventually got a very efficient and silent ventilating apparatus, but for a long time, ordinary forge bellows were the best means of supplying air, being almost silent. Anything like a rotary fan noise immediately drew heavy *straf*.

The first combined operation infantry attack, assisted by mining, took place in April, 1916, at St. Eloi. Here, four heavy mines, originally intended as part of the plan for Messines Ridge, were fired; these were 60 feet deep, our first deep mines. They were a useful adjunct to the operations which were at first successful, but eventually the craters were lost, as nearly always happened with British troops, and it was a case of "as you were," until June 7th, 1917. From these mines, we learnt what sort of clay the subsoil was, and the real effect of very heavy charges and the crater formed, also the appearance of a heavy mine when fired, the range of the flying debris, and time taken for falling fragments. All these were carefully noted for future use.

The next combined operation was the Somme battle.

This opened on July 1st, 1916. We had six or seven mines under various strong points; all were fired at zero, except one, which for some reason or other was fired at ten minutes before zero. This was done in spite of my earnest protest at G.H.Q., for I knew that, as soon as the crater was formed, it would be occupied by the Germans. This actually happened, and it formed an excellent advanced

post from which the enemy enfiladed "No Man's Land" with machine-gun fire.

Compare this result with another sector of the line, where the mine was blown at zero. No less than nine dugouts, containing the garrison of the trenches, were closed in, and our troops crossed "No Man's Land" with hardly a casualty.

In another place, the tunnelling officer who had to fire the mine was working at the junction of two brigades; he had his time from the right-hand brigade, and thought it must be the same in the other brigade, but after having made a final test of his firing apparatus, he returned to the trenches, having, as he thought, one minute in hand, when he saw, to his horror, the infantry forming up to go over. He rushed to his exploder and fired his mine, which was quite successful, and destroyed the enemy post, but several of the assaulting troops were temporarily laid out by falling lumps of chalk and clay.

Other mining assistance took the form of Russian saps from our trenches towards the German front line. These were tunnelled out about a foot beneath the surface, and the idea was that they should be opened up and connected with the German trench immediately after the first wave of infantry had gone over.

I think there were about 25 tunnels from first to last; some were never used, as the troops failed to get across; some were not required, because the Germans cleared off altogether; but in one or two instances, it was by means of Russian saps which were connected up with the German trenches that our troops were enabled to hold on to the portions they had taken, for by these covered ways alone could reinforcements get through to their destination without having to go across a machine-gun swept "No Man's Land."

Several tunnelling officers had unique experiences in this battle, in areas where the assault failed. They had been chosen to take charge of the working party, to connect up the head of the sap to the German trench. At each saphead was a m.g. or Stokes gun emplacement. The tunnelling officer and the gunner sat at the head of the sap, within 50 yards of the German trenches, anxiously waiting for the advance of our troops. They had a wonderful, but at the same time, a most heartrending experience, for not a man passed them. The lessons from this battle were carefully scheduled for future use. They were:—

1. All mines must be fired at zero, so as to run no risk of the craters being occupied before the troops cross "No Man's Land."
2. The synchronization of time is of absolute importance, and the tunnelling officer must be certain that he is right with the H.Q. of the troops he works for.
3. Russian saps have solved the difficulty of crossing "No Man's Land."
4. Our theoretical calculations were proved correct by actual practice.

After the battle of the Somme, we had ample opportunity to study the German mining methods, and found that :—

1. They hid their spoil, so that there was no evidence from air photos where their mines were ; our dumps, on the contrary, were mounds of chalk, visible for miles to the naked eye. This point was stressed with very good results at the Messines mines.
2. They were meticulous in their gallery work, and lined with wood the hardest chalk.
3. They marked up on the wood lining, where they started work and finished, and from this we got the information that they reckoned to do eight feet a day ; our pace was *ten to fifteen*, which accounts for our being able to catch them up.
4. A complete survey of the German mine systems was made, and from it many strange occurrences were accounted for.

Among the treasure trove, we found diaries of mining officers which, contrasted with the reports of our own officers, made amusing reading, for each side invariably reported their mines were entirely successful, and those of the enemy utterly harmless.

The last combined operation of 1916 was the Battle to take Beaumont Hamel. Hawthorne Ridge crater, which was occupied by the Germans since July 1st, was attacked by three mines, which were fired at zero, and this ended in complete success.

After the Battle of the Somme, we had in our possession the whole of the German mining systems of any importance south of Arras, and the tunnelling companies were employed in making underground shelters for the troops, and I estimated that accommodation for about 20,000 men was made for the winter. These numbers were compiled from reports of dugouts actually made.

The year 1917 was the miners' final triumph. The first combined operation was the battle of Arras, which included the capture of the Vimy Ridge. For this operation, all the information we had collected from experience of 1915 and 1916 was placed at the disposal of the Controller of Mines 1st and 3rd armies.

Mines did not form a very large part, but Russian saps were developed in a striking degree.

For the Vimy Ridge, only twelve were made, but on a much larger scale than before.

Instead of being only 12 in. underground, they were made shell-proof, that is, 25 ft. thickness of head cover. They were 6 ft. 6 in. high and 3 ft. wide, to allow men to pass through, standing upright, and wide enough for two armed men to pass. These subways were lit throughout by electric light, a water supply was laid on, and all along the subways were made dugouts, assembly chambers, dressing stations and formation headquarters.

They were run out to within 100 feet of the German line, arrange-

ments were made to connect the head of the subway with the German trenches by means of bored mines at a depth of 12 feet, *i.e.*, a bore hole, lined with a steel tube, which is afterwards loaded with H.E., which when fired formed an irregular trench, 30 ft. wide and 14 ft. deep; this was quite good enough to be converted into a covered way. These subways were a complete success and the Vimy Ridge was taken according to plan.

The leading feature of the Arras Battle from an underground point of view, was undoubtedly the exploitation of the "Caves" of Arras.

The caves are in reality the underground chalk quarries from which the hard chalk was taken to build Arras in the sixteenth century. Some few of them were found and used by the French as bivouacs, and these we took over. A few were found by chance, and then began a systematic search in which two main series were found.

These caves were, as a rule, not connected when we found them; they lay roughly in the line of the main roads leaving Arras, and approximately in the direction of the main attack.

The two systems were converted into a series of huge dugouts, in which nearly two divisions of infantry were housed, with their formation staffs, for some days before the battle began.

It was also found that a small river, called the Crinchon, had been conducted by a brick sewer, two metres in diameter, round a portion of the town; this sewer was also brought into the scheme and connected with the tunnels and the caves. The result of this was that troops could proceed underground from the centre of Arras to within 100 feet of the German trenches, under cover, and this was actually done, a total distance of about three miles.

The caves provided almost ideal accommodation, and were fitted out like a camping ground, with wash-houses, cook-houses, latrines, store-rooms for every conceivable store, lit by electric light, and ventilated by enormous rotary fans; they were a hitherto unknown feature in field warfare.

Great care was taken to obviate any danger from falls of chalk, even under the heaviest bombardment, and the precautions taken were entirely successful, no case of injury to any man occurred, and no case of penetration by an enemy shell occurred either.

The survey of the German mine systems, made after the battle, did not produce any important information, though it was quite evident that from the style of work they left, the majority of the skilled miners had been withdrawn, and the work was that of ordinary pioneers.

The general success of the underground work preparatory to the Battle of Arras was circulated to all companies, and G.H.Q. ordered that, if possible, the system of subways should be tried in the Messines area, and included in the underground work which was already approaching completion for the impending operations.

But the subsoil for a depth of not much less than 40 feet was far too treacherous to allow of subways being constructed, except with an enormous expenditure of time, material and men, none of which essentials were available. It was the treacherous nature of the ground that decided us to lay down that the minimum depth of any mine intended for the Messines Battle was to be 60 feet. Even at 70 feet, I have seen the 7 in. x 4 in. uprights of a gallery (only 4 ft. 6 in. x 2 ft. 3 in.) broken across their wider axis by the weight of the roof.

The blue clay in which we were working would not hold its own roof, unless it was continuously supported. In this respect, the mining in Flanders was far more difficult than similar work in the chalk areas.

The preparations for the Messines battles had been commenced in 1915, with what was known as the Berlin Tunnel at Hill 60. This tunnel was a long, inclined gallery, to a depth of some 60 feet, through a very wet and treacherous subsoil to the blue clay. It was from the experience gained by the construction of this inclined gallery that we decided that all shafts to mines in Flanders must be vertical.

Mining had been commenced in August, 1915, and was completed only on the very eve of the battle on the 6th June, 1917. Of 19 which were detailed to be fired on the date named, 19 mines went up.

Now it must not be supposed that this work was all plain sailing, though we were deep. Somehow or another, the Germans got to know that we were mining deep, and during 1917 made determined efforts to defeat our progress, but though only one mine was lost in this dispute, our galleries were broken on three other occasions.

At Petit Bois, our gallery ran under an old crater in "No Man's Land," which was occupied by the Germans, and as luck would have it, they heard us working below them; they blew a counter mine, which wrecked 150 feet of our gallery, and cut off 12 men. Although every effort was made to rescue them, by the time a new gallery was made round the break, ten days had elapsed, and when the rescue party broke into the gallery beyond the break, they found, as they thought, all the men of the original party dead. They went back to dinner, and, on their return, were scared to death at meeting a survivor crawling towards them. He was an old miner and had remained at the face where he knew the air was better; he had heard the rescue party break in, and had crawled down to meet them. Unfortunately, the doctors had him out of France before I could interview him.

Remember that this 150 feet of new gallery had to be made with every precaution against being heard by the Germans above, and the miners working there ran the risk of being cut off exactly as the men whom they were trying to rescue had been. But miners will

never abandon a pal while there is the slightest chance of rescuing him; that is one of their creeds.

Another gallery was wrecked quite close to the charge, which had been already laid and tamped, cutting all the leads. This gallery was recovered, the charge was reinforced with a priming charge of 1,000 lb. of guncotton, and everything restored to order, only six hours before zero. It was duly fired according to plan, and H.M. The King was photographed near its crater on the occasion of one of his visits to France.

A third gallery was destroyed at Hill 60, at the vital point of the junction of two galleries to two different mines, but by the most strenuous work, everything was restored to order by zero, and the mines were fired, and were both eminently successful.

When we had taken the enemy system of mines and carefully examined them, we found that in three places at least, they had commenced to mine even deeper than we were; we found shafts of varying depths up to 90 feet.

Hill 60 mining was one of the most difficult and dangerous propositions the miners had.

Mines were in three levels:—

Top level. Shallow system commenced in 1915; scrapping went on at this level nearly all the time.

Middle level. This was developed by us to counter a German effort at the same level. On this level we found a German gallery which had passed ours and was 150 feet behind our front line.

Low level. The mine galleries for the Messines battle.

The Germans heard us from the middle level, and blew a charge directly over the junction of Hill 60 and Caterpillar galleries, and cut all the leads. These two mines were actually recovered, though we heard the Germans working above. We couldn't afford to blow them, for this would mean retaliation, with probable damage to the two main mines. As we estimated that their gallery would miss our system, they were allowed to go on working, and were working at zero, 7th June, 1917.

In the preparations for the Battle of Messines, we made use of all the experience which had been collected in the previous two years. We knew the general appearance of a mine; we could tell accurately the dimensions of the crater.

We knew how long to allow for the debris to fall, and the area affected by the gases produced by the firing of the enormous charges.

But we did not know what the effect of the earth shake would be on the surface.

Regulations had to be drawn up to ensure against casualties

being suffered by our troops. Generally speaking, they were as follows :—

1. No troops to be within 200 yards of a mine.
2. All trenches to be empty at that distance.
3. All dugouts to be empty within 300 yards.
4. No troops to be in or near shell-shocked buildings or trees.
5. No troops to advance until 45 seconds after zero.
6. No troops to attempt to cross a crater or its lip.

The regulations were sufficient, and no casualties, as far as I could learn, occurred, except in the case of men entering craters against orders. These men were gassed. I found out later that men ought to be told that mines would be fired and what they would be like.

The battle was a complete success from a miner's point of view, in that we scored a possible 19 mines out of 19 fired ; some of the mines had been underground for 15 months.

The other side of the picture, however, must be considered. A very important number of the divisional commanders were urgent in their demands that the mines should not be fired ; the reason given was that the craters would limit the front over which their formations had to pass, and when you think that the craters in question were, on the average, 100 yards wide, there is a good deal in the objection. But the higher command ruled the objection out. We do not know what casualties were inflicted on the enemy, but we do know we caught two German companies at Hill 60, relieving one another, for we picked up alive the O.C. of the company relieved, and none of his company or the other were among the prisoners ; and we caught German troops forming up for a raid in the craters of St. Eloi, only one scorched German was found of this party.

The crater of this mine is the one which has been written about in *The Times*, and called " The Pool of Peace " ; there is a suggestion that it might be preserved as a sort of war memorial.

A curious rumour was started early in the morning of the battle, that heavy German mines had been blown in our support lines. On investigation, this must have been due to men or troops in salients in our line seeing mines go up apparently *behind* them, but in reality behind the German trenches in our re-entrant angles.

This will be readily seen on a map and is, no doubt, the reason why the Germans in Hill 60 and St. Eloi, thought our mines on the right flank had blown up the town of Messines. Our nearest mine was about a mile from this town.

For this and all succeeding battles, great attention was paid to providing dugouts for the Headquarters of all formations, down to battalions. As the Battle of Messines was one of limited objectives, this could be done, and was done, with the result that A.H.Q. was in much closer touch with the battle than had been possible before.

This system of providing dugouts for headquarters was developed very widely, and the lesson we were supposed to have learnt about the careful disposal of soil was again impressed upon us.

In Flanders, we had to get down to the blue clay, but woe betide the miner who showed this material on the surface. One instance I saw; we were making a dugout for a headquarters in an exposed position after the 7th June. Some blue clay had been spotted by the Germans, and I counted 13 hits on the immediate area by 8-in. shells, four of them direct over the dugout.

I am afraid there is no time to tell you stories of the wonderful feats performed by the miners; I have confined my remarks to the lessons learned from them, and you may be perfectly sure that, if you remember the lessons I have pointed out, the miners will always produce enough feats of valour to make stories of in your day.

I will conclude my remarks by the rather paradoxical advice. If you are in a position of responsibility in the next big war, do everything you can to prevent mining being done, except for strictly defensive purposes. In a long position taken up, there must, of course, be important features which are like the bastions of a fortress of ancient days, and which must be held at all costs; a mining defence here is legitimate, but wholesale mining under the front trenches should be discouraged. It is far better to sink listening posts and, by their aid, find out where the enemy are, and then to withdraw the line sufficiently far to prevent the enemy from occupying the old trenches, and at the same time throwing upon him the labour of another 50 yards or so of mining. This system was adopted by the French to a large extent and I am sure it is sound.

It is not generally known how mining eats into the infantry strength of an army, but when I tell you that I took a rough census of the number of men employed underground at a certain date in 1916, and the numbers were about 20,000, that is, two divisions of infantry, you will understand why I say cut down the mining to the lowest possible limit. No modern army can stand this drain on its strength.

Miners will always be required for making underground shelter for headquarters of all formations, numbers of troops, stores, etc.

This is useful mining, but in modern days with aeroplane bombs, heavy artillery, and all these other bolts from above, the blow from below is far too slow in progress, and cannot be readily adapted to the ever-changing schemes for the occupation of trenches on the surface.

THE ENGINEER SCHOOL OF VERSAILLES.

By GENERAL ROBERT NORMAND.

(Reprinted by permission from *Revue des Deux Mondes* of March 1st, 1929.)

*" Ad victoriam per scientiam."**

ON 5th March, 1927, when placing a Colour for the Engineer School of Versailles in the Marble Hall of the Castle, at the same time as for its sister school, the Air School, the President of the French Republic decorated the former and pronounced the following words:

> " By the part they took in action, by their military works, by their successful inventions, the officers of the Engineers contributed largely to the victory. As a recognition of their services the President of the Republic has decided to decorate their Colour.
>
> " Colour of the Engineer School, we make you Chevalier of the Legion of Honour."

This great recompense constituted a striking recognition of the training given to a group of officers, too many of whom unfortunately fell in the Colonies, and 700 of whom gave their lives for France in 1914-1918. It clearly defined the double character of these military engineers: soldiers and scientific experts. The Army inspires a sense of duty, science develops the character. It is not surprising that this double training provided us during this great war, as during those of the revolution and the colonial campaigns, with a magnificent Corps of incomparable engineer officers.

Amongst the great names of the War do we not see standing out in the first rank that of a " Sapper," who has had a long and magnificent colonial career, Marshal Joffre, whilst two of the greatest figures of the war of 1870 were those of two other Sappers—General Faidherbe, another colonial, and Colonel Denfert-Rochereau? Further back in the past and not so very long ago we also have Lamoriciere and Cavaignac—two heroes of the Conquest of Algeria—who joined the Engineers after passing out of the Polytechnic School. Lazare Carnot and Meusnier, during the Revolution, came from the Engineer School of Mezieres, which dates from 1748, and to which we also owe

* Motto of the School, suggested by Cadet Officer Schott.

the celebrated electrician Coulomb, the mathematician Poncelet, and the inventor of the first steam-driven vehicle, Cugnot.*

THE "NURSERY" OF THE ENGINEERS.

The school at Versailles is a recent creation. It was in 1884 that a new military school of artillery, engineers and train was installed in this old garrison town, with a view to giving certain N.C.O.s the extra training necessary for promotion as officers. Whereas the officers promoted automatically as 2nd-Lieutenants on leaving the Polytechnic continued to carry out their two years' study at the Artillery and Engineer (Advanced School) *Ecole d'application* of Fontainebleau, since 1871 the successor of the *Ecole de Metz*. These mixed schools had disadvantages as against obvious advantages, such as the *camaraderie* between "gunners" and "sappers." Moreover, if the School at Fontainebleau was very well equipped for practical artillery exercises, it was very badly equipped for those of the Engineers, and it was difficult to remedy this. Therefore, in 1912, it was decided to create a Military School of Engineers at Versailles to train in the same establishment—but with different courses—the *officiers-élèves*† and the *élèves officiers*‡ of the Engineers.

During the War this school worked, like a workshop with full output, in training the *aspirants* of the Engineers, designated for providing the future Army with officers, once these had been tried in the field. For, besides the great expansion of the Engineers necessitated by the most varied requirements, it was also necessary to fill up the officer cadres, since the losses which occurred in the four years through casualties involved a loss of about twenty annual promotions on the active list.

After the War, the school tended more and more to become, and is to-day, the cradle of the Engineers; in 1925, it assumed the name of *Ecole militaire et d'application du Génie*, and in reality comprised two parts:

Ecole militaire (the military school), a training school, comprising one year of study for the probationer officer of the "active" Army and the administrative probationer officers (until 1926 the latter were at the *Ecole de Vincennes*), a half-year for the probationary reserve officers.

Ecole d'application (advanced school), comprising: two years' study

* In 1770. It is to be seen at the *Conservatoire des Arts et Métiers* in Paris. The School at Mezieres also produced Rouget de L'Isle, the author of the "Marseillaise," a sub-lieutenant at the School in 1782 and nominated probationer sub-lieutenant in the Royal Corps of Engineers on April 1st, 1784, after being rewarded with the following notes: "Has but too much confirmed the impression which he gave last year of having little liking for his profession and only working as much as he is obliged; in the carrying out of his work he showed such carelessness and stupidity as to prove that he has no ambition. His character is gentle and honest, but he is very addicted to dissipation and futile things."

† Officer students. ‡ Probationer officers.

for the most efficient officers (who have been through the Polytechnic or other officers having a sound technical knowledge and having chosen the " active " Army) ; one year's study for former probationer officers or those having lower technical knowledge, especially the majority of the officers admitted to the Engineers with a view to absorbing the surplus of other arms resulting from war nominations ; six months' study for the officers who have passed through the Polytechnic classified as reserve officers of the Engineers, and who, as probationer reserve officers, should complete their legal term of service in a regiment as reserve officers.

The result is that, with the exception of a few *adjutants** promoted officers without examination but obtaining this favour by practical work, by seniority and long and loyal service, or ex-re-engaged N.C.O.s promoted reserve officers having obtained the certificate of the *Chef de Section* (section commander), no one can become now officer of the " active," reserve, or administrative, without having passed through the school.

Since, moreover, the newly promoted battalion commanders are called upon to go through a course of one month, and the general officers and colonels come to a refresher course at the Centre of Tactical Studies of the Engineers, we may conclude that this school is in reality the " nursery " of the Army.

An Arm with Multiple Roles.

The first phrase of our Regulations states that " the Engineers are a fighting arm."

During the War, it was given the most varied and sometimes the most unexpected missions, such as flame projector companies, the exploitation of woods, even at some moments the work of bombers and the construction of hand grenades. Its regiments were more and more transformed into lines of communication and signal units : for the former, roads, tracks, fixed or floating bridges, construction and working of railways of normal gauge† : for the latter, the installation and working of telephone, telegraphic and wireless systems, intercepting of enemy wireless, carrier pigeon service, and designing and construction of apparatus answering to the needs of war, such as those of ground telegraphy.

Further, the " sapper-miners " normally responsible for fortifications, concrete works, camouflage, destructions, mines, took part side by side with their infantry comrades in all the assaults, both for destroying the obstacles or enemy shelters as well as for connecting up captured positions with the jumping-off points. Under this

* Serjeant-majors.

† The Engineers constructed 7,000 kilometres of normal gauge, 4,000 metres of military bridges, and 4,100 metres of piles for normal gauges. Since the War, they have also been made responsible for the narrow gauge lines formerly constructed by the artillery.

heading we find to their credit innumerable acts of heroism, thanks to their wonderful *esprit de corps*.* Necessity often led them to take part in actions as infantry, although this was not their role. For "the Engineers are the working arm" states the Regulations. And this conception in itself is potent.

The "sapper" has, nevertheless, one monopoly in the struggle which no one will begrudge him; that is the war of mines, with its surprises, its ruses, its snares. Certain war cemeteries are exclusively filled with miners buried by explosions at unprecedented depths. Sometimes the mechanical installations required for these works, with compressor installations, narrow gauges, lighting, trestles and electric pumps, constitute veritable subterranean factories, and after several years of labour we find works, for instance, such as those at the Chapelotte in the Vosges, with 11 tiers of galleries at a depth of 110 metres under the natural soil, and covering an extent of several kilometres. The mine chambers sometimes contained 40 tons of explosives, and produced craters of 40 metres in diameter and 20 metres in depth.

The Engineer Service was also responsible for camps and quarters, for the whole of the road system of the Army zone, the water supply, the installations and the exploitation of electric lighting, the construction of material for quarters and fortifications.†

The technical role of the Engineers must inevitably become accentuated in the future. Fortification permits of an economy of forces, inter-communication facilitates the exercise of command, railways accelerate the transport of troops and supplies. The regimental officer must possess engineering talents; those of the administrative services, or the Engineer commanders, must combine the qualities of a staff officer with that of an industrial head manager.

This diversity of functions is, in fact, one of the characteristics of the Engineer, and, above all, the post-war Engineer. Besides the three great branches of the arm, miners, road makers, telegraphists, there are many more supplementary ones, electrical mechanics, bridge makers, transport sappers, heavy bridge makers, carrier pigeon attendants, and again the latter are even more numerous in the administrative services of the Engineers: construction, electricity, camps, administration of the military area, design branches, experimental committees, fortifications, roads and tracks, railways, and colonial public works, etc. The Engineers are, in fact, an arm both of the home country and of the colonies.

* We might mention here that the first French soldier who penetrated into the Douaumont Fort, on 24th October, 1916, was a sapper, the Master Artificer Dumont, who was decorated in the field with the Cross of the Legion of Honour, and received the following mention: "On his own initiative took command of four Colonial soldiers; at their head he was the first to penetrate the Douaumont Fort, and captured four officers and 24 men."

† Thus they supplied 7,500,000 spades, 5,500,000 pickaxes, 960,000 tons of barbed wire, 325 million sacks of earth, etc.

This variety of functions which the Engineer officer may be called upon to carry out, according to the vicissitudes of his career, his status or his abilities, constitutes the charm and the force of this arm. It is impossible for a man worthy of the name not to find one or several branches to suit his taste and his character. There lies the charm. It is also impossible not to find some means of employing the capacity and the temperament of each one to the best advantage; this is the force.

Students of Different Origin.

Let us now see how the instruction given copes with the preparation for these multiple tasks.

The diversity of origin of the students naturally influences the level of studies of each category.

The picked division, that is to say that which receives the highest practical instruction because it is prepared by the highest scientific training, is the *division d'application* (advanced division), which does two years' studies. It is mostly composed of former students of the Polytechnic School. Recruiting, in post-war years, fell off considerably, and was a cause of grave anxiety in the Army, one of the causes being the great needs of industry, which was also obliged to reconstitute its cadres; it was also a cause of anxiety for the Polytechnic School, which could not fulfil its essential mission of providing technical experts for the State. The crisis is now more or less over, and the engagements in the Engineers have fortunately risen these last three years. In 1925, 32 officers; in 1926, 46; and in 1927, 20 passed from the Polytechnic School into the Engineers, and they have nearly all remained in the Army. These figures are higher than those of 1910–13; they are almost sufficient for requirements. The very small deficit is easily made up from the new sources which have become available since the War, firstly from the other great schools, *Centrale, Ponts et Chaussées*—unfortunately in very small numbers—secondly and principally, from certain officers of the reserve who have developed a taste for the Army; finally, those officers who have come from other arms or the ranks, and possess sufficient technical knowledge to follow these higher scientific courses.

Nevertheless, an *Ecole d'application* (advanced school) cannot be a centre where theoretical studies will form the principal training. The instruction is, in fact, directed above all towards the practical side, in order to train officers to be capable forthwith of taking over their duties in the very varied career of an Engineer officer.

To this end, at least one afternoon per week in the winter, the student officers profit from the innumerable resources offered by Paris and its environs for visiting all types of installations and factories which bear upon their studies, from lime kilns, cement works, brickwork, up to the factories for dynamos, pumps, saw-mills,

central heating installations, various laboratories and the geographical service, with its interesting annexe of plans of fortifications in relief, in the Invalides; in the summer they are nearly always absent on visits to the frontiers, fortifications (north-east in the first year, south-east and Toulon in the second year), and the hydro-electrical region of the Alps, the mines and factories of Lorraine, comprising a study of the industrial organization of work and output, wherever this is possible. If we add the numerous topographical surveys and exercises for the defensive organization of the ground, the first rudiments of which they learn in the neighbourhood of Versailles, the more advanced side being carried out in regions favourable for the purpose or during their time in camp, and finally if we take into account the stay of a fortnight which the officers have made each year since 1927 in a regiment (Metz in the first year, Grenoble and Avignon in the second), we see that the training is not only practical and out-of-door, but that, while stimulating the spirit of observation and making them acquainted with the wonderful country which they will have to defend, it is also essentially varied.

The other divisions of officer students comprise both the former probationer officers, who are carrying out their second year of studies as 2nd-Lieutenants, as well as those who have been through the Polytechnic who have chosen one of the government careers which are connected with the Engineers (*Ponts et Chaussées*, Home or Colonial Woods and Forests, and the Post and Telegraph Engineers), or those who, in private business, choose this arm of the service as officers of the Reserve.* They all go through six months' preparation before their six months in a regiment, where they take a command. But nothing could be more homogeneous than this division, composed of young men endowed with a desire for knowledge, keen to learn, and who are on the threshold of life after a long period of school training.

Each of these divisions has a different mentality, due as much to the past training as to the future career which they have chosen. The work is heavy everywhere, for if it is difficult to train an engineer officer in two years, and even then incomplete, but sufficiently prepared to perfect himself in any given speciality, the problem with which we are faced is all the more complicated, when it is a case of a one year's course, based on a slight preliminary training—as, for instance, the six months for the reserve officers—even limiting it to training merely for regimental duty. It will be easy to comprehend that, for an Army which will, above all, be an Army of reserves, it is of capital importance that all these young men, coming from different strata of society, having different temperaments, training and ambitions, should mix together in everyday life. It is one of the most

* The new recruiting law will place the former students of the *Centrale*, *Ponts et Chaussées*, Mines of Paris and Mines of St. Etienne Schools on the same level.

precious privileges of France, thus to be able to draw from all her resources, to avoid the single school, that is to say, the lower levelling.

" The single school would be impotent as regards touching all social *milieux* and attracting the different intelligences," wrote General Debeney. " Recruiting touches all social strata and calls upon all types of mentality ; the aim of professional training is to provide a methodical development of the intellectual flexibility of the race ; the ideal is to draw from the most purely national sources. This Corps of officers is not a caste . . . and herein lies the secret of its force."*

Nevertheless, we must—and this is the antithesis—melt it all down in one melting pot. Now if the exercises and the courses are nearly all separate, there are nevertheless some others which are common, and this is also the case in the daily life, mess, clubs, parades, fêtes, etc., excellent opportunities for creating the *camaraderie* and *esprit de corps* which are the best guarantees of cohesion.

At the moment when the Engineers, both on account of their expansion as well as inadequacy of recruiting, were very below strength, had absorbed officers of other arms which were in excess of establishment, infantry, cavalry, tanks—but especially infantry—technical instruction had to be given to all those who were capable of taking advantage of it. According to their abilities the latter were drafted to the division of those who had passed through the Polytechnic, or to a special division giving training essentially for regimental duties, but very few for the more technical engineer branches. Those who were considered less able were classified as accountant officers, thus relieving the more trained Engineer officers of these duties.

For lack of quarters the officer students have to live in town, at their own expense and without allowances, during the last few years even without a servant. This detail appears trivial, and yet it has a great importance, for the difficulties of everyday life and the expense incurred in keeping domestic servants obliges the Command to-day to be less exacting as regards uniform, accoutrements, and smartness, on account of the early hour of the first exercises ; and this has a disastrous influence on the training of young officers. If they have gold braid on their sleeves it is obviously so that they may appear commanders. Everything should contribute.

The military school is all under one roof. The only difference in *régime* is that all the probationer officers are quartered above their classrooms.

The probationer officers of the " active " army and the probationer administrative officers† are few, chosen from amongst candidates after a competitive examination—the number of whom is steadily

* See the article by General Debeney, " L'Officier," in the *Revue* of 1st May, 1920.

† These probationer administrative officers will no longer exist in 1929 by virtue of the fusion provided for in the new *Loi des cadres*.

decreasing—drawn from a Corps of N.C.O.s who are also decreasing in strength and quality. The new measures taken with regard to re-engagements will no doubt improve these two factors in recruiting. But, owing to a severe training, these future officers, on passing out, are literally different beings to what they were at the time of their admission. The unit commanders declare that they are satisfied with what they receive. It is a just recompense of the trouble taken by the school instructors.

The probationer officers of the reserve—too long a title for the younger generation—quick and hustling—who write and pronounce it E.O.R.—constitute a subject of legitimate pride for the School of Engineers, as also for similar schools. Recruited from the principal technical schools *Centrale, Mines de Saint-Etienne, Arts-et-Métiers, Beaux-Arts, Ponts et Chaussées*, public works, different schools of electricity, etc., after an examination of higher military preparation, or coming from the contingent after a stay in a special platoon also followed by an examination, they form a body of picked officers carefully sifted after a stiff training. Further, it is a custom, in view of possible falling off of numbers, always to name more E.O.R.s to the admission of the school than there will be posts for officers on passing out. Hence an excellent stimulant, which combined with the perfect spirit which reigns amongst these young men, produces a *milieu* particularly favourable to emulation and a wonderful efficiency. A complete transformation is effected between admission and the passing out; the double military and technical knowledge acquired in six months is considerable. Moreover, all instruction is oriented towards the practical side. It may be said that there are hardly any courses, but exercises, mostly out-of-doors, a few indoor, the whole completed by examination on the regulations or the few general subjects which every officer should know.

These reserve officers constitute one of the most interesting elements of our regiments during the six months of service which they carry out on leaving the School. Only one objection arises. What becomes of this knowledge and these rudiments of experience a few years later, when life has removed them far away from the past studies? It is a fact that those who come back with the reservists no longer possess the same assurance, through lack of practice and keeping up with the subjects. Now, the first battles, which will be vital for the future of the country, will in all probability take place about the fifteenth day. At this moment our Army of reserve—in which, moreover, there will no longer be either "active" or reserve since everyone will be mixed up, and officers of the "active" army will be lost in the flood of reserve officers—should already have acquired its whole force.

It is, therefore, indispensable that the latter should keep in touch, not by furnishing lecture halls as audiences with a view to obtaining,

thanks to a certificate of attendance, a free railway warrant, but by preparing for war, by the effort of decision and the habit of command. We must not mislead the issue for reserve officers, who sacrifice a part of their time at the expense of their profession, of their incomes, or their holidays, by making them follow oratory exercises. In war we do not talk, we act.

The taste of the reserve officers for the Army is shown by the number of officers who ask to enter the " active " army. But as it would be undesirable to get in by this way quicker than by the other, it was necessary to place an age limit. Despite this restriction the 20 or 25 annual posts offered are regularly taken, and some candidates have even to be refused. The test has been conclusive and the result gratifying. Those who choose the military career when older and after having tried another profession must in reality have the vocation. This is a very interesting source of recruiting ; a stay of one or two years at the School as officers of the " active " army completes their training.

As a total, about 500 Engineer officers pass through the School annually, both from the " active " army and the Reserve.

These young generations appear less gay, but more mature than their elders, hence equipped with a greater practical sense, more courageous also from the point of view of their matrimonial duties, of which they boldly accept the burdens, thinking that the nation will understand that it should assure them the means.

To stay still is to retrograde. The School progresses in full prosperity. A new jewel was added to its crown in 1926 by the creation of the *Centre d'études tactiques du Génie* (Centre of Engineer Tactical Studies) intended for defining the doctrine of the employment of Engineers in war, and to spread it in the Army, and particularly amongst the Engineer corps itself, where their routine duties often separate the officers too much from their mobilization functions. It receives the battalion commanders of the Engineers, Colonels and Generals of all arms, who are set problems on the organization of ground, destructions, reparations, inter-communications, crossing of water courses, etc., under war conditions such as will be faced by the Engineers or by the commanders called upon to employ them.

The Sapper should explain the possibilities and impossibilities before Commanders of other arms at the service of whom they will always be placed ; this is why he is christened in our Regulations by the somewhat pompous title of " technical adviser." The spirit of discussion, the fruits of work and logic, the defence of personal opinions, the give-and-take, does not always run smoothly. It is a force and it is a weakness ; a force with those who ask to be enlightened, a weakness with those who wish to be obeyed.

As a result of living modestly, rather apart, the Engineers end by

being the only arm unknown in the Army, unknown even by their brother officers, on account of its variety and its complexity. Moreover, from its creation, the centre of tactical studies was immediately sought out. It thus contributed to the breaking down of water-tight compartments and the closer co-operation of different arms. It also receives foreign generals and colonels.

Finally, an advanced course for reserve officers of the Engineers of the Garrison of Paris has just been created at the School of Versailles, taking advantage of its cadres and its resources. The courses and exercises might be extended throughout France, thus permitting outside training.

THE CADRE.

We should be neglecting our duty if we did not say a few words on the Cadre which provides for these various needs. In conformity with the unbroken traditions of the Engineers, inculcated by Vauban and always maintained by his successors, the sapper never spares himself. The work which each one is called upon to carry out must be done: it is done here at the price of endless repetitions, caused by the number of divisions, with the different types of instruction involved in each one according to the scientific standard or the duration of the course.

Eight divisions in 1928, with distinct courses, represented heavy work for the Cadre. About 50 professors and instructors suffice for this task. Their task is indeed extraordinarily hard, and those of them who ensure annually 596 hours of courses, visits, or examinations —in ten working months—without counting correction of work, deserve our respect.

These instructors only remain a few years at the School, after which they either return to regimental duty or some other post. Moreover, each one perfects the courses of his predecessor, being content with merely adding the fruits of his own personal experience. Military work has the great honour of being impersonal and collective. These courses thus constantly polished up and repolished are kept well up-to-date with scientific progress and practical work, without exacting from the officers a work for which they are not always thoroughly trained.

Besides the six principal courses—construction, fortification, employment of weapons in combat, applied science, topography and geology, administration and public law—there are naturally also courses or classes which, although having smaller coefficients, are no less of great importance; modern languages (German, English and Arabic), physical exercises and equitation. For the T.O.E. (Foreign Theatres of War) where nearly all the officers of this arm serve—it is essential that the Engineer officer should know how to ride, carry out reconnaissances, and go through the shops, etc. The annual fête at the School is before all a sporting meeting, and the riding events

of the Sappers are in no way behind the famous Tilting Yard of their artillery comrades at Fontainebleau, although lacking the incomparable background of the forest.

Finally, there is the real military part, that is to say the training for regimental duty, comprising a study of the regulations, the number and variety of which increases each day, even more in the Engineers than elsewhere on account of the complex requirements of modern armies which the Engineers have to satisfy; the Sapper is also obliged to learn the military regulations of other arms in addition to his own technical regulations.

Nearly all this part has to be absorbed in the first six months, since the young officer should be available for mobilization within this period. Some find this a bigger chunk than they can chew. This would be the case particularly for mathematical brains, who, to begin with, are not well prepared for such an effort of pure memory. Fortunately, however, practical exercises—navigation, bridging, destructions, mines, fortifications, telegraphy, various mechanical work, electricity—facilitates this assimilation, hardening and developing the physical body which has often suffered from want of an open-air life. These works are sporting and health giving. It is necessary to arrive at a good balance of brain, physical fitness and character; the brain, by the spirit of accuracy, method, clear-headedness; the physical, by the taste for endurance and physical exercise; the character, by cheerfulness, sense of humour, cultivation of will-power and smartness. Few words, orders, actions. To inspire a taste for action, a task well carried out rather than making a fetish of regulations.

This is essentially the mission of the military instructors, who, on principle, should not leave their "brigades" during the whole of the stay of the latter at the school. The rule is to be very strict with the junior ranks; give latitude, but never to be slack; harden the body and strengthen the character; the Army should be a school of discipline and energy. An increase of discipline is always interpreted by an increase of well-being, and the development of energy by a supplement of force.

Means of Instruction.

As means of instruction, the School has, besides its laboratories, collections, practice ranges, etc., unlimited resources from the industrial centres of Paris, the directors of whom afford every facility for officer students to visit their installations or factories.

They have also, from the military point of view, material from the two Engineer regiments at Versailles. The first Engineer regiment has both all the resources of an old regiment of sapper-miners as well as entirely new workshops amply fitted up quite recently by a battalion of electrical mechanics. The 5th Engineer Regiment of Rail-

ways possesses considerable and very complete yards and docks, at the practice range *des Matelots*; thus the whole railway service can be studied on the spot and in traffic working.

Finally, the battalion of telegraphists of *Mont-Valérien, la Tour Eiffel*, the central establishment of military telegraphy, offers from this standpoint a special aspect of all the elements of instruction, and also gives the young men practical examples of the most recent progress in this branch, in which France has always been the pioneer, thanks to General Ferrié and his collaborators.

From the point of view of bridging alone, the absence of a river at Versailles, the limitation of the resources to a small branch of the Grand Canal of the park, might be disadvantageous, if two courses of a fortnight had not been arranged on the Moselle at Metz and on the Isère at Grenoble, at least for the principal divisions.

Finally, Versailles is a veritable military university where there is an air school, a tank school, a centre of infantry studies, a school for signals and intercommunication, etc.

In a school of this type personal work is naturally limited to the class work. However, at the end of the second year the officer students are called upon to produce, within an average limit of two months, studies of a more personal character, for instance a memorandum on the subject of fortifications, distinct for each one, or a study of permanent fortifications, where the variety of solutions prove that there still exists imagination in our youth, and the finish of the work shows the interest taken by the students.

Examinations at the end of the course are mostly taken away from the School, in the field, for everything of a specially military character, and only bears upon the class-work itself in the exclusively technical subjects.

Officer students pass out from this School "jacks of all trades" but masters of none. The intellectual knowledge given to an officer should permit him to start life and continue to advance along the ways which open up for him; he should not be an end in himself, upon which we can depend by just using him without improving him. The Army and the Engineers, perpetually evolving, have long ago absorbed these principles.

HISTORICAL BUILDINGS.

As regards buildings, the School, which has been increased by a new division each year since 1923, has not been able to increase its accommodation in proportion. The result has been a certain disintegration; the divisions have been distributed over five different points at Versailles without counting the working or exercise grounds. The parent building, where the original Artillery and Engineer military school was situated, is nothing more than the old *Hôtel des bureaux de la guerre* constructed in 1759 on the old site of the royal

kitchen garden under the Belle-Isle Ministry, by the Engineer Berthier, father of the Marshal; it was there that the future Major-General of Napoleon I, himself an engineer officer, was born. At the time of the visit of Louis XV, for its inauguration, the Engineer Berthier, with a view to proving to the King how fireproof this building was, lighted a large wood fire in the interior of a room; no fire resulted, and the King congratulated him. The monumental door, which is classed as an historic monument, is decorated with bas-reliefs, where may be seen fortress plans, gabions, cornucopias picturesquely pouring out officers' crosses and decorations, etc. The School is perpetuating the tradition. The crown which dominates the beautiful doorway in sculptured wood, between the two pillars surmounted by trophies, fortunately was not damaged by the Revolution. On the other hand, a decorative border in the Court, in which to-day the bust of Lazaire Carnot has been let in—an Engineer officer before he became the organizer of victory—has been deprived of its charming bronze panels which represented victories during the reign of Louis XV, as may be ascertained from contemporary engravings; the figure of Victory—modern—which, bending over, crowns the bust of the great Carnot, certainly cannot replace them.

This house is a neighbour—in the best sense of the word—of the former Ministry of Foreign Affairs, to-day a library of the town of Versailles and a most interesting museum on account of the value of the volumes, bindings and collections which are in it. The building is decorated with a splendid doorway and charming interior decorations.

The School was enlarged in 1922 by taking in an annexe in the same street, the former *Hôtel de la surintendence des bâtiments du Roi* (hotel of the department for royal buildings), which was inhabited by the great Mansart and which also served as a depot for the King's pictures, before it was transformed into a small seminary.

The annexes of the other military buildings have no architectural interest, but this cannot be said of the small stables, where the cavalry section of the School, its riding schools, its physical exercise ground, its Artillery museum and its Engineer museum, are accommodated. This forms a splendid *ensemble*, constituting a worthy setting for the Place d'Armes and the courtyard of the Château. Although devoid of decoration, there are undoubtedly no stables in the world to compare with them, solely on account of the perfect lines and art of their proportions; which has been rightly called the essence of architecture. Has ever chance been more providential than that which has thus placed under the eyes of the future military constructors such a model to inspire them with the art of making buildings beautiful without unnecessary decoration? It is well that these young men should absorb this truth so well expressed by Diderot:

"There are no follies which last so long, are so marked, as those which are carried out in stone."

No doubt the Engineer officer would be glad to be relieved of this very thankless task of building barracks, where he is torn asunder between the conflicting requirements of limited resources and very extensive requirements, which keep him far from the command of troops, which is a far more agreeable life. The Minister for War is obviously the only minister who thus possesses his own Corps of Architects. The fact is that the designing of plans and the direction of the workshops is indispensable for the training of officers for their role in war and their service in peace in the colonies or in fortifications. The distinction between civil and military work is often subtle, and it is thus that each year our Engineer regiments carry out public work for the communes, roads, bridges, etc., or for the State, railways, telegraph lines and permanent fortifications, which contribute to their training whilst benefiting the general public. The immense system of 60-cm. railway lines in Morocco was planned, and worked, by the Engineers.* The sapper is before all a constructor and a producer.

How successful he has been, the forts of Verdun are a living witness. Whereas all the foreign works were pierced by German shell, our concrete of Douaumont and Vaux triumphantly defied the largest calibre of the two adversaries, thus affirming the victory, incontestable in the circumstances, of armour over guns.

FUTURE OF THE SCHOOL AND ITS INFLUENCE.

The Military School of Engineers, by developing amongst the officers of the Engineers which it has trained, the spirit of scientific research, initiative, the cult of military duty, even to the point of sacrifice, deserves well of the country. The above mention in Army Orders of 22nd May, 1922, confirmed the services rendered by the School of Versailles during the War.

Engineers have one sole advantage over the majority of the other arms, that is, that their studies and their work, touching almost every branch of applied science, construction, electricity, railways, is obliged to keep up-to-date. An advantage, it is true, but also a disadvantage, for the efficient officers are naturally attracted towards industry, which offers employment no doubt more exacting—despite what is thought—but better remunerated. Therefore, we should respect those who, possessing a great technical knowledge, resist these tempting offers—there are some, and not the least efficient—and follow

* The Engineers even have native units in Northern Africa, in the Soudan, and in the Far East. Far from the mother country, the sapper like all good Frenchmen becomes a politician: but it is railway politics. The result is colonization by steam. In our colonial empire, which is larger than Europe, in this greater France of nearly one hundred million inhabitants, the sapper, after having survived the epic of the war and victory, lays down his weapon to take up the tool. Work is his *raison d'être*, his life.

the military hierarchy and contribute to maintain scientific men in the Army in accordance with its fine tradition.

Moreover, how wrong it would be to wish, as some have attempted, to divorce science from morale; science raises morale; the two complete each other and are not incompatible. Whatever capital importance faith and patriotism have, they do not suffice to level mountains, nor even to repulse the invader. Science and the art of war are still required. Science is represented by our technical arms; art is represented by the command and its staff; the task of the other executants is still sufficiently heavy for us to refuse to compare their merits. The contrary thesis becomes all the more false since all the arms to-day are more or less slaves to technical knowledge. The technical side creates the tactics; the tactical and moral requirements on the other hand impose the technical and material solutions. The two aspects of the problem are intimately connected. It would be a serious error to attempt to divorce one from the other.

The Engineer School fulfils its mission of silently training modest officers having a very high sense of duty and developing their technical knowledge every day of their lives. Devotion to duty is essential, particularly in an arm always called upon to serve others. "To render service" might very well be the device of the Engineers, if other arms were not tempted to rob it later.

Although the Engineers are the least known arm of our Army, it appears on the other hand that foreigners are deeply interested in our studies. The School has, in fact, veritable tentacles abroad; its printed courses are asked for everywhere, and constitute the most effective propaganda, whilst rendering service to our friends; its relations are kept up with Belgium, the Argentine Republic, Poland, Czecho-Slovakia, Roumania, Holland and even Italy.

Each year a few Polish, Roumanians, Esthonians, Finnish, Lithuanians, Greeks, Turks, Peruvians, Chilians, Mexicans, Persians—the latter as officer students, even wearing French uniform—come to receive the extra training and to learn to love France. Although generally older and more senior in rank, they live as good comrades with the young French officers, and the interchange of ideas which results is not the least mutual benefit. When they return to their country they are all warm supporters of French friendship and culture.

The Editor of the *Revue des Deux Mondes*, when kindly giving permission for the reproduction of this article, wrote as follows:—"Son auteur était le Général Normand qui, détail tragique, mourut trois jours après la publication de cet article, en tombant du train qui de Paris le ramenait à Versailles; le Général Normand, jeune encore, était directeur de l'Ecole du Génie dont il parle dans cet article."—EDITOR, *R.E. Journal*

SURVEY IN RELATION TO GUNNERY PROBLEMS IN MOBILE WARFARE.

A Lecture delivered at the S.M.E., Chatham, on October 3rd, 1929, by COLONEL M. N. MACLEOD, D.S.O., M.C.

THOUGH in the title of my lecture Survey and Gunnery are given first place and Mobile Warfare comes last, I think it advisable to start on the tail by defining what I mean by mobile warfare, for there are some people who appear to think that the next war will be composed exclusively of encounter battles between forces travelling at well over the legal speed limit.

I must ask you to imagine my war as starting at the point when these law breakers have collided with one another and have been removed to hospital. The mobility I have in mind takes place principally between battles, and I assume that both sides will be prepared to devote a certain time to the prosaic tasks of finding and fixing the enemy before they commit themselves to the more spectacular work of hitting and being hit.

I propose to take up my tale at the end of the Great War, for the Great War saw very notable developments in the survey line, and when, after about three years of it, the gunner and the surveyor at last achieved a working alliance, they did great things. Indeed, I am prepared to demonstrate to anyone who will come round the corner afterwards that this alliance was the turning point of the War. I will spare you that now.

What I want to do this afternoon is to talk about the future of that alliance, and explain, if I can, what it means to the sapper (*i.e.*, the surveyor), what it means to the gunner, and finally, what it means to the rest of the Army, particularly to the infantry soldier.

Now, survey has always been a very important science to the soldier. Not for a long time past has an Army been able to function without maps. You probably know that it was military requirements which started the Ordnance Survey, and that the only man to whom Napoleon confided his plans was his chief topographer; both significant facts. Nevertheless, I think it is correct to say that the military authorities, at any rate in the past, have regarded the surveyor rather in the light of a necessary evil, a sort of hybrid, half civilian, half reservist, whose job was done entirely in peace-time,

and who, if he went to war at all, should certainly be left at the Base.

At any rate, it is a fact that at the commencement of the Great War all available survey personnel, both officers and men, was immediately withdrawn from survey work and parcelled out to Field and Army Troops Companies, with the result that, as I said before, it took three years for the gunner and the surveyor to arrive at an understanding.

Some people seem to think that the survey developments which took place during the Great War are a normal attribute of siege warfare only, and that with a renewal of mobile conditions the old days will return. I shall try to show you why I think that this is not so, and that the war function of the surveyor was never more vital than it is to-day; that his work influences, or can be made to influence, tactics in a greater degree than ever before, for there have occurred recently, advances in survey technique, which, if we can make use of them, promise to have far-reaching effects on artillery action, and through it on tactical doctrine.

Let us first, then, note this doctrine; it is summed up in Sections 13 and 15, *F.S.R.*, 1924:

Section 13: "The duty of the infantry is to close with the enemy and destroy him."

Section 15: "The role of the artillery is to assist the other arms in breaking down opposition and to afford all possible support to the infantry, with whom the eventual decision rests."

In studying this doctrine, it may occur to some of you to enquire why it is that, although we possess weapons which will kill men, cut wire, blow in trenches, knock out tanks, etc., from miles away, *F.S.R.* still insists on the need for "closing with the enemy" and finds it necessary to say (Section XIII (3)) "fire alone will seldom drive determined troops out of their position." The explanation is, of course, that "fire alone" is not of much use unless it hits the enemy, and in the past it has not always done so. On the other hand, if it does hit the enemy, it will do better than "drive him out of his position": it will lay him dead in it.

When, as in defence, fire can be made to hit the enemy, it does all the destroying that is required. Indeed, the strength of the defensive, which is the outstanding feature of modern war, derives directly from the ability of the defender to do all his fighting by "fire alone," while he prevents his assailants from doing so by hiding himself in a hole in the ground.

It is only when he gets to close quarters that the attacker can compete with such an opponent on equal terms: hence the instructions to spare no effort in getting him there in the best possible fettle.

In conformity with these instructions, we have found it necessary to try a great variety of tactical experiments: open formations, supporting fire, night operations, smoke screens, etc., and finally, tanks, all of which involve an ever-increasing complication, which makes the control of the forces on the battlefield more and more difficult.

There are few people, I think, who would claim that we have yet found, even in the tank, a completely satisfactory solution of this problem; so difficult is it, that one can observe a constant tendency to try and evade its most difficult phases by falling back on the vicious principle of trying to push in the attack by piling up numbers. Witness, for example, the diagrams in *Tank Training* showing four big, square tanks stalking one poor little anti-tank gun, or, again, the tendency to replace one big tank by several little ones, in the hopes of overwhelming the anti-tank defence by rush tactics and weight of numbers. The Great War showed very clearly that, against modern weapons, weight of numbers may be a broken reed and rush tactics mere suicide.

This principle may be all right for Continental nations, who think in terms of conscription and cannon fodder; let us be on our guard against it. In searching for an alternative, let us remember that this deadly close-quarter business would not be necessary at all if our shells and bullets could be made to hit the enemy; in short, before we consider any further complications in the mounting of an attack, let us look carefully into the question of hitting targets and see whether there may not have been defects in our former methods of doing so which made it necessary to send forward crowds of bayonet men to do work, some at least of which might have been done just as effectively by H.E. shells.

When we examine it in this light, we shall see that the pre-war procedure for guiding shells to their destination had some serious defects which made it particularly ineffective under mobile conditions. I think I am right in saying that the pre-war gunner expected to do most of his shooting over open sights, and that when, quite early in the War, he found himself compelled to give this up, he had to improvise a new procedure in rather a hurry.

In the first place, it was necessary for him to see the target, so that its range and direction could be measured: next, this range and direction, measured usually from an O.P., had to be transferred to the gun, which might be some distance away. This was done by a very rough-and-ready calculation and was only intended to be sufficiently accurate to ensure that the first round, when it was fired, would fall near enough to the target to enable it to be observed. If this result was achieved, a correction was passed to the battery, and the correct range and bearing were found by actual shooting, by a system of trial and error.

You can see that if the target was so inconsiderate as to move during this process, it caused no little inconvenience to the battery commander; moreover, there was always the danger that "A" might mistake one of "B's" rounds for his and apply a correction which he might then try to confirm by one of "C's." You can well imagine how difficult it was to work a great concentration of artillery like that for the Battle of the Somme, when several hundred batteries were all trying to range in a limited area at the same time.

I doubt, however, if the mere difficulty of ranging is the worst objection to this system. However skilful the gunner may become in working it, he cannot prevent his target making off or going to ground long before the ranging is finished. To get the best results from artillery fire, particularly in mobile warfare, the very first rounds ought to take effect before the enemy can get away or under cover. In a well-regulated artillery attack, fire should commence not with a single round, but with a concentration, and the enemy should never have a chance to know what it was that hit him.

This is where the surveyor steps in, for the effectiveness of the surprise bombardment depends on three things.

(1) The exact range and direction of the "target" must be known.
(2) The gun must be laid in this direction with an accuracy commensurate with its performance.
(3) The prevailing meteorological conditions and their effect on the performance of the gun must be known.

The last is a gunnery matter with which I will not deal beyond saying that it is a problem definitely capable of solution, but the first two are essentially survey problems in which the chief thing to be considered is the standard of accuracy required.

Now, the 100 % zone of the field gun at ordinary ranges is an ellipse about 100 yards long and 10-20 yards wide. If the target is considered as a point and the elements are determined in such a way that they lead to greater errors of "laying" than this, no shell can possibly hit, however many rounds are fired. The shape of the zone shows also that errors in "line" (*i.e.*, direction) are much more destructive to the best performance of the piece than errors in range.

The determination of line and range reduces in practice to the determination of the positions and heights of gun and target and is complicated by the fact that the most important targets cannot generally be seen from the front at all; *e.g.*, hostile batteries, concealed machine guns, and columns of troops marching into position. As to the latter, obviously from the gunner's point of view the time to catch them is while they are in concentrated formation; troops make the best artillery "target" before they deploy and not after. This they always do behind cover, hence whether guns fire from tanks or from the ground (a point I shall come back to later), if the artillery

want to kill the enemy and not merely support the infantry, it must attach special importance to *indirect* fire at targets which cannot normally be seen except from the air. How is such a target to be located within the limits of 20 yards or so given above ?*

I see only one way, and that is by aerial observation aided by a map on which the airmen can pinpoint the target accurately enough by direct reference to map detail. What sort of a map does this imply ? Will the 1" map which we use in England serve this purpose ? Certainly not ; because, apart from all questions of accuracy, it does not show enough detail to enable a target to be pinpointed in this way, and we cannot measure on it distances so small as 20 yards. The artillery are agreed that the smallest scale on which this sort of thing can be done is about 1/25,000, which is nearly three times as large.

Nor are things very different in respect to hostile batteries using indirect fire. I do not see how we can possibly attack these except on the basis of location from the air. In France, it is true, we made use of flash spotting and sound ranging for locating hostile batteries, and got good value from them, but flash spotting only functions at night, while both—more particularly sound ranging—are difficult to work in mobile warfare, and neither can fix the height of the target, which is one of the elements of the problem. Hence we are again brought back to a complete dependence on the map, for the airman, though he may be able to range a battery on to such a target, cannot give a location accurately enough for unranged fire except with the assistance of a detailed map.

Lastly, we come to the concealed machine-gun. This is *the* great conundrum which has exercised military minds for the last 15 years. How is the concealed machine-gun to be engaged ? Officially there are two main "solutions"—the "accompanying gun" and the "tank." I will deal with these in turn.

The idea of the first is that, if you can bring a gun up near the attacking infantry, it will act as a sort of "big brother" to them, and when the infantry are held up by machine-gun fire they can turn round and shout for help and "big brother" will somehow or other step forward and clear the way. Everyone who has tried to work out schemes involving "close support" of this kind knows that this solution fairly bristles with difficulties ; for one thing "big brother" in order to keep near the infantry at all has to become a very "little brother," and unless he is in a tank he has to halt and unlimber before he can fire, hence he must get left behind if the attack is to get on, and if he gets left behind, how is he to know what to shoot at next ?

* *N.B.*—It may be as well to state here that the gunner does not usually think in terms of anything less than a section of two guns, so that these limits of error may perhaps legitimately be doubled. This does not alter the fact that a small target like a machine gun will be missed by one or other of two guns laying down shells on a 40-yard front.

When you work it out you always find that " close support " from any kind of gun involves :—

(1) location by the leading troops of the machine-gun which is holding them up ;
(2) passing this information back to " big brother " ; and
(3) effective action by " big brother."

If the target has to be pointed out and then ranged on or engaged by direct fire, one round of smoke in the right place will stop the whole performance, and one can see endless possibilities of difficulty, delay and failure. If, on the other hand, it can be located at all, the gun should be able to hit it more easily and more quickly from the comparative safety of the artillery zone further back. Moreover, in this case, support can be given by any or all available pieces without the same restrictions of size or ammunition expenditure.

Now, what about the " tank " ? Many people seem to think the tank provides a complete solution, at any rate on ground over which tanks can operate.

I think so, too, as long as it is only machine-guns against which the tank has to operate ; but if the enemy, as he certainly will, brings up anti-tank guns and hides them in the infantry position, then we are up against the old problem in a slightly different form, and instead of foot soldier *versus* machine gun we have tank *versus* anti-tank gun.

Bitter experience tells us that in this contest the foot soldier always comes off second best ; all he can do is to go to ground and call for " big brother." Analogy indicates that the tank will fare no better if as well, for though he moves faster he is bigger to hit, harder to hide, and cannot go to ground.

I think it is now generally conceded that against a properly organized defence the tank cannot hope to succeed without artillery support, but some optimists seem to think that this support can be given by artillery tanks trekking along close behind the infantry variety. I am afraid I am not one of them, because I think that the tactics of the defence will be to hold its fire until the tank attack is committed beyond recall, and that it will be able, owing to the more advantageous conditions under which it fires, to overwhelm attacking tanks before they can retaliate at all.

I notice in many recent writings on tank warfare (and not excepting official documents) that it is usually assumed that the tank will have a target to shoot at and will be able to return the fire aimed at it. I think this is asking a good deal. The whole difficulty in this matter, as I see it, is that the attacker, whether infantryman or tank, either never gets a clear target to shoot at (particularly if he has enveloped the position in smoke), or, if he can see the target, has to shoot at it

himself with a flat-trajectory weapon which, as we know, has very little effect against well-entrenched troops.

The best " close support " against entrenched troops is that given by a high angle fire. This being the case, I do not see how satisfactory solutions of the " close support " problem can be found except on one or other of two bases—either the attack must go forward, as it did in France, under cover of a barrage, aimed at nothing in particular, or everything in general, whichever way you like to look at it, or else the attackers must discover some way of locating the positions of their opponents and of passing this information back, so that they can concentrate their available artillery fire on these places.

As to the barrage system, it has been tried in France, and it will work, and work well, if you have enough guns and ammunition, but it requires prodigious amounts of both, much of which is not only entirely wasted, but sometimes, as we know, actually creates spare defences and obstacles for the protection of the enemy. On the other hand, if you can locate the enemy correctly and can concentrate your fire on him, there should be far less waste of ammunition and should sometimes be no necessity to send the infantry against him at all, for a concentration of artillery, if sudden enough and accurate enough, will do all the " destroying " that is necessary.

Is it possible to locate the enemy well enough for this ? To answer this I feel inclined to quote the man who was asked if he could play the violin and replied, " I don't know, I have never tried." I can, however, say this, that the location of anything on the earth's surface is a survey problem, and if the surveyor can find a solution of this one, he has paved the way towards a tactic which seems to me to offer much greater chances of success than any which has yet been suggested, armour plate notwithstanding. In my opinion then the first step towards the solution of the " close support " problem is the provision of an accurate map, on which every relevant detail of the landscape is shown. We must not be content to show only roads, railways and the things we are at present accustomed to ; in many places they do not exist. We must, if necessary, add rocks, bushes and anything and everything sufficiently prominent and easily identifiable, so that the moment the enemy discloses his position by opening fire, he can be marked down by reference to the nearest feature shown on the map.

This I regard as the surveyor's first task—to provide the troops with a map, or maps, one of the functions of which is to enable targets to be located. I will now pass on to the assistance he can give in the matter of hitting these targets.

Assuming that the target has been successfully located, the next thing to do is to fix the gun. Unless we insist on pushing it up alongside the infantry and keeping it constantly on the move, this is relatively an easy matter. We may use a map here also, or, if not pressed

for time, we may resect, traverse, or triangulate. Fixing the gun is a straightforward survey problem susceptible to a variety of solutions, of which a trained surveyor may be trusted to select that best suited to the circumstances of the case.

Knowing the position and heights of gun and target, the line and range can be calculated. This, again, is a straightforward business about which all I need say is that the calculation is simplified and much expedited if the positions are defined by plane rectangular co-ordinates; and that, as the application of plane co-ordinates on the curved surface of the earth is only permissible within certain limits and must be done in certain systematic ways, the surveyor who devises these ways and defines these limits must have an exact knowledge of the shape of this surface and of the methods of representing it on a flat plane. He is thus, much against his will, brought into contact with those thorny subjects, geodesy and map projections, which the ordinary R.E. officer views with such alarm and despondency.

Having then calculated line and range, the last step is to lay the gun in the required line. Here it is necessary to watch the accuracy rather closely. An angular error in pointing the gun of only 8′ will, at 5,000 yards, throw the 100 % zone (only 12 or so yards wide) right off the target, and although we may make some allowance for the burst of the shell, it is clearly preferable to get the target in the centre of the zone rather than on the edge of, or actually outside it. In practice we do not want to allow errors greater than 5′. The gun, as you probably know, is laid by means of a dial sight (a sort of crude theodolite, of which the gun forms the lower plate), and an aiming point. The gunner puts on the sight the angle between the bearing of the aiming point and the calculated bearing of the target and lays the telescope of the sight on the former.

The laying of the gun depends, therefore, on the correctness of the accepted bearing of the aiming point, and if the position assigned to the gun is used for calculating this, obviously the aiming point must be at least as far off, and preferably further off, than is the target, for any error in position will cause an error in bearing inversely proportional to the distance of the object.

Guns, however, are usually placed in valleys and places from which aiming points 5,000 or more yards distant cannot be seen. Hence the positional error which is permissible in fixing the gun must be kept out of the business of laying it, and we must give line in a different and more accurate way. This means, in practice, that the laying of the gun must be carried out on a trigonometrical rather than a graphical basis, and the second task of the surveyor is consequently to provide a trigonometrical control which will serve the double purposes of the map-maker and the gun-layer.

Having now explained what the surveyor has to do and what his

work is for, I will go on to deal with some technical aspects of these tasks.

As my lecture has been concerned with gunnery, I have so far made no mention of what may be called the ordinary maps required to plan the campaign or to guide the army to the battlefield. These are old and well-recognized survey tasks which have lost none of their importance. The great area of theatres of war in which modern armies may have to operate compels us to use small scale maps for the manœuvre and march periods before battle is joined, and we have, therefore, to legislate for three distinct kinds of map :—

(*a*) Small scale for strategical and general use.
(*b*) Medium scale for march and manœuvre.
(*c*) Large scale for battle.

Maps of category (*a*) are required only by Commanders of units and formations and by the staff. A few sheets will cover the largest theatre of war. Category (*b*) must be issued more freely because, although it is used chiefly while troops are moving in formed bodies, it is necessary to allow for unforeseen deployment. Category (*c*) is only wanted for a stand-up fight.

This is where the new survey technique, which I referred to at the beginning of my lecture, comes in. Such maps are not to be found everywhere—indeed they are the exception rather than the rule—but thanks to the developments in aerial photographic surveying we can now undertake to produce what maps we require almost anywhere, in a time which definitely makes them a practical proposition in all cases where there is sufficient knowledge of the situation to get the area photographed from the air at least twelve hours in advance.

I have no time, nor, I think, is it necessary for me to go into any technical details here, but I must make a few remarks on the question of photography.

To map in the way I have mentioned, it is absolutely essential that the photographs should be taken vertically downwards in long straight flights with a uniform overlap and from a fixed height. As this type of flying is particularly liable to interruption and interference by enemy action and by weather, we would be very ill advised to wait until we have bumped into a position or arrived in any area before we did anything about getting it photographed.

It will have to be the business of the General Staff and the Royal Air Force to see that the photography is kept well ahead of immediate requirements. Once the area has been photographed in strips, there is no further necessity for this dangerous type of flying ; defences and any other details which appear on the ground subsequently can be added very easily from any kind of air photo.

Air photography is, of course, only the data from which the map is afterwards prepared, and I think it well to remind you before leaving

the subject that it is not a substitute for a map. An air photo shows neither heights nor contours, and is subject to a variety of distortions which may make it impossible to derive the required information from it without the aid of special apparatus and special training. In the hands of the inexpert man, the air photo without a map is nothing more than a snare and a delusion.

The preparation of maps is the job of the Field Survey Companies, R.E. Hitherto the map-maker has been given a pretty free hand in issuing to the troops whatever sort of map he thought best.

If my conjectures are correct and the soldier is going to use the map to help him mark down the enemy and fight him, it seems to me that the man who makes the maps must be in constant, close, and direct touch with the man who fights.

He has got to judge what can be done in the time available, for time will always be a limiting factor, what can be omitted without compromising methods of fighting, and what can be added to simplify and improve them.

He must work as close up to the front as circumstances permit, for not the least difficult of the problems he will have to solve is that of getting his products hot from the press up to the fighting line.

Remember that in war the face of the country changes very quickly and very often. A map may be out of date in some vital respect almost before it is printed. The type of map I have described, in particular, would require constant renewal, there is never going to be time to send it back even to the base to be printed; even from Army H.Q., where they will most probably be prepared, the problem of getting new editions out to the fighting line, where they are to be used, and preventing the old ones falling into the hands of the enemy (who would probably give a lot for them) is one which will only be solved with the intelligent co-operation of all ranks.

I do not anticipate any particular difficulty about producing the maps. Printing machines have been mounted in lorries, and it should be possible to design equipment which can be taken pretty well anywhere where a modern army can go and which could turn out maps at almost any desired rate.

Now as to the other half of the survey task, the provision of the trigonometrical control. Here again, we have a specialized problem. In civil practice, the triangulator can generally manage to reconnoitre his ground and to select and beacon his points before he starts observing. The military triangulator, on the other hand, has to try and fix his points, if he can, before he arrives on the ground. In a few cases the points may exist beforehand and he can do any additional work he requires by resection. More often he will have to fix points on ahead by observations from stations he has established himself. Sometimes he can perhaps get along by finding stations or erecting beacons so conspicuous that resection can be done from them for a

considerable distance on ahead. Most frequently of all, perhaps, some gunners will arrive on the ground before him and will carry out small local surveys of their own, which he must connect up and incorporate as quickly as possible in the main triangulation system which he brings forward. All this will have to be done against the clock.

Time will not allow me to discuss the problem in detail. Admittedly, it is no easy one, but I see no reason to doubt that we shall be able to find a satisfactory solution.

Those, however, who think that the military surveyor of the future is going to be a gentleman who spends all his time in a comfortable office somewhere in the back areas, directing the efforts of a lot of C.3 draughtsmen, are sadly wide of the mark. The task of providing a trigonometrical control whenever it is required is likely to take the surveyor into the very forefront of battle, and as many people will be waiting for the results of his work without perhaps troubling to understand the details of it, I foresee that he will lead a strenuous life. This, of course, need not alarm us unduly, for it will certainly be an interesting one.

In conclusion, I would like to add a few more words on the tactical aspect of the surveyor's work, how I think it might be used to the best advantage in future, and some facts as to the results achieved by using it in the past.

I advocate, as you see, a survey-brand warfare in which, in attack, the artillery might be asked to take a direct and considerable share in the " destroying " of the enemy, and in which, at any rate at certain stages of the attack, the infantry might be asked to give " all possible support " to the artillery by trying to discover where the enemy is, by marking him down, and preventing him running away. In principle, the defence should first be " drawn " and then, with as little delay as possible, as much of it as can be located should be crushed by a concentration of artillery fire before it can move. The defence in its turn should be concerned to see that it does not disclose itself prematurely and should try to reserve its fire until it can be delivered with decisive effect. I imagine that the defender is quite safe as long as he lies 'doggo,' especially against tanks who use direct fire and can hardly carry enough ammunition to shoot up every likely hiding place on the chance of its holding a hostile gun. He can, moreover, when suitably armed, rely on stopping the fiercest unsupported rush, in quite a short distance.

I know that many people will say this kind of attack is a counsel of perfection. Experienced gunners will tell you that this is asking too much of the artillery. In reply to these I would like to say that you never know what you can do until you try. Hitherto, the gunner has not been asked to do more than support, and I have actually heard responsible artillery officers extolling the virtues of inaccuracy because of the " scatter-gun " effect thereby produced. If they are

asked to get down seriously to the job of "destroying" the enemy, I believe it will be found that they can do far more than they now believe to be possible. I remember only five years ago how few senior R.A. officers would admit that artillery could be worked on a survey basis in any form of mobile warfare, yet after the last manœuvres the C.R.A. of the 3rd Division is reported to have described the artillery survey work done there as the greatest advance in the employment of artillery for three generations. If he can say that of tactics based on a distinctly shaky technical foundation, I don't think we should despair too soon of the results which can be achieved when the technical foundation is well and truly laid. My own opinion is that the artillery attack, if we can deliver it in the form of very sudden, very accurate, and very intense concentrations, coming as it will from an unseen foe, will prove more destructive and infinitely more demoralizing than the fiercest and fastest charge of cavalry, infantry, or tanks, that we can hope to deliver under modern conditions.

I do not say that it is going to be easy to operate in this way, there are a whole host of problems to be worked out and difficulties, both technical and other, to be overcome which I have not time to discuss here. It is with the technical problems that the Corps is primarily concerned. It is on the skill with which the technical foundation is laid that the success or otherwise of the tactical superstructure will depend, and I suggest that the problems I have described are worthy of the best brains we can give to them.

In essentials, the tactics I have outlined are little more than an extension of those used with such uniform success during the concluding stages of the Great War. Compare, for example, the Somme or Passchendaele, with their fearful losses and insignificant gains, when the artillery bombardment was designed only to clear the way for an infantry rush, with an operation such as that of the 8th August, 1918, when the whole attack was built up round a surprise artillery barrage based on maps and surveys.

Let me, however, end with a word of caution. The survey we have to develop is a specialized science, adapted and again adapted to the changing requirements and conditions of warfare. The military surveyor, if he is to make good, must, I think more than almost any branch of the Corps, keep in the closest touch with both the military and technical aspects of his calling. He must, in short, be a first class surveyor and a first class soldier. How to ensure this is beyond the scope of this lecture, but if I cannot promise that all of you young officers here who may be attracted to the survey line of business will finally end your careers as Generals, I can at least promise that you will find it a subject of absorbing interest and of high and increasing military value.

A SUGGESTION BASED ON THE OFFICIAL HANDBOOK ON MECHANIZATION.

By BT. LIEUT.-COLONEL G. LE Q. MARTEL, D.S.O., M.C., *p.s.c.*, R.E.

THE handbook on mechanization which has recently been issued has been welcomed by everyone. It contains much valuable data on mechanization generally and provides a common basis for discussion; at the same time, it is in no way dictatorial, and leaves many aspects of the case open. It is therefore proposed in these notes to give the outline of a suggestion for an ideal small professional army, of the type which we might be able to afford and construct in perhaps five years' time and use in most parts of the world. It is based on this book, but as many of the vehicles referred to are only in a very early stage of development, some minor deviations are made in their organization and the work which they are considered capable of.

We will take the case of an army consisting of three infantry divisions and one cavalry division and some Corps or Army Troops, and we will make the following assumptions as regards their organization and the capabilities of their mechanical vehicles.

The first assumption is that the armoured machine-gun carrier is a vehicle with armour in front capable of resisting any S.A.A. armour-piercing bullets, and that the side armour will resist them up to 45° angle of impact. The machine is low and inconspicuous and capable of traversing any natural country with ordinary ditches and hedges, and has a maximum speed of ten miles an hour. As it is short, it is not steady enough to produce accurate fire on the move, but it can sprinkle the ground in front, and can halt momentarily behind any small mound or in a depression, and produce accurate machine-gun fire. It does not possess a revolving turret for all-round fire, but it can fire 15° on either side of straight ahead with its Vickers machine-gun, and it is a comparatively cheap machine, made largely from commercial parts, and can be replaced in war fairly quickly. It has a crew of two, and the remainder of the machine-gun crew march in rear. It is assumed that these armoured carriers, when used in sections of four, can definitely assault enemy machine-guns in open or semi-open warfare, assisted, of course, by the usual covering fire. Each infantry battalion possesses sixteen of these carriers, and in defence some of these guns can be dismounted and used on the ground, keeping the remainder mounted for use with counter attacks. The dismounted guns would be joined by the remainder of the machine-gun crew, and in the case of the mounted

guns the spare numbers in the crew would serve as reliefs and to assist at times in mechanical maintenance.

The second assumption is that of the three divisions, one division has its first line transport entirely mechanized and all men who normally march are carried in lorries. This division has one light tank battalion as divisional cavalry.

The third assumption is that the cavalry division consists of two light armoured brigades and one cavalry brigade. The light armoured brigade consists of three light tank battalions, each with its 50 light tanks. As opposed to the armoured carrier, the light tank has a maximum speed of 30 miles an hour, it has a revolving turret containing one Vickers machine-gun, and can shoot more steadily on the move. It is assumed that it has a crew of two and is proof at all ranges in front from S.A.A. armour-piercing bullets and proof on the sides from the same bullet at anything except short-range normal impact. As regards artillery, each light armoured brigade has 24 close support tanks, organized in a suitable unit. These take the form of 3-pounder guns mounted on a track vehicle and provided with a shield giving the same protection from the front and flanks as the light tank. It can thus advance and give very close support to the light tanks. The Cavalry Brigade is normal, but is supported by a mechanized 3·7-inch howitzer battery. The cavalry divisional troops include a brigade of mechanized field artillery and a mechanized field squadron R.E., and an armoured cavalry regiment.

The Corps or Army Troops contain two medium tank battalions, and also medium and heavy artillery.

We thus have an army organized in a simple manner into three types of formation. The cavalry division form the mobile troops, corresponding to the light cavalry in the past. The remainder are combat troops, but, of these, one division is mechanized so that it has at least double the mobility of a normal formation, and as it is in addition just as capable of hard hitting as a normal formation, it may be compared in some degree to the heavy cavalry who were used for the main flank attack in the past. Lastly, there are the army troops in the form of medium tank battalions and heavy artillery, which are not required in the opening phases of the war. We can now consider the employment of this army in a normal form of warfare.

The mobile troops advance to obtain touch with the enemy, sending armoured cars a long way ahead for this purpose, and working in co-operation with the air force. The enemy may be advancing in two, three, or more columns, and on his dispositions will depend the dispositions of our cavalry division. As information comes in, the commander forms his plan. He may decide to hold off one column while he strikes another column, but whatever plan he forms he must keep two points in mind. The first is that the light armoured brigades in the cavalry division are capable of controlling the enemy

to a considerable extent, and making him conform to his wishes, but only if the ground is suitable to their employment. The second point is that he must endeavour so to control the operations that the main battle occurs on ground that is suitable to himself, or he will obtain little value from his mechanical vehicles when the combat troops meet. We will assume that one particular column of the enemy is advancing in strength, and that one light brigade is detailed to delay the advance of that column in order that our combat troops may meet it in the most favourable manner, and further that the brigade is instructed to weaken and harass this enemy column as far as possible. This task should not have been given to a light armoured brigade if the ground is very broken or densely wooded, but if the ground is at all suitable no task would be more suitable. On the march, the main column is defenceless against sudden attacks by light tanks. Hence they will have to put out flank guards, as well as advance guards and rear guards, and they will have to move from position to position, because they are also comparatively defenceless on the move. Hence the speed of the column will be at least halved, and the provision of so many protective troops is most exhausting. In addition, if the enemy leaves an important point such as a bridge on his line of communications unguarded or insufficiently guarded, it is a simple matter for a unit such as a light tank company accompanied by some sappers to destroy this bridge. Hence the enemy will have to leave many detachments to guard these points. There is, therefore, every chance that the commander will be able to use his cavalry division to control the advance of the enemy columns so that they conform to his plan, and that one or more main columns may arrive partially exhausted and denuded of many valuable detachments, and that the main battle will take place on ground suitable to himself. To carry out this work, little more than light tanks are needed on ground that is suitable to their use; they do not need to be accompanied by very much artillery, because their policy will be to avoid striking the enemy at a point where he has taken up a position and established his anti-tank weapons in defence. If the enemy does not do this, but continues on the march, he can be safely attacked; if he does do this, the light brigade have achieved their result by the delay that they have caused, and there should be plenty of opportunities for short, sharp, but decisive actions by the light tanks against weak detachments or columns, unless the enemy definitely stops and refuses to move, and thus loses all initiative.

This action on the part of the light brigades would, however, produce counter-action on the part of the enemy, and although—as will be shown later—it is far easier for us to produce armoured forces than a nation with a conscript army, yet they would certainly produce something in the nature of mobile armoured anti-tank weapons. Hence the light brigades require the close support tanks

with their shielded 3-pr. guns. These machines would not be capable of assaulting in and among the enemy by themselves like medium tanks, but this does not appear to be necessary in this case; they could, however, follow immediately behind the light tanks and deal with any enemy tanks that appeared in small numbers, or with armoured anti-tank weapons; the light tanks can protect themselves against everything else in this type of work.

So far, we have considered the action of the mobile troops ahead of the main bodies or combat troops, and we have seen that their action may have a decisive result on the course of the campaign. We will now consider the action when the combat troops meet in battle. Our combat troops may have advanced in two or three or more columns; they may have been directed on one or more main enemy columns, but it is suggested that the same principle for the employment of the combat troops applies in each case, if the maximum value is to be obtained from the mechanical vehicles. In the first place, there may be a temptation to send the mobile portion of the combat troops (the mechanized division) on ahead to strike the enemy ahead of the main body. Although this might be very effective under some circumstances, it is suggested that this is wrong in principle; there is little value in giving the enemy a hard but indecisive blow if the main body is too far away to profit by the result. Hence the commander should keep this mobile portion of his combat troops in hand; they should march either on the flank or in rear of the columns of the normal formations. The first stage is, therefore, the contact between the infantry in the normal formations and the enemy combat troops, and the commander must endeavour to close with the enemy and pin him to the ground under conditions suitable to himself. The main point is that the ground on one flank or the other must be suitable for the delivery of a sudden attack by the mobile portion of the combat troops. The second stage is, therefore, the launching of the mechanized infantry formation on this turning movement. As their lorries are unarmoured they require protection during this movement, and this is provided by the light tank battalion belonging to this division or a portion of this battalion. These troops cannot move under these conditions with great rapidity; the necessity for providing for their protection takes time, and they have to dismount from their lorries and deploy some way back from the front, but they can nevertheless accomplish this movement two or three times as fast as a normal formation.

Wider still on the flank comes the cavalry division or a portion of this division. Some of them have already been in contact with the enemy during his advance. They now take part in this turning movement on the outer flank. If they strike a flank which is weakly held, they advance and so assist the advance of the mechanized infantry. If they find the flank securely held, they go further round. The enemy cannot possibly allow these mobile troops to go right

round and attack his gun positions from the rear, and will be forced to extend his flank, and this at the same time as he is being hard pressed by the normal formations in front and the mechanized infantry in flank. But there are limits to the extent to which he can extend his flank, which will eventually break, and he will be overrun or forced to withdraw, pursued by the mobile troops.

Finally, we come to the stage where the enemy has had time to prepare fairly elaborate defences, and has secured his flanks in some manner. This case is fully dealt with in existing manuals, and needs little alteration as the result of the recent developments and thought. The light tanks would probably be unable to cross the obstacles, which would have been created by the enemy, and the medium tanks come into their own and lead the assault. If our reasoning has been correct, it may be that few or none of these medium tanks will have been required up to this stage, and that the medium tank can be kept back and brought up like heavy artillery for the main battle only. If this proves to be the case, it will solve many administrative and mechanical problems connected with these machines.

The above is a very brief outline of a simple organization which might reasonably be expected to work as indicated. It is in no way intended as the final solution at which we should aim in the more distant future; in fact, the mechanical vehicles which are proposed are all within sight, although some of them need several years for development. The proposals as regards the mobile troops are not particularly controversial, but there are many alternatives as to the way in which mechanized vehicles can assist the combat troops, when the main armies first come to grips. A medium armoured brigade which consists essentially of two light tank battalions and one medium tank battalion could have been used instead of the mechanized infantry on the flanks. It is likely, however, that the enemy will secure his flanks as far as possible with anti-tank weapons, and he may have these in considerable numbers. Tanks and especially medium tanks are very expensive, and will not be easily replaced in the early stages of a war. It is true that the medium tank is a less unsteady gun platform, and can produce a considerable volume of fire, but the control of this fire among the smoke, noise and uncertainty which exists in the front line presents many difficulties. Hence, there will be an inclination to let these more mobile arms seek the extremities of the flanks and work round, rather than assault the positions where anti-tank weapons exist. For this work light tanks alone are sufficient, and we used over-mobile troops for this work, backing up the light tanks by a close support gun, which is a much less elaborate and expensive vehicle than the medium tank. If one is looking further ahead than the present or immediate future, it would seem that there may be more scope for an increased number of improved armoured machine-gun carriers as the substitute for the mechanized infantry used as the flank attack. They may have heavy

armour in front and protect their flanks by manœuvre and fire, and if used in large numbers on suitable ground it will take a very good anti-tank defence to resist them; these views have already been expressed by the author in several journals some years ago, but they dealt with the future, while we are now dealing with the present or immediate future.

In all these discussions the case has been considered more from the point of view of our army possessing a reasonable proportion of these fighting vehicles against an enemy possessing fewer of them and few or no armoured formations. This is reasonable enough, as there is little chance of our meeting such opposition in our small wars, and any conscript army that we might meet in a great war is very handicapped compared with ourselves in the production of armoured formations. With us, we can create very large savings by comparatively small reductions in strength, because our pay bill is a large one, and it is largely by this means that we have been able to make such headway in the production and provision of these mechanical vehicles. Not so with a conscript army.

The supply problem is one that has not so far been referred to, and it is too big a problem to enter into here in any detail. That there are considerable administrative difficulties connected with the use of armoured fighting vehicles is obvious; it is possible, however, that we may find the supply problem less serious than it appears to be at first sight. The most alarming figures were produced for the requirements of the old armoured force, and this gave rise to the idea that the supply problem alone would throttle any extension to the mobility of armoured forces. It should, however, be remembered that this armoured force was a mixture of combat troops and mobile troops, and that the combat troops, which should not form part of the mobile troops at all, consumed over three-quarters of the petrol required by the force. A medium tank will probably be found to consume six times as much petrol and oil as a light tank. If, therefore, we restrict the mobile troops to the lighter type of fighting vehicle, the supply problem assumes reasonable proportions. For instance, four 30-cwt. lorries will probably be found sufficient to carry the petrol and oil required by a light tank battalion for 100 miles. The heavy types such as the medium tanks require considerable supplies of every kind, but if they are marching with or near the main bodies the problem of supply is not so difficult.

In conclusion, the author would like to make it clear that no part of this paper is written in a spirit of criticism. The subject is one in which no one can see more than a very short distance ahead. In any case, when it is remembered that we were the first army to produce an armoured force for trial, and are again the first army to be in a position to produce a practical handbook based partly on field trials, there is little room for criticism, and this advanced state of progress appears likely to continue for many years.

THE MECHANICS OF "MECHANIZATION."

By VICTOR WALLACE GERMAINS.

"The War has proved that an adequate provision of fire-power is the best antidote to heavy casualty lists."—MAJOR BROOK, "Evolution of Artillery in the Great War," *R.A. Journal*, Jan., 1929.

"The best protection against the enemy's fire is the fire of our own guns."—FARRAGUT.

THE mechanization of our Army continues to excite popular interest and enthusiasm, but the mechanics of the problem are too often lost to sight. The power developed by an engine is no more *unlimited* than is the muscle-power of men or horses; there enter considerations as to the ratio of horse-power to weight, of fuel-consumption to energy produced, and of the transmission of energy into work done. In its fundament it is an engineer's problem, but it is more than an engineer's problem, for such factors as terrain, the interaction of arms and services, must be taken into account. Thus it is a problem which is complex and many-sided, which calls for team-work between the soldier and the engineer, and one must be cautious as to how one accepts hasty generalizations of the type popular in the Press.

What is popularly termed mechanization is in reality *vehicularization*. The essence of the thing is the mechanically-propelled vehicle. The gun, rifle, or machine-gun are all just as much machines as the armoured car or tank. And in the strategic sense vehicularization is not new, but very old. Apart from the classic instance of Napoleon, who in his campaign of 1814 mounted infantry on carts to get increased mobility, the use of railways and road-lorries for supply-services and strategic movement was well understood before 1914; armoured trains and armoured cars represented a tactical application of *vehicularization*. The use of wagon-laagers by John Ziska in the Hussite Wars, and by settlers in the Western States of U.S.A., against attacks by Indians, are familiar to every schoolboy. Similar instances occurred in S. Africa. The classical chariot with its scythe-armed wheels was a very early development of the cross-country fighting vehicle, and must have been an awkward antagonist for infantry armed with bows and arrows, spears or slings. The mechanically-propelled cross-country fighting vehicle is a modern development of a very old principle, and fire in movement whether from chariots, Kentucky rangers at the Battle of the Thames in the

war of 1812, or by Boer mounted riflemen, has been used successfully in many periods of history.

"Mechanization" at the present time may be divided into two headings, *strategic* and *tactical*. The first is a matter mainly of rapid transport of troops, guns and stores by means of motor-lorries or motor-traction, and includes supply services for an army. The second is a matter of the *fighting vehicle* in the form of armoured cars, tanks, or self-propelled guns. Here again we must distinguish between what are primarily road vehicles and those which are primarily cross-country vehicles. All vehicles use roads for approach-marches, but the armoured car, except under limited conditions, is tied down to roads; the tank, however, possesses the power to manœuvre off the roads, save when she encounters forests, deep streams, swamps, hills, etc. Thus even the tank is limited to favourable terrain, and the armoured car even more so.

Between tank proper and armoured car proper we have various compromise types; semi-tracked vehicles, six-wheelers, etc., but these all suffer, in a more or less degree, from being neither flesh, fowl nor good red herring. The semi-tracked vehicle has neither the mobility across country of the genuine tank nor the speed of the genuine armoured car. The six-wheeler, perhaps the most successful "compromise" produced to-day, has not alone a very limited efficiency "across country," but the pneumatic tyres can be riddled even by an ordinary infantry rifle. Various experiments are being made to overcome this: mail-shirting, self-filling or semi-solid tyres, etc. It is, however, so easy to devise a bullet to counter *any* form of protection that the tyres will always remain a vulnerable element in such cars.

"Mechanization" is at present in a very fluid state; there is such a medley of types of vehicles, and these are all so obviously destined quickly to be superseded that it would be profitless to discuss them. It seems wiser to confine ourselves to certain problems common to all and which are likely to present permanent factors. Whatever the distinction in design and purpose between *Lord Nelson*, *Mauretania*, the tramp steamer, the light cruiser and the destroyer, they have this in common, that they are all *ships*; their designers must all calculate in terms of "hogging," "sagging," metracentric height, etc., etc.; their principal job was in all cases to produce a thing which could *float*; the speed in knots, the thickness of armour—if any—the freight space available, the strength-factors involved in providing recoil-platforms for guns, depend upon the *purpose* of the ship and are a matter, fundamentally, of *distribution* of a sum total of weights available. Moreover, in naval design we observe certain factors of permanence which have endured over the entire period of armoured, mechanically propelled ships. When *Warrior* was designed in 1859 her designer must not alone produce a ship which could *float*; he must arrange for the most efficient and economical distribution of

weights among armour, armament, engine-power, fuel, provisions. Given the limitation in general weights due to the size of the ship, any increase in the one element must be purchased by sacrifices in others; thus the design when completed was a compromise. When *Rodney* was designed 62 years later, the problem was still to produce a ship which could float and still to distribute a sum total of weight available among conflicting claims for armament, armour, speed, endurance (fuel and munitions supplies, etc.). A period of experiment and research exceeding half a century and costing vast sums of money had not affected the basic elements of warship design; the only practical result was to render the problem much more complex, for meanwhile there had been introduced mines, torpedoes, air-bombing, etc., while the recoil-strains involved in the firing of *Rodney's* 16-in. guns would have made *Warrior's* designer's hair stand on end.

The basic distinction between tank and armoured car is the distribution of the weight of the vehicle over a very broad bearing surface—the caterpillar tracks—instead of this being carried on wheel-points. The tank *floats* on a raft-like body, and if we observe the deep impressions left on the soft ground we are struck by the fact that there even applies, in a very limited sense, the principle of displacement. The armoured car does not *float*, her wheel-points are borne by an artificially-hardened surface, the road, and her capacity to move across country depends upon whether the soil is naturally strong enough to support her wheel-points. If this is the case, she is much more mobile than the tank. This happens, however, very rarely.

The tank is not a land-*ship* but a land-*raft*, and she suffers in comparison with the ship proper very serious disadvantages which, being inherent in her design, are unlikely to be materially affected by future developments. The power of her engines is applied *via* wheels to a very large number of bearing surfaces, the *shoes* of her tracks, and the loss in efficiency is immense. Every engineer knows what happens if you give a ship a very large number of small paddlewheels instead of two big ones. This is very analogous to what happens with the tank. In the Mark I tank, a 105 h.p. Daimler motor achieved with difficulty a speed of 3·7 miles per hour. The same engine applied to an armoured car over roads would have meant a speed ten times as great. Since then enormous strides have been made in developing the efficiency of the track, but engine-power for engine-power, mechanical efficiency measured against mechanical efficiency, surface for surface, the track cannot be anything like a fair match for the wheel. To this comes the element of friction involved in dragging a length of track over hard surfaces. The tracks very soon get worn out, even when moving at a moderate speed. One does not quite see how this difficulty can be overcome save by building the tracks of some material lighter and stronger than any we know to-day. The

exposure of the tank's tracks, not alone to enemy fire but to dust and dirt, will be patent to every observer. Incessant cleaning is required. Here again one observes the defect without being able to suggest any remedy.

It is the custom to put forward some very misleading analogies between tanks and ships, but to argue that because war at sea has produced *Super-Dreadnoughts*, therefore war on land will produce a *Super-Dreadnought* tank is about as logical as to reason that because a carrot and a potato are both vegetables, therefore a turnip is a cauliflower. Conditions on land and by sea are fundamentally different. The editor of a very well-known Service journal* declares, "It is clear, however, that if the development of the tank is really to be a contest between the anti-tank gun and the tank's armour, the weight of the gun or firearm must be increased, and that at a very early stage in this development the firearm will become too heavy for the infantry soldier to carry or to handle in action." The statement scarcely shows adequate knowledge of the mechanics of this problem. It was the relatively free hand possessed by the naval designer in increasing the *size* of his ship, and in concentrating armour upon *vitals* which was truly responsible for the rapid increase in the size and power of ship's guns.† We have, for instance, a jump in dimensions from 2,162 tons in *Victory* through 9,210 tons in *Warrior* to 41,200 tons in *Hood*. The limitations on the size of the tank due to the necessity of being able to use roads, railroads, and bridges for approach marches, however, render a parallel development on land out of the question; nor can the tank-designer apply the principle of concentration on *vitals* to anything like the same extent. The entire tank is raised up above the land and exposed to fire. The duel, therefore, between tank-armour and anti-tank gun is thus limited on both sides by considerations as to weight-carrying: on the side of the tank to the maximum size which will not entail loss of strategic mobility, *i.e.*, power to use existing railroads, roads and bridges: on the side of the anti-tank gun to the maximum weight of weapon which can be handled in action by a man or two men. In this connection, however, it must be remembered that the tendency for the last ninety years has

* *Army Quarterly*, 1928.

† The 68-pdr. smoothbore was succeeded by the 6½-ton M.R. This increase of weight, 35%, led to the introduction of the "belt and battery" ironclad. To increase the weight and power of the gun is, from the mechanical standpoint, a much simpler business than to increase the weight of armour. *Alexandra* (1874) had 25-ton guns, roughly speaking a five-fold increase on the weight of the heaviest gun on *Warrior*, but, despite developments in engines, a two-fold increase in the general weight of armour was all that could be achieved without the sacrifice of other elements. Thus to get a thickness of 12 in. meant a reduction of the *area* armoured. The problem to be solved by the tank-designer is, however, infinitely more onerous than that of the armoured ship, and to produce an unarmoured *gun*—whether tractor-drawn or self-propelled—capable of piercing tank armour, will always be, from the mechanical aspect, cheaper and simpler than to produce a tank armoured to resist it. Any development of tank armour aimed at rendering the tank invulnerable to improved infantry weapons—by reducing the speed and "circuit" of the tank—would render her increasedly vulnerable to artillery.

been for all classes alike of ordnance and of small arms to become immensely more powerful proportionately to the weight of the piece. The modern equivalent, for instance, to the 68-pdr. ninety-five hundredweight, smooth-bore guns of *Warrior* would be a 5-in. quick-firing gun, and in range, smashing-power and rapidity of fire the modern weapon can beat the older one hollow. To say that the 5-in. quick-firer could riddle the 4½-in. wrought-iron plates invulnerable to the 68-pdr. of 1859 is to put it very mildly. Such a weapon can pierce at close range more than its own calibre-thickness of the best modern armour. Other naval calibres such as the 16-in., 15-in., and 13·5-in. gun show the same tendency in even more marked degree. This also applies to infantry firearms. Brown Bess of 1803 weighed 11 lb. 4 oz., had a calibre of ·753 in., and with a bullet weighing 490 gr. had an effective range of 200 yd. A well-trained man could fire three shots per minute. The Short Lee Enfield of 1903 weighs only 8 lb. 2¼ oz., has a range of 2,800 yd., fires a bullet 215 gr., and sixty aimed shots can be fired a minute. Nobody can "scientifically" predict the development of weapons ten or twenty years hence, but it is wise to remember that the rate of acceleration now compresses into a decade a process of evolution which previously required a century; thus if we are to surmise the effect which the development of the tank is likely to have on infantry rifles and machine-guns, one would need to state an equation something thus:

Brown Bess : Short Lee Enfield : : Short Lee Enfield : Rifle *x*

On this showing Rifle *x* will range perhaps 20,000 yards, penetrate 3·4 inches steel up to 1,000 yards, reach an aeroplane at 10,000 feet, and fire perhaps 10 to 20 times as fast as any present weapon.

Many people will proclaim such a weapon to be fantastic: one can only say that all accounts of experiments on the Continent show a steady movement in this direction. The real range of the German Mauser exceeded 4,000 yards, although it was not sighted for this range: muzzle velocities have now been achieved double and triple those of pre-war days, and we are still only in the infancy of this development. If it was possible to make the tremendous stride in velocity from Brown Bess to Short Lee Enfield, whilst not alone lightening the weapon but reducing the effect of the recoil upon the shoulder of the man firing the piece, it is not quite clear why we should expect this process suddenly to cease because some of our staff officers have chosen to see in the tank a means of enabling our tiny army to achieve against Continental armies such as the French or Italian, feats analogous to those of Alexander against Persian "hordes," or the semi-legendary exploits of Sabutai. To double the muzzle-velocity of the bullet is to quadruple its smashing-power. Thus with the prospect in the near future of rifles with five-fold the muzzle-velocities of 1918 we have the pleasing prospect that tanks will need 4-in. to 6-in. armour against them.

A very important point, but one which some of our staff officers, in their enthusiasm for the exploits of the Mongols, are apt to overlook, is the extent to which the Continental tank designer can "save" owing to the fact that his tank is supported on the one hand by numerous infantry: on the other by a powerful artillery. Armour against hostile infantry is, after all, for him somewhat superfluous: he has his own infantry to deal with these: his powerful artillery should deal with anti-tank weapons. What *he* needs is thus speed to cross the fire-swept danger zone, guns heavy enough to knock out enemy tanks, endurance to carry on through long periods of fighting. To gain in these qualities he can afford to sacrifice many others which the British tank-designer considers essential. The same thing applies, of course, to Continental infantry and artillery. If British infantry be eliminated or very greatly reduced, Continental infantry can equip themselves mainly for fighting British tanks: Continental self-propelled guns would find armour superfluous. At short range any armour would be riddled by machine-guns firing A.P. bullets, but for the gunner to engage the tank at close range is to throw away all the advantages due to the superior range and smashing-power of his piece.

The unfortunate tendency of the British Army to-day to use "Mechanization" and "Armoured Warfare" as synonymous terms obscures the vital truth that the two things are in reality quite different.

The attached tables of the depth of penetration of armour-plate by anti-tank guns of various calibres, taken from the *Militär-Wochenblatt* of Sept. 25th, 1928, although somewhat out of date, makes significant reading. One observes that a 20-mm. machine-gun (·8 in.) firing a projectile slightly exceeding 5 oz. in weight, can pierce close on 2-in. steel at close range, and, if it gets a direct hit, can pierce 1½-in. plates at 500 yards. Such a gun can riddle light tanks at 1,000 yards, and armoured cars up to 1,500 yards. With steel of exceptionally good quality, or if the bullet strikes at an angle, the penetration might be less, but when one thinks of the infinitesimal weight and cost of a ·8-in. gun and the relatively enormous weight and cost needed to produce a tank efficiently armoured against it, the prospects for "armoured warfare" pass under a cloud. An armour plate of 1 square metre in surface, 1 mm. in depth, weighs 8 kg. = 18 lb.; if 22 mm. in depth the weight increases to 175 kg.; and armour plate of this thickness with a surface 2 metres x 2 metres x 3 metres weighs six tons, minus stays, bolts, etc. A tank efficiently armoured "all over" even with 20-mm. steel would weigh some 24 tons, and such a tank will still be vulnerable at very long range; to armour her "all round" with 37-mm. steel, plus the necessary factors of speed, armament and endurance would increase the total weight to some 80 tons. A ·8-in. machine-gun could still pierce this armour at 100 yards; a 1.8-in. gun could do this even at 1,000 yards. One is forced to the

conclusion that, as the mechanics of the problem suggest, even at first glance, there is happening on land, but even more rapidly and on an enhanced scale, what has already happened at sea: viz., the gun has beaten armour. When *Warrior* was designed in 1859, 4½-in. wrought iron could beat any gun afloat; *Monitor* and *Merrimac* battered one another for a very long period with their guns almost touching. But neither ship could damage the other, the action was indecisive, *Merrimac* was destroyed by her own crew to save her from falling into the hands of the Northern Army, *Monitor* foundered at sea. The action impressed popular imagination, but was in reality much ado about nothing, for *Merrimac* lacked the sea-going qualities needed to be truly dangerous to Northern shipping; the Federal ships she destroyed were at anchor in smooth water. Armour once introduced, however, there followed a tremendous development in rifled guns. *Alexandra*, designed some fourteen years after *Warrior*, had 12-in. iron armour; *Inflexible*, a few years later, had 24-in. plates, and our latest battleships, *Rodney* and *Lord Nelson*, have 14 in. to 16 in. of chemically-hardened steel. Even this thickness is vulnerable to an enemy 16-in. gun at 10,000 yards; for such a weapon point-blank range.

Given the much more onerous conditions under which the tank designer tackles his job, the triumph of the gun is bound to occur much earlier and to be much more signal. The extent to which the tonnage restrictions of the Washington Conference have revolutionized naval design is scarcely appreciated by soldiers; but the naval designer for the first time tackles his problem under restrictions as to dimensions analogous to those on land. One notes the tendency to "cuts." Compare *Lord Nelson* with *Hood*, approximately the same size, for "standard" tonnage and "full load" tonnage are very different things. To get the enormous thickness of armour needed has meant cutting down speed from exceeding 30 knots to 23, the concentration of armament in three 3-gun turrets forward is a very artificial and debatable feature, forced upon the designer by the vital necessity of economizing weight. If we turn to the post-Washington cruiser, we observe the other side of the medal; the "cut" made is in armour. *London* carries relatively much less armour than *Warrior*, designed 70 years earlier; her weights for armament are also slightly less; the gain, measured comparatively, is almost entirely in speed, 32 knots against 14·8. To get this has required an increase in dimensions from 9,210 tons to 14,000 deep load; in horse-power from 5,267 to 90,000; in cost from about £600,000 to about £2,000,000. Her 3-in. armoured ammunition hoists can be pierced at 3,000 yards by a 5-in. gun, equivalent in weight to the old 68-pdr., she has *no* side-armour, and her armour-deck would be useless against the 8-in. guns of contemporary foreign cruisers. One gets the impression that such armour as the ship possesses is more a "survival" than the result of a reasoned policy.

The opinion of the balanced critic upon contemporary tank-design will be that the tendency is to attempt too much upon restricted dimensions; designs suffer from the vice of "overcrowding." Brig. Collins in his recent valuable and instructive article has admitted the unsuitability of the present type of medium tank, and that experiment is still necessary to get a really good armoured car. The fault lies less, I am afraid, with our tank designers, who are an extraordinarily able body of men, than with staff officers, who do not always possess a really adequate grasp of the mechanics of this problem, and who perpetually urge the tank-designer to work to "ideal" standards and to produce something to gratify *doctrinaire* theories. "Overcrowding" is familiar to all students of naval design, and it took the naval officer generations to grasp the need for "elbow-room." The U.S.S. *Indiana, Oregon* and *Massachusets* are classic instances of "overcrowding" at sea. Designed in 1889, they carried an armament weight exceeding that of *Royal Sovereigns* and *Majestics*—about a third larger; they had 16-in. belts as compared with 9-in. belts in *Majestics*. Their only apparent inferiority was in speed, 16 knots as compared with 18 knots. A popular civilian naval critic made very disparaging comparisons between these and the British ships. But the belts of the *Indianas* were so narrow that when fully loaded they were nearly awash; stops had to be put to save the blast from the 8-in. guns from rendering unworkable the 13·5's; the ports for these were so large and vulnerable that their officers covered them up with painted canvas screens when visiting foreign waters; well-informed American critics admitted that to render these ships efficient would have needed an increase in dimensions by 2,000 tons, and they would even then have been inferior to *Majestics* in speed, endurance, and capacity to fight their guns in a sea-way. Instances of "overcrowding" almost as bad can be quoted from early British battleship designs. And whether it is tanks or ships, the test of a design is not what it looks like on paper, but how it works in practice. Tanks are not likely to meet the enemy with engines freshly "tuned up," men in the pink of condition; they are much more likely to meet the enemy with tracks bespattered with mud and dirt; men weary from the strain of long marching, engines developing "moods." Capacity to stand the rough and tumble of service conditions; a clear field of fire for her guns, absence of interference of gun with gun, are the qualities most urgently needed. Armour looms largely in popular writings anent "mechanization," mainly because their authors are obsessed with the vision of tanks fighting *infantry;* but the tankman's real enemy, in a European war, is much more likely to be another tank, and unless he can settle this, his chances of fighting foreign infantry will be remote, for either his soul will be in Kingdom Come or his body in the hands of the enemy. In the combat of tank *v.* tank, quickness "on the draw" will assume a role far transcending the importance of

armour. First, *whatever* armour is carried won't really matter a tinker's curse; it will still be vulnerable to a gun-armed enemy; second, the conditions of a duel, tank *v.* tank, recall those of a cowboy fight in a Wild West novel. Given accuracy of fire, a gun heavy enough to do the job, and the man who gets in the first hit—wins. If we are to produce a really efficient tank, we must make more drastic "cuts" in designs; a more generous use of the principle of differentiation—and take a firmer hold on fundamental principles. We cannot afford to approach a practical problem from a standpoint of "philosophic doubt." If, for instance, the tank—and this is admitted—cannot attack infantry armed with anti-tank guns unless covered (*a*) by smoke-clouds, (*b*) by overwhelming artillery fire, isn't her armour after all somewhat superfluous? If she *has* cover by smoke-clouds or artillery, she does not *need* armour; if she *hasn't*, any armour which is a practicable proposition will be riddled anyhow. Why not an *unarmoured* tank? A foreign conscript army, faced with the menace of British tanks, is not likely to build tanks to deal with British *infantry;* it will build tanks to run down and destroy British *tanks*. For such *tank-destroyers*, however, the essential qualities are superior speed and endurance, heavier guns; given equality in dimensions and efficiency of design, the Continental designer can *only* produce such a destroyer by sacrificing armour. But for wire-cutting, moral effect, and surprise attacks, such unarmoured *destroyers* would be just as valuable as armoured tanks.

It seems to me that we must distinguish between tanks needed for colonial wars against rifle-armed tribesmen and the types most suitable for European warfare; a really efficient light or medium tank can only be produced by scrapping armour; the *armoured* tank must be a form of land-monitor, sacrificing speed and cruising qualities to the sheer element of weight and power. The value of such a land-monitor will be as limited as that of the monitor at sea.

Finally, we must not make a fetish of "mobility." It's no use catching one's enemy if he turns out to be a Tartar when caught. There is no great difficulty in producing an anti-tank gun capable of being handled by two men in the fashion of a Lewis gun and of piercing tank-armour up to 300–400 yds. Unless powerfully supported by artillery, tanks are likely to find an attack, even upon an infantry column in movement, no easy business. The tendency is too much to look to *Get-Rich-Quick-Wallingford* theories of winning wars, and to forget that a Continental Army is likely to be handled by men who know their job and who will match "Science" against "Science." In this case, however, superiority can be attained by no means other than superiority of *effort* applied to superiority of *resources*. There are no means actually available or likely to be produced to enable a British Army 60,000 strong to stand up to a Continental Army ten times its own size.

TABLE OF PENETRATION OF STEEL FOR ANTI-TANK GUNS.

Taken from *Militär-Wochenblatt*, Sept. 25th, 1928.

Calibre.		20 *mm.*			37 *mm.*				77 *mm.*	
Range in metres.	Weight of projectile. M.V. m.s. Depth of penetration in millimetres.	0·14 kg. (·32 lb.)			0·6 kg. (1·35 lb.), 0·8 kg. (1·8 lb.)				6·3 kg. (14·4.lb.)	
		1000	800	600	800	600	800	600	600	400
100		47	35	22	51	33	63	42	87	49
500		35	25	16	39	25	51	35	77	44
1000		24	16	11	27	18	40	28	67	40
1500		16	11	9	20	15	30	22	60	35
2000		11	9	7	16	12	25	18	53	33

SHISHI BRIDGE, CHITRAL.

Constructed by the Chitral Section, K.G.O. Bengal Sappers & Miners, under LIEUT. A. H. G. NAPIER, R.E.

THERE are two pack transport roads between Drosh and Chitral, one on each bank of the main river. Shishi *nala* joins the main river on its left or east bank about 2½ miles north of Drosh, and therefore must be crossed by the east bank road.

The Shishi stream is easily fordable during the winter months, but during the summer, when the snow is melting, is impassable, and it is also liable to sudden floods.

A field type of suspension bridge, span 301 feet, had been in existence for a number of years, but was accidentally destroyed by fire in 1926. As a result of the destruction of this bridge, the east bank road was closed for military traffic during the summer months.

It was decided to build a new bridge to take pack transport. The present policy is to maintain the east bank road for military purposes up to the standard of a good pack transport road, while the west bank road may be improved for motor traffic. Bridges on the east bank road are not, therefore, required to take loads heavier than pack transport.

Shishi *nala* is a stony river-bed, through which runs a stream 50 or 60 feet wide in winter, and variable in summer up to the whole width of the bed in a flood.

The first proposal was for a timber pile bridge at the site of the old bridge, span 301 feet, 9″ x 9″ deodar piles at bay interval of 10′. It was, however, doubtful whether the piles could be driven to a safe depth, and experimental pile driving was therefore carried out by this unit in April, 1927. The maximum penetration obtained was 7′ in a place where 16′ was required for safety; in consequence of this, and of the fact that Shishi stream, when in flood, brings down with considerable force boulders and quantities of logs from avalanches near its source, it was decided to abandon the pile bridge scheme, and to build a suspension bridge.

Accordingly a design was prepared for a suspension bridge, at a new site about 300 yards upstream, where the gorge narrowed to a gap of only 168 feet. This design was approved by the C.R.E., and the bridge was built by the Chitral Section, K.G.O. Bengal Sappers and Miners.

The span was 168 feet clear with high rock cliffs on each bank. New approach roads were required on each bank leading to the new

SHISHI BRIDGE, CHITRAL.

Shishi Bridge

Shishi Bridge

site from the old site. The construction of the approach roads, over very difficult ground, largely offset the saving on the bridge itself due to the decreased span. Work on approach roads and bridge site was carried out during the winter, 1927–28, by coolie labour by the M.E.S.

It was decided to use a stiffened splayed cable suspension bridge for pack transport.

Clear span, 168 feet.
Width of roadway, 7 feet between handrails.
Dip of main cables, $\frac{1}{12}$ loaded span = 13 feet.
Horizontal splay = $\frac{1}{3}$ vertical dip = 4·33 feet.
Calculated load = 300 lb. foot run equivalent dead load.
Weight of bridge = 280 lb. per foot run.
Wind pressure allowed for = 40 lb. per sq. ft. over exposed area of bridge.

The cables were slung direct from anchorage to anchorage, there being no pier. This was made possible by the height of the cliffs on each bank. The main anchorages were situated on platforms blasted in the face of the cliff. They consisted of reinforced concrete anchor bars, joined to the rock by steel bars in jumper holes, with masonry buttresses in front of the anchor bars, and a weight of masonry on the top. The whole calculated to be of sufficient weight not to slide horizontally on the bottom joint of masonry, assuming a coefficient of friction of ·7, and the dimension of the structure such that the resultant thrust came within the middle third of the base. The anchorages were thus designed to be stable structures, ignoring the fact that they were fastened to the rock by jumper bars.

Each of the main cables consisted of seven steel wire ropes, five of which were $\frac{7}{8}$″ diam. steel cable from the Khyber ropeway, and two were $3\frac{1}{2}$″ circumference G.I. cable from the dismantled Ghairat Bridge.

A timber girder was used below the roadway, ensuring adequate cross bracing. Effective depth 6 ft.

A new departure was the provision of horizontal bracing for the roadway, by laying the decking diagonally at 45° and spiking it to the booms of the girder. This made the bridge very stiff, and was a great improvement on the Ghairat Bridge, which sways laterally under load.

The wind bracing consisted of $\frac{7}{8}$″ diam. steel wire ropes, stretched in a horizontal parabola, one on each side of the bridge, with wind slings to each transom, made of G.I. wire and fitted with adjustable union screws. These wind braces were anchored by R.C. blocks fastened to the rock by steel bars in jumper holes.

The site was very carefully marked out in order to place the anchorages accurately in their pre-determined positions. The

length of the main cables was calculated and also the position of the slings. Each steel wire rope was carefully stretched over pegs on shore and marked.

Stretching was done by means of a capstan, which enabled approximately the same strain to be put on each rope before marking. The seven ropes forming each cable were placed separately across the gap, each being fastened at the marked points to the anchorages, and passed through its assigned position in templates to enable the whole cable to be bound up over the gap.

The cables were joined up when in position over the gap by putting on the main cable clips and slings at the marked points, movable templates holding each rope in its correct relative position during the process.

The stiffening girder was built on shore, parts were numbered, and it was then dismantled preparatory to re-erection over the gap.

The erection of the stiffening girder over the gap was carried out without difficulty as follows: Transoms and temporary roadway were laid in the ordinary way. The roadway was loaded for the adjustment of cables to correct dip and equal strain. The girder was then built below the temporary roadway, working outwards from the centre of the bridge. This was done by suspending from the roadway movable frames in which the bottom booms and a platform could be rested. Bags of earth were used to load that portion of the roadway, where construction was not in progress. This was to keep the cables in their correct parabolic shape, and to enable the girder to be joined up straight.

By this method of erection it was found that the correct dip of the cables was arrived at without any guesswork or "trial and error" methods.

Wind cables were made up complete with wind slings on shore and were fastened to their anchorages at calculated marks. Very little subsequent adjustment was necessary.

The total time taken to build the bridge was 131 working days. The work included building a hut camp for the unit, and a large dry-stone retaining wall at one of the approaches; dressed stone, sawn timber and all materials had been collected previously.

Working strength:— 1 Indian officer.
1 British N.C.O.
50 Indian O.R.s.
20 experienced local coolies.

AFGHAN WARS.

By COLONEL F. C. MOLESWORTH.

DURING the last ninety years we have three times been engaged in war with Afghanistan. The first war, from 1839 to 1842, is memorable chiefly for the disastrous retreat from Kabul. In the second war, 1878 to 1881, occurred the massacre of the Minister and his guard, and Roberts' march from Kabul to Kandahar. The third war, 1919, was little more than the repulse of an Afghan attempt to invade India—the first time in history that such an invasion has been foiled. In the third war more men were engaged on our side than in any other war in our history, the Great War and the South African War only excepted.

THE COUNTRY (*Map I*).

Afghanistan, as a reference to the maps will show, is a country shaped like a parallelogram, 900 miles from N.E. to S.W. and 500 from N.W. to S.E. Its extreme north-east angle abuts on the Pamirs—the Roof of the World—whence a number of broken mountain ranges spread fan-wise in a south-west direction, gradually lessening in height until along the Baluch and Persian borders they have sunk almost into the plain. Of its rivers, some, of which the most important is the Kabul, make their way into the Indus, and none, except those which are tributaries of the Indus, reach the sea. The Helmand discharges into the Hamun, a swamp in Seistan, largely in Persian territory, while the Oxus and Hari Rud, which drain the northern provinces, lose themselves in the sand in Soviet territory. These rivers are rapid and unfit for navigation. In many parts water is scarce and often brackish. Cultivation is confined to a few fertile valleys; otherwise the country is sterile. There is little timber except in the higher ranges.

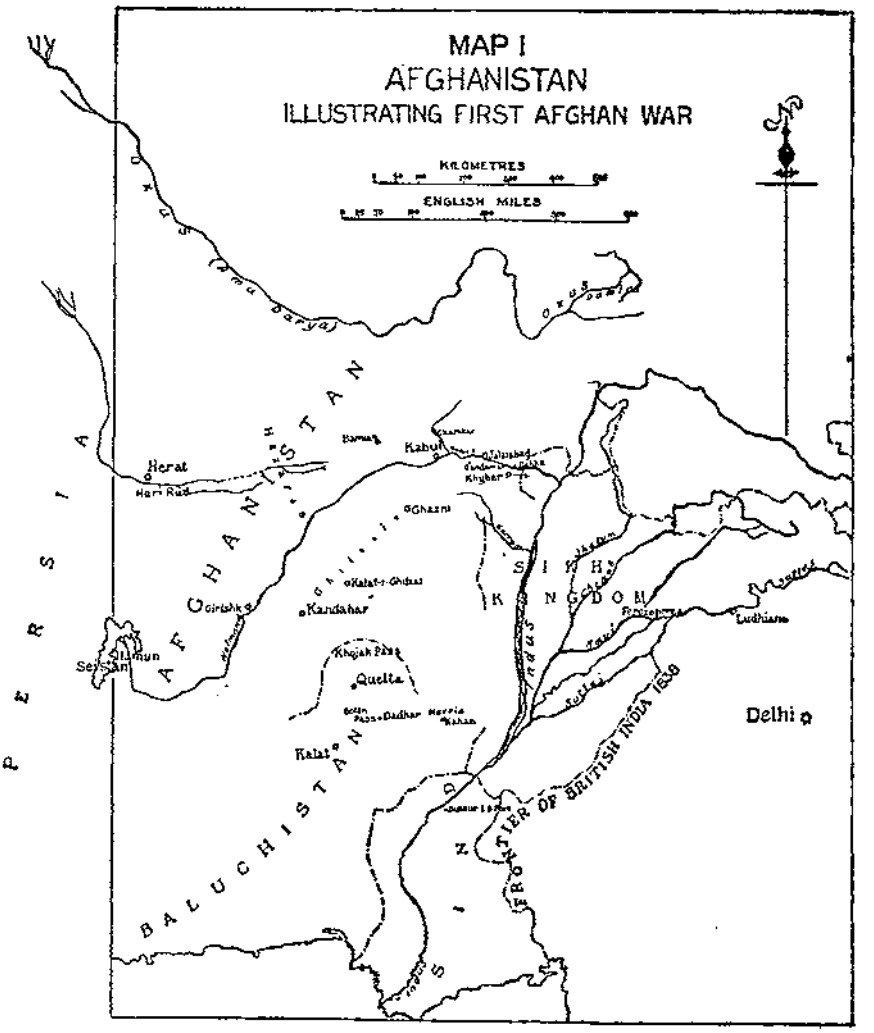
The people call themselves Afghans or Pathans; there are, however, Persians in the west, a Mongol remnant called Hazaras in the centre, Usbegs and Tajiks in the north. All, almost without exception, are Musalmans. Hazaras are of the Shia branch of that religion, and so are disliked by their neighbours, who are Sunnis. The language is Pushtu, but Persian is used in the west and is also the court and official language.

The climate is one of extremes. The winter in the mountainous districts is intensely cold, while the summer is intensely hot in the low-lying parts and warm elsewhere.

The boundaries were ill-defined during the First Afghan War, and to a slightly smaller extent until after the Second War.

The neighbours of Afghanistan are British India on the east and

south, Persia on the west, and the U.S.S.R. on the north. It is noteworthy that in the latest Soviet maps the southern boundaries of Turkmanistan, Tajikistan and Usbekistan, recently formed Soviet republics, are unmarked, but the boundaries shown between these states penetrate far into Afghanistan and Persia. Chinese territory marches for a few miles with Afghanistan in the Pamirs.



EVENTS LEADING UP TO THE FIRST WAR.

In the middle of the eighteenth century, Nadir Shah of Persia, the last of the great Asiatic conquerors, overran the whole of the territory now known as Afghanistan, and even sacked Delhi. On his death, one of his generals, Ahmad by name, carved out for himself a kingdom with its capital at Kabul. His dynasty remained on the throne until 1929. Whenever the reigning monarch has

been strong enough, the kingdom has been fairly united, but as often as not the control of outlying provinces has been of the weakest, and not infrequently there have been internecine wars between rival claimants to the throne, and many tribes in Afghan territory have given the Afghan government almost as much trouble as those on our Indian North-West Frontier have to us.

In 1837, the Persians, with Russian help, besieged Herat; the city would almost certainly have fallen but for the fortuitous presence of Eldred Pottinger, a subaltern of Bombay artillery, who infused such life into the defence that, after a siege of eleven months, the enemy retreated.

The Indian Government, under Lord Auckland as Viceroy, was naturally alarmed at this attack, and although the British frontier at the time was the Sutlej, between which river and Herat lay the independent kingdom of the Sikhs and the greater part of Afghanistan, it was decided to prevent future menaces by placing a friendly king on the throne of Kabul. An unfortunate choice was made in Shah Shuja, who had been driven out some thirty years before and was living in Ludhiana. He was permitted to raise an army of Indians with British officers, which, in conjunction with a British force, was to invade Afghanistan and set him on the throne.

The British force was composed of two divisions from the Bengal army with cavalry and guns, under Sir W. Cotton (12,000 men and 48,000 followers), and a Bombay contingent of a brigade, under Major-General Willshire. The whole was to be under the command of Sir John Keane. Shah Shuja's force consisted of about 6,000 men. The command of this force was under the Political officers who accompanied it—an arrangement which was to produce friction, defeat, and disaster.

The Persians abandoned the siege of Herat in September, 1838, and the Indian Government might thereupon have, with good face, abandoned the whole enterprise. The Governor-General, however, decided to carry it through. On December 2nd, Shah Shuja's force started from Ferozepore and the British force followed it eight days later. The direction of the march was south-west down the Sutlej, in order to effect a junction with the Bombay force, which had to travel by sea and land in Sind—then foreign territory. By this route also Sikh territory was avoided, as it was in the highest degree desirable to avoid a collision with that power.

First Afghan War.

First Phase.

The Army of the Indus, as the Bengal Force was named, began its march on December 10th, following Shah Shuja's army. Troubles arose almost as soon as the force was in motion. The provision of depots of supplies along the route had been entrusted to Political

officers, who, in many cases, failed to collect enough, and the consequence was that the troops were speedily reduced to half rations. Camels were over-worked and not allowed sufficient time for grazing. Their drivers deserted in large numbers, taking their animals with them. Thus the efficiency of the force was diminished long before the enemy was encountered.

On January 24th, 1839, the army reached Bukkur, the selected crossing-place of the Indus, and here came the first great engineering feat of the campaign. To bridge the river, here about 1,000 yards wide, there were available only the local large, unwieldy boats. The sappers had to cut planks, make anchors and even manufacture ropes. Difficulties were, however, successfully surmounted, and the force proceeded on its way, heading in a north-west direction for the Bolan Pass.

Now came a stretch of desert, where water was scarce and often brackish, and supplies almost wanting. The army had perforce to cross this waste in detachments; the natives of those parts were enterprising and proceeded to kill stragglers and drive off baggage animals, and the Politicals with the force were averse from reprisals. The result was that the Baluch raiders became bolder, and military difficulties increased. The desert was, however, surmounted, and by March 10th the force was concentrated at Dadhar, at the foot of the Bolan Pass.

The Pass is a narrow defile, running for some 50 miles through a jagged mass of mountains. Such road as existed was little better than the bed of a stream. Through the pass toiled the army, losing every few yards camels and bullocks, whose carcases remained to poison the air and water. Marauders were ever on the look-out for stragglers. Nevertheless, the force got through somehow, and on March 26th Quetta, then a mud village, was reached, and here, on April 6th, Sir J. Keane, who had up till then accompanied the Bombay force, arrived and took over charge.

The situation that faced him was not encouraging. The fighting force was on half rations and the followers were almost starved. Supplies could not be brought up in time and local resources had long since been exhausted. The only course to take was to move on Kandahar, and so, on April 7th, the army resumed its march. The Khojak Pass presented difficulties similar to those in the Bolan, though on a smaller scale; yet the staff had not profited by its experience, and a terrible jam occurred. Most of the transport remained loaded up without food or water, for two days and the intervening night. This was, however, the last serious difficulty, and Kandahar was occupied, fortunately without resistance, on April 26th. The cavalry, owing to bad and insufficient water, little or no grain, and, later, a surfeit of green fodder, had practically ceased to exist.

We must now revert to the Bombay Force. Sind, it must be remembered, was a foreign, and potentially hostile, country. The first operation of the force was, therefore, the landing on an unknown coast, which was effected between November 27th and December 3rd. Negotiations were made with the Amir of Sind for the safe passage of the force, which, without opposition, marched up the right bank of the Indus and struck out across the desert, where, owing to the advancing season, it suffered considerably from heat, and reached Dadhar on April 5th. From there on it followed in the footsteps of the Bengal force, which it ultimately joined at Kandahar on May 4th.

A halt was now necessary to await supplies, which were ultimately obtained by the harvesting of local crops as well as the arrival of a convoy from India. During this period the only military movement of any importance was the occupation of Girishk on the Helmand. On June 27th the force marched for Kabul, with the Indian troops still on half rations.

The way was barred by the fortress of Ghazni, impregnable in native opinion, where the army arrived on July 21st, with only three days' rations in hand. The siege train, such as it was, had been left behind at Kandahar. The walls of the fortress were sixty feet high and immensely thick, the gates, with one exception, had been walled up, and there was a wet ditch. Sir John Keane decided to blow in the one unguarded gate, as the alternative to starvation. By astonishing good luck, as well as by audacity, the gate was successfully demolished by the Sappers, one of whom, Lieutenant Durand, lived to become Lieutenant-Governor of the Punjab.

No further resistance was met, and Kabul was occupied on August 7th. Dost Muhammad, the Amir, had fled, and Shah Shuja was placed on the throne.

So ended one of the most astounding marches that the British Army, or for that matter any other army, has ever been called on to make. The distance traversed, 1,500 miles, is greater than that between Moscow and the French frontier. Great though the military blunders of the campaign had been, the commander and army certainly deserved credit for the successful accomplishment of their stupendous task.

By this time a line of communication had been opened through Sikh territory and the Khyber Pass. In the latter, however, the tribesmen were invariably hostile, and gave a great deal of trouble to successive convoys.

Second Phase.

With Shah Shuja on the throne, and the country fairly peaceful, it was now possible to evacuate a proportion of the British and Indian troops. The Bombay force was the first to go. On its

way it was employed to take Kalat, whose *khan* had given a good deal of trouble both during and after the passage of the army through his territories. The place, a walled city garrisoned by 2,000 Baluchis, was taken by assault by Major-General Willshire, with 1,000 troops and a few light guns, in the space of two hours.

Keane followed, taking with him all of the Bengal force, except such as were left to garrison the country. He handed over command to Sir W. Cotton.

The force remaining in Afghanistan now consisted, in addition to Shah Shuja's army, of eight battalions, two of which were British, two Indian cavalry regiments, and some artillery. The places garrisoned were Kabul, with an outpost at Bamian, Jallalabad and Dakka on the northern line; Kandahar and Quetta on the southern line, with Ghazni as a connecting post. Shah Shuja's force was entirely, and the British force to a certain extent, under the Resident, Sir W. Macnaghten. This dual control was considerably to blame for the subsequent disasters. The force was often frittered away in useless expeditions, in the initiation of which the military commanders had no say at all.

Troubles meanwhile had arisen on the lines of communication. The country south of the Bolan Pass is one of the hottest on earth. During the summer of 1839, many officers commanding posts marched their men up to Quetta and other cooler places without troubling to ask for leave—such was the state of discipline at the time. Cholera appeared among the rest, and the surrounding tribes were not slow to take advantage of the disorganization.

Kalat was captured by the insurgents and had to be recovered. On the other side of the lines of communication a small post at Kahun, originally placed to keep the Marris in awe, was forced to surrender after two unsuccessful attempts at relief. Quetta and Dadhar were attacked and only relieved when large reinforcements arrived from India. The Politicals endeavoured to reduce these incidents by wholesale payments to certain tribes, a policy which seldom produces the result desired.

So passed 1840. By the beginning of 1841 everyone concerned, from the Government of India downwards, with the possible exception of some Political officers with the force, was heartily sick of the enterprise, and wished for nothing more than the immediate evacuation of Afghanistan. This, however, would have ensured the massacre of Shah Shuja as well as of any friends the British had in the country. A new Commander-in-Chief arrived in June, 1841—Major-General Elphinstone, who, invalid as he was, was not able to stand up against "the gentleman employed to command the army," as the great Duke of Wellington referred to Sir W. Macnaghten. A brigade from India, consisting of the 44th (now the 1st Battalion,

Essex Regiment) and some Indian battalions, arrived about the same time, after having successfully acted as escort to Shah Shuja's harem, consisting of 600 women, which was now brought up from India. The brigade relieved the 13th L.I. and an equal number of Indian troops, which were now ordered to move to Gandamak, *en route* to India, under Colonel Sale of the 13th.

Sale started on October 20th and reached Gandamak, not without some fighting; for the Ghilzais, one of the most powerful of the Afghan tribes, were up in arms against us. On this march, we hear for the first time of the practice of "piqueting the heights," which has since become a routine precaution of frontier expeditions. In spite of this, there were two occasions when British and Indian troops had to retire before Afghan tribesmen.

At Gandamak, owing to events presently to be related, Sale received orders recalling him to Kabul. He professed himself unable to comply, alleging deficiency of transport and that he was encumbered with wounded. These were probably sufficient excuses, but he had none for what he actually did. He moved his force to Jallalabad, 30 miles nearer India, and by the same distance further from Kabul.

Scarcely had Sale left Kabul when the storm burst. Practically the whole country rose in arms; the small force at Charikar was overwhelmed, and some of the Shah's force murdered their British officers and joined the insurgents. Burnes, one of the Political officers, was murdered in Kabul city, almost within sight of the British force, and nothing was done to avenge his death.

The force, numbering about 4,500 combatants and three or four times that number of followers, had constructed, and was occupying, fortified cantonments north of the city. With incredible stupidity, the treasury had been placed in a house in the city, and almost the entire store of rations for the force was in a fort some 300 yards outside the cantonment ramparts. The treasury was speedily overrun, and the commissariat fort soon shared its fate, and only half-hearted attempts, all of which failed, were made to recapture it. Thereafter the army subsisted on what it could obtain by raids on neighbouring forts, or purchase at exorbitant rates from friendly Afghans.

Cantonments were never seriously attacked; yet constant operations took place, mostly to recover forts and other points of vantage whence the enemy annoyed our troops. These affrays were generally mismanaged, and as a result the force lost its morale, and a dismal spirit of croaking set in. The truth was that General Elphinstone was too much of an invalid to command the army Winter was coming on and all began to talk of a retreat.

Sale was summoned from Gandamak, with what result we have seen. Nott, whose force had kept its tail up, was directed to send

a brigade, which however found its way blocked by snow and had to return to Kandahar.

At last Macnaghten opened negotiations for a retreat, the terms of which were that the British should evacuate Afghanistan with transport and supplies provided by the Afghans, and that Dost Muhammad, who had, in a fit of depression, surrendered himself, should be restored to the throne. Unfortunately for himself, Macnaghten listened to a proposal by Akbar Khan, son of Dost Muhammad, went to meet him with only a few companions outside, but within sight of, cantonments, and was speedily murdered. The army made no attempt to avenge his death.

A comparison has already been made between this expedition and that of Napoleon to Moscow in 1812. The events which follow provide an even more exact one. On January 6th, 1842, the British force evacuated Kabul, and, ill-fed and ill-clad, began its march towards India. Snow covered the ground, and even at mid-day the temperature was below freezing point. Fruitless negotiations were opened every day with the Afghan chiefs, and many officers, including General Elphinstone, were removed as hostages.

For six days they struggled towards India, losing many men from Afghan bullets, but more from cold and hunger, until one wounded man, Dr. Brydon, the sole survivor of 16,000, rode into Jallalabad.

The hero of the march was Brigadier Shelton, of the 44th. Twenty-nine years before he had stood unmoved before his tent in front of San Sebastian, while the surgeons removed from its socket his right arm. During the retreat he was the life and soul of the army, hurrying from point to point, rallying fugitives, never sparing himself, until, on the fourth day of the retreat, he was hurried into captivity along with his general. The 44th covered themselves with glory, and "44th Hill," near Gandamak, is the name given to the place where the last survivors gave a terrible account of themselves.

The task before the Afghans was now to drive the remaining British out of the country before reinforcements could arrive. In this they were singularly unsuccessful. It is true that the garrison of Ghazni was overwhelmed, but Kalat-i-Ghilzai put up a very strong defence, and the Third Regiment of Infantry of Shah Shuja's force, which took part in it, was taken on the strength of the Indian Army, and is now known as the 2nd Battalion (Kalat-i-Ghilzai) of the 2nd Bombay Pioneers. The garrison was eventually relieved by Nott, in spite of the fact that he had his own troubles to contend with.

The chief interest centred round Jallalabad, where Sale arrived on November 12th, and was attacked on November 13th. The attacks were never pressed hard, for at all times he seems to have been free to retire to India. Once an earthquake laid low his

defences, but the energy of his Engineer officer, Broadfoot, restored them before the enemy tried to take advantage of his misfortune.

Reinforcements for Sale were on their way, but the first attempts to force the Khyber were unsuccessful, largely because the sepoys were disheartened, and a Sikh contingent, sent to help, was actually mutinous. It was not till Major-General Pollock,* of the Bengal Artillery, arrived with an additional brigade that discipline was restored. The combined force then marched through the Khyber with little loss, and relieved Sale. By this time, Government had decided to recover the prisoners and then to evacuate Afghanistan as soon as possible. Pollock, therefore, advanced to Kabul and burned the great bazar. Nott had meanwhile brought the greater part of his force from Kandahar, and the two divisions evacuated the country *via* the Khyber, where the Khyberris, up to the last, molested the retiring troops. Dost Muhammad was restored to the throne in place of Shah Shuja, who had elected to stay in Kabul, where he met his death.

The results of the War were deplorable. Everything we had fought for had been given up, and a lasting legacy of Afghan distrust of the British bequeathed. Yet the difficulties of a campaign in an inhospitable country, 1,000 miles from British territory, were enormous. It is true that there was one appalling disaster, but even this might have been prevented had a general of the calibre of Nott been in command at Kabul.

The Sappers came well out of the campaign. Mention has been made of Durand. Broadfoot, at Jallalabad, single-handed stood out against retreat to India, when that course was proposed in a council of war, and by sheer force of will converted Sale and the rest to his way of thinking. Lieut. Sturt, although suffering from a knife wound which prevented him from dressing, staggered to his feet to direct the operation of demolishing a small fort outside the Kabul entrenchment; he was the only Sapper officer to perish in the retreat. Fortescue records some other instances where commanders consulted, and took the advice of, their engineer officers, on matters quite outside their normal duties, preferring their advice apparently to that of their staff.

Events Between the First and Second Afghan Wars.

(Map II.)

It was not long before British India and Afghanistan became actual neighbours. Sind was annexed by the British in 1843, some of Nott's battalions, on their return to India, taking part in its subjugation. Then the Sikhs were conquered, and the Punjab annexed, after two hard-fought campaigns (1845–9). The old Sikh border then became our border, though between this line and the country subject to the Amir lay a belt of independent tribes. To

* See note on page 614.

this day, this old border line forms, generally speaking, the administrative boundary of British India. Dost Muhammad sent a force to help the Sikhs, which took part in their final defeat at Gujrat, and was pursued in ignominious rout through the Khyber.

Then, in 1857, came the Mutiny, in the suppression of which the newly-conquered Sikhs gave us invaluable assistance. It was long doubtful what attitude Dost Muhammad would adopt, but the attitude of the Sikhs, as well as his recent experiences in the Sikh War, led him to a policy of non-intervention.

On the south border we had, more or less peacefully, extended our control over Baluchistan, and in 1876 Quetta was annexed to India and a garrison established there.

Dost Muhammad died in 1863, and was succeeded by his son Sher Ali.

All this time, the Russian dominions were spreading steadily southwards. Events in Turkey, where war between ourselves and Russia at one time seemed probable, led to a growing distrust of Russia's aims. In 1878, Sher Ali received a Russian mission and

immediately afterwards refused admission to one of ours. It was therefore decided to send a mission backed by force, and an ultimatum was accordingly sent.

Our railways at this time ran as far as Jhelum, 180 miles from the frontier, and Sukkur, which were connected by a line running through Lahore. During this period we had been in a state of almost continuous warfare, now with one and now with another of the trans-frontier tribes, whose attitude in the event of another Afghan war was always problematical. One or two minor campaigns actually did take place while the Second Afghan War was in progress.

In the thirty-six years that had elapsed since the First Afghan War, the Amirs had raised an army, estimated in a police report—there was no Intelligence Department in India at that time—as 62 infantry battalions, 16 regiments cavalry, 49 batteries of elephant, horse, mule, and bullock guns, in all about 52,000 men. The value of most of this force was problematical, but we could be sure, in the event of our invading Afghanistan, of strenuous resistance from local tribesmen, now very much better armed than when we had previously entered the country.

Second Afghan War.

First Phase.

It was decided to invade Afghanistan by three routes; with two of these, the Khyber and Quetta-Kandahar routes, we are already familiar. The third, known as the Kurram line, led *via* Kohat up the Kurram valley and then over two passes, the Paiwar Kotal and the Shuturgardan (or camel's neck) to Kabul.

The forces detailed to operate on these lines were the Peshawar Valley field force, under Sir Sam Browne, consisting of one cavalry and four infantry brigades (with one of each in reserve); the Kurram Valley column, under Major-General Roberts (subsequently Earl Roberts), of six battalions infantry with cavalry and guns; and the Kandahar column, under Lieut.-General Stewart, of two divisions; while several brigades were organized in India to act as reserves.

War was declared on November 20th, 1878, and on the same day Sir Sam Browne entered the Khyber. The Afghans here had taken up an extremely strong position across the pass, centring on the fort of Ali Masjid. A frontal attack proved fruitless, but the Afghan retreat was threatened by a wide turning movement through the mountains to the north, whereupon the position was evacuated during the night. Twenty-four guns were captured.

The Peshawar Valley field force then advanced slowly as far as

Gandamak. Little further resistance was made by the Afghan regulars, but the local tribesmen gave us considerable trouble.

Sher Ali died soon after the invasion of his country, and was succeeded by his son, Yakub Khan, who speedily came to terms, and on May 26th, 1879, signed the treaty of Gandamak, by which he agreed to receive a British Minister at Kabul and to cede the Khyber, Kurram and Chaman. The Peshawar Valley field force then withdrew to the Khyber.

The Kurram Valley force began its march from Thal on the same day as the Peshawar force At first its advance was unopposed, for the inhabitants of the Kurram Valley were well disposed, but the Afghans had prepared a position on the Paiwar Kotal, which was naturally very strong. The difficulties of the attacking force were great, as it was impossible to reconnoitre, and the summits of the hills were thickly wooded. A night march was, however, made, and after some sharp fighting the Afghans retreated, losing 17 guns.

Difficulties of supply and transport prevented a further advance, and consequently the force contented themselves with occupying Ali Khel, on the west side of the Paiwar Kotal. Troops were retained in the above positions during the summer.

Further south, the Kandahar field force advanced almost unopposed to Kandahar, and occupied Girishk and Kalat-i-Ghilzai. The Khojak Pass, as in the First War, proved a difficulty. The 5th and 9th Companies of the Bombay S. & M., aided by Pioneers, constructed a ramp for guns, which, for the first 450 feet of its length, sloped at 30°, and thereafter at a slighter gradient for 400 yards.

The force had the usual trouble with tribesmen. Mention should be made of a certain Lieut. Wells, R.E., who, in command of 36 men of two Indian cavalry regiments, scattered a band of marauders, killing the leader, his two sons and his nephew.

The force remained in occupation of South Afghanistan all the summer, as it was unwise to risk marches during the heat. The evacuation of Kandahar was begun on September 1st, but was stopped on September 3rd, owing to events now to be related.

Second Phase.

On the 24th of July, Sir Louis Cavagnari, the British envoy, arrived at Kabul with an escort of 75 of the Q.O. Corps of Guides, under Lieut. Hamilton, V.C., a secretary, and a doctor. They were given quarters in a house within 200 yards of the Amir's palace. On September 3rd they were treacherously attacked by Afghan regulars. For nearly the whole day they kept up an unequal fight. One by one the British officers fell. The sepoys fought on until they were exterminated to a man. In the words of the official commission which investigated the massacre, "The annals of no

army and no regiment can show a brighter record of devoted bravery than has been achieved by this small band of Guides." The Amir was unable, or unwilling, to put a stop to the carnage.

It was at once decided to occupy Kabul and avenge the outrage. The Kurram force was nearest to the hostile capital, and was obviously the instrument to use. It was, however, short of transport, and could take the field only by using the transport of the Peshawar field force, which was thereby rendered immobile. Even with this assistance, it could only advance half at a time; the leading portion marching while the rest halted until the transport was once more available. The force, now designated the Kabul field force, was placed under Sir F. S. Roberts, and consisted of 1 cavalry and 2 infantry brigades, with two more on L. of C. They advanced slowly but steadily on Kabul, which was occupied on October 9th, after a severe action at Chaharasia, immediately south of the city. The Amir, who had surrendered, was deported to India.

Once in Kabul, the position of the force was somewhat precarious. The Kurram route was soon afterwards closed by snow, while the Peshawar force was unable to advance immediately owing to lack of transport. Moreover, the Afghans were collecting in very large numbers, estimated at 60,000, no doubt expecting a repetition of the events of 1841–42.

The General had, with great foresight, concentrated his force, numbering about 7,000 men, into a fortified enclosure built by the late Amir for his troops, named Sherpur. This was rectangular in shape, about 3,000 yards from E. to W., by 1,000 yards from N. to S. Two of the sides were formed by a wall 16 feet high, with banquette and loopholes, but on one, the eastern side, the wall was unfinished; the fourth, or north, side was unprotected, but a range of hills, known as the Bimaru heights, gave some amount of cover, and attack from this side was unlikely as at a distance of 1½ miles was a marshy lake several miles long. The country round in all directions was flat, but several villages, which it was deemed impolitic to destroy, masked the field of fire. The position was strengthened and supplies collected.

Several attempts were made to disperse the enemy, now rapidly collecting from every side; but their numbers were too great, and Sir F. Roberts decided to retire into Sherpur. Scarcely had he done so when a fierce attack was made on the position. After a few hours' fighting the Afghans retired, losing about 3,000 men, with insignificant losses to our own people. A few days later (December 27th) the force joined hands with the Peshawar column.

On the southern line, the evacuation of the country was summarily stopped on receipt of the news of the massacre at Kabul. Kalat-i-Ghilzai was re-occupied, and transport collected for a march on Kabul. By this time the railway had advanced as far as Sibi.

At the end of March, a force of 2 brigades, under Lieut.-General Sir D. Stewart, leaving a garrison at Kandahar, began its march to Kabul. One sharp action was fought at Ahmad Khel, about mid-way between Kalat-i-Ghilzai and Ghazni, where a body of Afghan horse, backed by fanatics on foot, supported by about 16,000 of the enemy infantry, suddenly attacked the column on the march. After an action lasting only an hour, the Afghans were utterly defeated. Our force, with a loss of 7 killed and 124 wounded, continued its march, and by the end of April had occupied Ghazni and joined hands with Roberts. Fighting of some severity continued in the neighbourhood of Kabul for many months.

The Political authorities were meanwhile looking for an Amir; a candidate was soon forthcoming in the person of Abdurrahman, a nephew of Dost Muhammad, who had been for many years an exile in Russian Turkestan. He returned to Kabul, and was formally installed as Amir. As soon as this occurred the evacuation of North Afghanistan began, but took an entirely different course from that expected owing to the receipt of news of a disaster to the South Afghanistan field force.

This disaster was the result of an encounter with the forces of Ayub Khan, son of Amir Sher Ali. He had collected a force, estimated at 20,000 men, in Herat, and in June began to march towards Kandahar. The Wali of Kandahar moved out with local troops to meet him, supported by a brigade of British and Indian troops under Brigadier-General Nuttall. When the force arrived at the Helmand, the Wali's troops deserted, and lack of supplies drove Nuttall's force to Khushk-i-Nakhud, about half-way between the Helmand and Kandahar. Ayub followed up, and on July 27th, 1880, was reported at Maiwand, about 12 miles N.E. of Nuttall's force, and so in a position to threaten the British communications. Nuttall moved to attack, carrying with him his whole train and his sick, for he had insufficient men to leave a detachment. Very soon he found himself in the presence of an immensely superior force. The enemy pressed back his line into a horse-shoe, and even his baggage guard was hotly engaged. At length, after standing considerable punishment and losing most of its British and Indian officers, an Indian regiment broke; this was the signal for a general retreat, which speedily became a rout. The broken army covered the 45 miles to Kandahar in 33 hours, losing guns and stragglers.

The 66th (now the R. Berkshire Regiment) covered themselves with glory. Out of the 19 officers and 497 men, 12 officers and nearly 300 men were reported killed or missing. Most of these perished in a last stand in a walled enclosure, where also fell Lieut. Henn, R.E. The enemy suffered severely, and were unable or unwilling to make any effective pursuit.

The troops remaining in Kandahar, with the defeated remnants

of Nuttall's force, now prepared to stand a siege. Cantonments were evacuated and the troops concentrated in the city, a walled enclosure about 6,000 yards in perimeter, whose inhabitants were cleared out. The place was besieged for about a month by Ayub's army; no serious attack was made, but a sortie, aimed at the clearing of a neighbouring village, resulted in a loss of 14 officers killed and wounded.

Relief came from the direction of Kabul. On receipt of news of Maiwand, Roberts was placed in command of a force, known as the Kabul-Kandahar force, consisting of an infantry division, a cavalry brigade, and three batteries of mountain guns. It left Kabul on August 8th, and from that date until its arrival at Kandahar was absolutely *en l'air*. There was practically no opposition, but in the later stages the force suffered from heat, and the wastage of transport animals was heavy. At Kalat-i-Ghilzai, where a halt of one day was made, the small garrison was picked up and carried along. Kandahar was reached on August 27th. A distance of 280 miles had been traversed in 20 days, or 19 actual marches.

The fact was deservedly commemorated by a special medal. Yet, as we have seen, Sir D. Stewart, with a smaller force, had already traversed the route, and fought a battle to boot.

The task now remaining to Roberts was to defeat Ayub Khan, whose army had retired from before Kandahar and taken up a position in the hills N.W. of it. In this task Roberts was completely successful, dispersing the enemy and capturing all his artillery, including our guns lost at Maiwand.

In the relief of Kandahar Roberts just forestalled a force under Major-General Sir R. Phayre, which advanced from Quetta, and reached Kandahar on September 3rd. This force had immense difficulties to overcome; on the receipt of news of Maiwand, the whole countryside from Sibi to Chaman rose in arms, and the usual difficulties of collecting supplies and transport were increased by scarcity owing to the failure of the rains for the past two years; while intense heat made marching difficult.

For many months the question of the retention of Kandahar was debated, it was thought that its evacuation, before Abdurrahman had consolidated his power, would lead to anarchy. It was eventually decided, however, to evacuate all S. Afghanistan, retaining only Chaman. The return march to India, in April and May, 1881, was uneventful. From that time the only representative of British rule in Afghanistan was an Indian officer as Political Agent at Kabul.

Little mention has been made of the L. of C.; but the difficulties here were even greater than during the First Afghan War, as the inhabitants were much better armed. To take the period immediately before the final evacuation of Kabul, when the force there

consisted of one infantry division and one cavalry brigade, on the L. of C. from Peshawar to Kabul, both exclusive, were three cavalry regiments and 18 infantry battalions; at Peshawar were a cavalry brigade and a strong infantry brigade. The Kurram force, whose role during the summer of 1880 was to protect an alternative route from India to Kabul and Ghazni, consisted of one cavalry and two infantry brigades. Kandahar and Kalat-i-Ghilzai accounted for one weak cavalry and two weak infantry brigades, while on the L. of C. from Sibi westwards were three cavalry regiments and 14 infantry battalions. The L. of C. troops, in effect, equalled what would now be called the striking force.

Though the Sappers had little work of a spectacular nature, they were busily employed on every line of advance. The defence of Sherpur and Kandahar gave them work of a most congenial kind. Nearly every S. & M. Company formed part of the force at one time or another. Capt. Leach, R.E., attached to the Survey, gained the V.C. for covering the retirement of his party and escort, after some hand-to-hand fighting, during which he received a knife cut on his left arm.

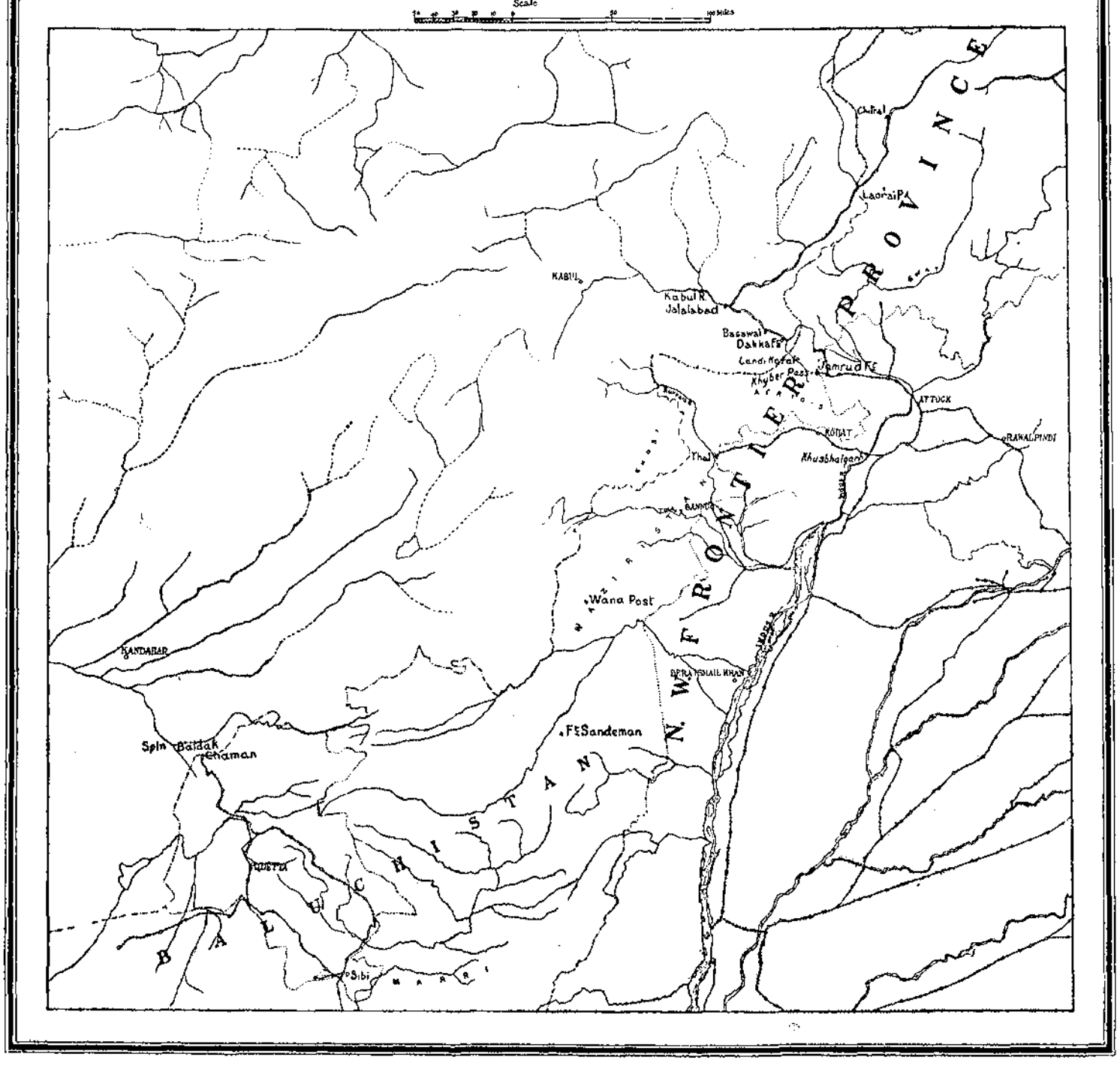
PERIOD BETWEEN THE SECOND AND THIRD AFGHAN WARS.
(*Map III.*)

Amir Abdurrahman and his son and successor Habibullah ruled over a country which was probably more united and peaceful than since the days of Nadir Shah. There were, of course, internal troubles, and Russian aggression on the North Frontier, culminating in the Panjdeh incident of 1885, nearly led to war between Great Britain and Russia. But, generally speaking, except among frontier tribes, the authority of the Amir, if not undisputed, was paramount.

The Panjdeh incident led to the exact delimitation of the Russo-Afghan border. The west and south borders were also defined, and an agreement made in 1893 described the spheres of influence of Great Britain and Afghanistan among the frontier tribes. The boundary is known as the Durand line, and between this and the old administrative border lie the Wazirs and Afridis and many other tribes we have had to punish so often in the past for their raids on British territory.

Railway communication in India was improved. The N.W. Railway was carried on as far as Jamrud and Kohat, and from the latter place a narrow gauge line ran to Thal. Further south, the line from Sibi was taken *via* Quetta to Chaman, where material was stored for an extension to Kandahar. Railway bridges crossed the Indus at Attock, Khushhalgarh, Sukkur and Kotri. But there was no railway connection to the west of the Indus, except between Kotri and Sukkur.

MAP III
AFGHANISTAN
ILLUSTRATING THIRD AFGHAN WAR



Road communication was not so far forward. The Grand Trunk Road ran alongside the railway up to and through the Khyber, but Quetta had practically no road communication with India, and the only lateral road was one connecting Peshawar with Kohat, Bannu and Dera Ismail Khan, whence a series of unmetalled tracks joined the Quetta system. Karachi was, and still is, isolated from the rest of India.

The Great War produced a series of minor frontier campaigns from Swat in the north to the Marri country in the south. Afghanistan, though attempts were made by German agents to attach it to the Central Powers, remained neutral.

To prevent the arrival of German agents, we and the Russians stationed small forces along the Perso-Afghan frontier. On the Russian collapse, this force, known as the East Persia Cordon, extended northwards to the N. Persian border. By November, 1918, this force had reached and passed Merv in Trans-Caspia; the line of communications was 1,250 miles long, less than half of which was by rail.

In India itself, in addition to a covering force on the frontier and internal security troops, a force consisting of four divisions was kept in readiness for a limited offensive. The British troops in these divisions were almost all territorials, as all except nine battalions of regular infantry and a few regiments of cavalry and brigades of artillery, had been sent overseas. By this time, of course, the territorials had hardened into first-line soldiers, but by the spring of 1919 were naturally anxious for relief, which could not be effected until new regular battalions were available from home.* The Indian troops were largely recruits, and it was calculated that with each battalion there was an average of 1·7 pre-war British officers only. Severe disturbances, the worst since the Mutiny, took place in April, 1919. India was almost denuded of medical and engineering stores, and the hot season was one of the severest known. The Afghans could not, in fact, have chosen a better moment for the invasion of India.

In Afghanistan things remained quiet until, in February, 1919, the Amir was assassinated, and was succeeded by his young son, Amanullah. The War party immediately took up the reins of power and, at the beginning of May, proclaimed *jehad*.

The Afghan regular army consisted of about 7,000 sabres, 42,000 rifles and 260 guns. A large number of tribesmen, estimated at 120,000, well armed with modern rifles, was available to act in conjunction with the regulars, and there were potential allies in every tribe along our border.

* Demobilization, closed during the disturbances of April, 1919, was opened again on May 5th, but closed the next day on the outbreak of the Afghan War.

THIRD AFGHAN WAR.

On May 3rd, 1919, Afghan troops occupied certain springs in disputed territory in the Khyber, stopped a caravan with a militia escort, and killed five coolies employed by the M.W.S. They were then in a position to cut off water from Landi Kotal, an important post in the Khyber. The Government of India, therefore, resolved on war, and the Field Army was mobilized.

The arrangement of the forces at our disposal was:—

The N.W.F. Force, comprising three infantry divisions, on the Peshawar line, under General Sir A. Barrett.*

The Baluchistan Force, comprising one infantry division, on the Quetta line, under Lieut.-General Wapshare.

The Waziristan Force (originally part of the N.W.F. Force), under Major-General Climo.

The first problem confronting the N.W.F. Force was to clear the Khyber. This was effected in two actions on May 9th and 11th, and on the 13th Dakka, 8 miles within the Afghan border, was occupied without resistance. But a mounted reconnaissance the next day towards Basawal revealed the presence of Afghans in large numbers; these followed up the retiring cavalry, who had to charge the enemy on their way back to Dakka. The enemy then occupied a position immediately west of Dakka, from which they were dislodged the next day with heavy loss. By this time, two divisions had been concentrated between Peshawar and Dakka, and preparations were in hand for a forward move of four marches.

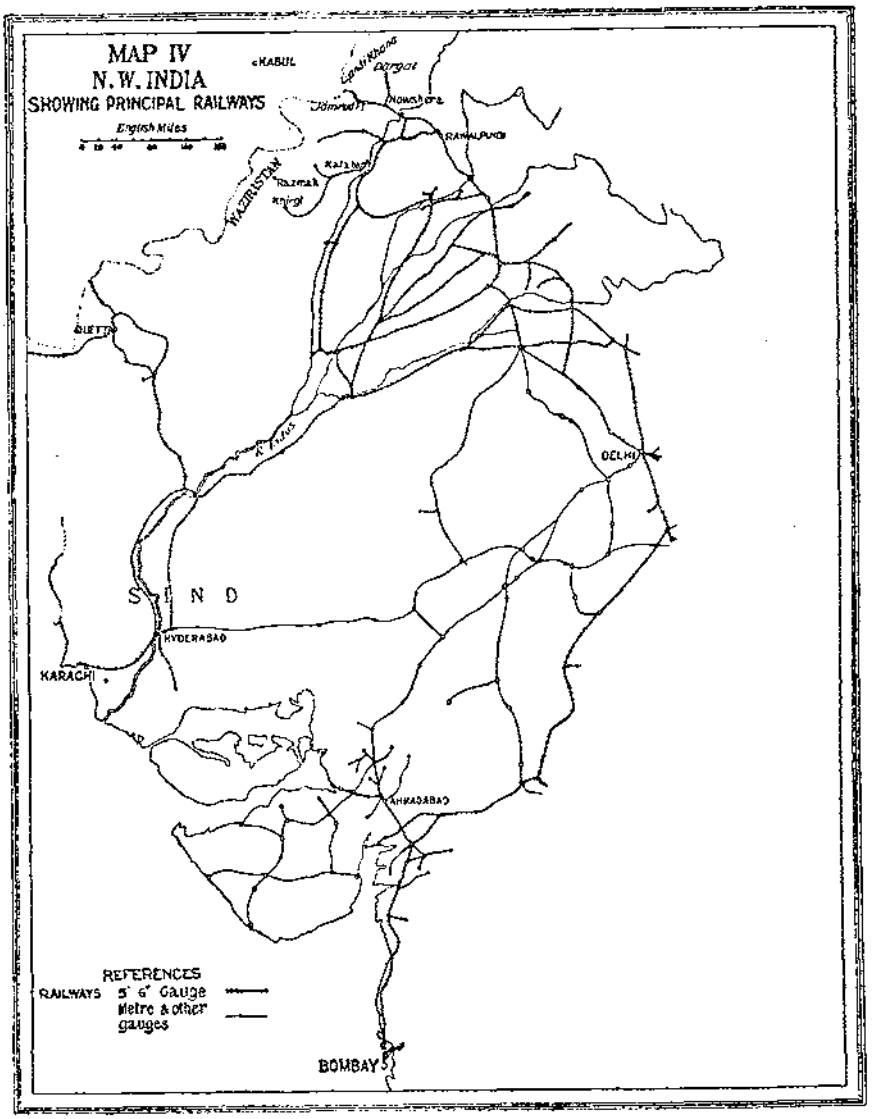
The Royal Air Force, though only old machines were available, carried out some important bombing raids Jallalabad was bombed on three occasions, on one of which a parade of 2,000 troops formed an excellent target. On May 24th, a R.A.F. officer bombed Kabul, and there is no doubt that this event contributed largely to inclining the Amir towards peace.

To the north, the Afghans invaded Chitral territory, where a force, consisting of an Indian battalion and the Chitrali scouts, signally defeated them and captured four guns. A later attempt, in July, to cut the communications of the Chitral force, near the Loarai Pass, was similarly defeated.

Further south, the possession of Khost gave the enemy a salient whence they could threaten our forces in the Kurram and the Tochi. They were not slow to take advantage of their position, and on May 27th advanced against Thal, occupied the city and besieged and shelled the fort and camp. The 16th Division, en route for the Khyber, was diverted to Kohat, whence, on May 31st, a relief force under Brigadier-General Dyer advanced and occupied Thal.

* Sir A. Barrett had, as a subaltern, taken part in the Second Afghan War.

In the Waziristan area, the policy before and during the Great War had been to occupy the Tochi and certain posts in the south of the country by militia, largely recruited locally. Up to date the policy had been fairly successful, but it was feared that, should



Afghan regular troops appear in support of the Mahsuds, the loyalty of the militia would be unduly strained, and consequently orders were issued for the evacuation of the upper Tochi and Wana. The latter operation proved very difficult. The loyal remnants of the garrison reached Fort Sandeman in Baluchistan after losing 4 B.O.s

killed and 2 wounded, out of a total of 8. Among the killed was Lieut. McCorstie (25th London Regiment), Garrison Engineer, Wana. The history of the re-occupation of the posts belongs to a later period than it is proposed to cover in this narrative.

The Baluchistan force had in front of it a hostile force of about 16 battalions and 5 regiments, with about 40,000 tribal auxiliaries. They had also an extensive area to guard where disturbances were probable. They were not strong enough in transport to undertake any considerable offensive, but had to content themselves with the capture of Fort Spin Baldak, the Afghan reply to Chaman. The fort was captured on May 27th, after an operation which reads more like a page out of Napier than any modern battle, for scaling ladders formed part of the equipment of the attackers. After 2½ hours' bombardment the fort was rushed, and of the garrison of 600 all, except 30, were killed or taken prisoner.

There was considerable danger that the Afghans would invade Zhob; Mahsuds and Sherannis did indeed cause us one of the greatest reverses ever sustained in trans-frontier warfare. They successfully attacked a convoy near Fort Sandeman, capturing two mountain guns and the greater part of the transport. When a punitive column was at last available, the tribesmen had dispersed.

The Amir sued for peace as soon as he saw that the invasion of India was not such an easy proposition as he thought. An armistice was declared on May 31st, and conditions of peace finally laid down on August 8th at Rawalpindi. They included the demarcation of the frontier in the Khyber, and the renunciation by the British Government of all control over the foreign affairs of Afghanistan.

EVENTS SINCE THE THIRD AFGHAN WAR. (*Map IV.*)

The operations in Waziristan, 1919-25, already alluded to, resulted in the establishment of a British force at Razmak, with good road communication with India. It may be said that this part of our frontier is more peaceful than ever before.

In 1928 civil war broke out in Afghanistan, resulting in the abdication of Amanullah. Order has not yet (Oct., 1929) been restored.

Note:—The Pollock Prize was founded to commemorate the services of Major-General Sir George Pollock, in the 1st Afghan war. The gold medal as now presented bears on the obverse his portrait with the words "Pollock, Cabul, 1842," and on the reverse:—

"Pollock Prize, Royal Military Academy: Founded by the British inhabitants of Calcutta, to commemorate the eminent services of Major-General Sir George Pollock, G.C.B., and awarded to the most distinguished cadet of the season."—ED. *R.E. Journal.*

LARGE SCALE SURVEYING IN THE TROPICS.

By MAJOR S. W. KIRBY, O.B.E., M.C., R.E.

It is probable that the words "Large Scale Surveying" may convey a vision of the Ravelins at Chatham to many who have served their apprenticeship at this type of work at the S.M.E. It may, therefore, be of interest to study the problems involved and the methods employed for their solution, when such work was carried out in the field under the more difficult conditions to be found in the tropics.

It fell to my lot, when in charge of a topographical survey, to be called upon to undertake at short notice the survey on the scales of 1/2,500 (vertical interval 10 feet) and 1/360 (vertical interval 5 feet) of a number of areas varying in size from an acre or two, to a square mile. On investigation these areas, with one exception, proved to be either covered by tropical jungle or thick cultivation. In the former case the view from any spot was limited to a few yards, while in the latter, though the view was greater, it was seldom more than 50 yards. For many reasons it was impossible to clear the jungle or cultivation prior to the survey, while the completed maps had to stand the test of accuracy when the vegetation was cleared at a later date, prior to building operations.

In this particular case it was essential that each area should be in its correct position with relation to the others and to the earth's surface: in addition the contours of each had to be referred to the same datum point and had to be correct to mean sea-level within a few inches. The work, therefore, fell into four distinct portions.

(*a*) The trig. work necessary to fix the areas in their correct positions and the provision of a datum point for the heights.

(*b*) The close control within each area on which the actual survey would be based.

(*c*) The clearing of the necessary pathways in the jungle to permit the surveyor to carry out his work.

(*d*) The actual survey of detail and contours.

The methods employed for the actual survey of the areas varied with the scale adopted and the type of tropical vegetation with which each was covered. In order to prevent any delay due to surveyors being held up for lack of data or for the necessary pathways in the jungle,

these four operations were carried out by separate parties. The first two operations were placed in charge of officers, who were also responsible for the necessary clearing work, while the fourth operation was carried out by N.C.O.s working in pairs.

There was no difficulty in making these arrangements, as I was in command of a Colonial Survey section, consisting at that period of four officers and 15 N.C.O.s engaged on a topographical survey within 40 miles of the scene of this large scale work. The necessary officers and men were, therefore, relieved from their work on the topographical survey so that each of these operations were started as it were in echelon, one behind the other, so that there was neither waste of time nor unnecessary overlapping.

The trigonometrical work and levelling. The country in which the large scale survey had to be undertaken was covered with a primary triangulation, and in those areas where topographical work was in progress this triangulation had already been broken down. The inclusion of those areas to be surveyed on the large scale presented, therefore, no serious difficulties as to triangulation, and the larger areas were supplied with two or more trig. points and the smaller ones with only one. Greater difficulty was, however, experienced with the heights. It was soon discovered that not only were the trigonometrical heights of the primary points in error locally, but that the whole system required a constant correction to bring it in true relation to mean sea-level on this part of the coast. Fortunately the neighbouring town had a bench mark established by the naval authorities whose height above mean sea-level was known. From this bench mark a line of levels was run out to those areas within reach. Some areas, however, were cut off by a mangrove swamp and areas of jungle in which any attempt at precise levelling was obviously impossible, or were situated on neighbouring islands. A line of levels was therefore run to two principal trigonometrical points and transferred from them to these areas by carefully observed reciprocal vertical angles, precautions being taken to avoid refraction errors as far as was possible.

The Close Control. Each area, having been provided with one or more trigonometrically fixed points, a starting azimuth and datum level, was encircled or split up by trigonometrical traverses. As the measurement of the legs of these traverses by surface chains or tapes was found to be too inaccurate, especially in those areas which were hilly and covered in jungle, a more up-to-date method was employed. A graduated steel tape was supported every fifty feet by means of a stake driven into the ground and subjected to a known tension. Measurements were taken to a raised mark, similar in idea to the tripods used in bases measured by Invar wire hung in a catenary, (see S.M.E. pamphlet), and allowance made for sag and

slope. The improvement in accuracy was immediately noticeable, and over the most difficult ground with a single measurement for each leg an average closing error of only 1/9,000 was obtainable.

In the case of those areas to be surveyed on the 1/2,500 scale, the height control was carried forward by means of reciprocal vertical angles observed with a theodolite, a staff with a movable vane being used as a mark. This method, much speedier than levelling, gave an average closing error of some three inches per mile, and as no single traverse ever exceeded a mile in length this was amply accurate for the purpose in view.

In those areas to be surveyed on the scale of 1/360 which incidentally were always small, four hundred yards square or less, the height control was obtained by the usual method of levelling. In considering height control, it should be remembered that the surface of the earth in this type of country consists of some two to three feet of decaying vegetation, and is by no means a stable surface to work to. In fact, no two men working separately would produce quite the same results. It was thus obviously a waste of time to attempt to obtain rigorously accurate results.

The Clearing Operations. The cutting of pathways in the jungle to facilitate the work of the surveyor was carried out by gangs of coolies under headmen, who were experienced in the use of chain and compass. This work was supervised by the officers who were employed on the theodolite control in the near neighbourhood. It was found that three coolies could cut a three-foot pathway leaving a clean ground surface at the rate of three to four hundred yards a day, the larger trees being sidestepped, the smaller being cut down.

The Survey of Detail and Contours on the 1/2,500 Scale. The surveyor was supplied with the grid co-ordinates and heights of all control points within his area and, in those cases where the area was covered with jungle, a diagram of the pathways cut prior to his taking over the work. The methods employed naturally varied with the type of vegetation met with and are explained below.

(*a*) *Jungle covered country.*

Parallel pathways were cut in the jungle at an average distance apart of thirty yards, which on this scale represents 0·43 inches on paper. This distance was chosen for the reason that in jungle a view is usually obtained up to ten yards on either side of a pathway or clearing. Thus when the contours were even and straightforward they could be fixed on each pathway (every 0·43 inches apart on paper) and put in by eye over the intervening distance, while in those cases where the country was difficult they could be fixed on each pathway and at points ten yards on either side of the pathway, thus ensuring an accurate fixation every 0·14 inches on paper.

The surveyor having plotted his grid and control on his board proceeded as follows :—

(1) He chained along the control traverse between fixed points, plotting on the board the ends of the pathways. At the same time he obtained the ground heights of the pickets left at the end of each of the pathways, using an Indian clinometer as a level in conjunction with a staff having a movable arm and graduated in feet and decimals of a foot.

(2) Using his clinometer in the same way he then moved down each pathway in turn, finding the crossing points of the contours and if necessary their location at a distance of ten yards on either flank. The heights carried through each pathway were closed on the picket at the further end and any necessary adjustment then made. If the work was carried out carefully the closing error in a three hundred-yard-pathway was generally less than a tenth of an inch.

(3) He then surveyed each pathway with a chain, picking up the detail and the crossing points of the contours and using offsets to secure the position of pickets marking the contours on either flank.

In actual practice the last two of these operations were carried out simultaneously, the chainmen working just behind the surveyor. The work was plotted in the field direct on to the board, so that any error could be detected immediately and corrected on the spot.

(*b*) *Country covered with tropical cultivation.*

Under these circumstances a view was generally obtainable up to fifty yards in any direction ; it was therefore unnecessary to cut any pathways. It was, however, found to be quicker and more economical to use the method explained above, *mutatis mutandis*, than to employ *in toto* the textbook methods.

The contours were located on parallel straight lines, and on either side of these lines as far as the visibility would allow, but the average distance apart of these lines was some 70 to 100 yards, instead of the thirty normal in jungle country. In the most common type of cultivation the trees are planted in straight lines and at regular intervals ; there was, therefore, no difficulty in running the lines mentioned above without the use of a compass except in isolated cases.

The surveyor therefore proceeded as follows :—

(1) He surveyed the control traverses both for detail and to obtain the crossing points of the contours, plotting direct on to the board.

(2) He laid out parallel lines, finding the crossing points of the contours and laying out his contours for a distance of thirty to fifty yards on either side of the line. The heights were closed on a control point at the further end. It was found more convenient to use a level in place of a clinometer for this work, since one setting of the level sufficed for laying out the whole of one or possibly two contours, whereas the clinometer had to be relevelled for each observation.

(3) He surveyed each of the straight lines with a chain, picking up the detail and contours. In those cases where the offsets to pickets denoting the position of the contours were too long, an intermediary line was surveyed. Each line was tied in position by chaining to the nearest control point. The work was done as a rule on an auxiliary board and adjusted and drawn on the fair board in camp.

In actual practice, two surveyors were usually employed on an area of this nature, and the work so arranged that operations 2 and 3 as explained above were carried out separately, the surveyor who undertook operation 3 following close behind the surveyor who undertook operation 2. This was found to produce the speediest results.

The Survey of Detail and Contours on the 1/360 *Scale.* The scale in this case being so very large, it was necessary even in this type of country to use more refined methods. The surveyor was provided with the grid co-ordinates of his control points and the height of one control point to act as datum. The methods employed varied as before with the type of vegetation and are explained below.

(*a*) *Jungle-covered country.*

Parallel pathways were cut in the jungle at an average distance apart of ten yards. This distance represented one inch on paper. In places where the country was flattish and the contours even and uniform, a point fixed every inch along the contour gave sufficient accuracy. Where the country was steep or broken, the contour was located on either side of the pathway to a distance of three yards, thus providing a fixed point on the contour every 1/3rd of an inch along its length.

The method employed was as follows:—

(1) Pickets were driven into the ground wherever one of the pathways crossed the control traverse. A line of levels starting at the datum point was run round the control traverse, fixing the heights of each of these pickets and the crossing points of any contours that happened to cut the traverse.

(2) Using the Indian clinometer as a level (as explained earlier) the crossing points of the contours on each of the pathways were obtained and points on either side if necessary. Pickets were driven in to mark these points.

(3) All lines were then surveyed by chain and booked in the normal way.

(4) The area was then plotted in the office, taken on the ground for examination, corrected and finished in the usual manner.

(*b*) *Country covered with tropical vegetation.*

For a small area the view being more or less unlimited the normal textbook methods were employed, with the exception that the Indian clinometer was used in place of the level if the country was very steep.

Conclusion. There are two points of special interest in the procedure outlined above.

(1) The use of the Indian clinometer in place of the level for this kind of work. The value of the former lay in the fact that the country was usually so steep and the view always so limited that the normal advantages of the level were counteracted, and the lighter weight and speedier setting up of the clinometer gave it a decided advantage over its more accurate rival.

(2) The use of the grid method* for large scale work as well as for topographical work in a country covered with tropical vegetation. It is submitted that this method is the only really practical way of surveying a country of this nature on scales from 1/25,000 to 1/360. By its use the possibility of gross errors are reduced to a minimum (a check being automatically provided at frequent intervals) and within very small limits a similar standard of accuracy is obtained by different surveyors, and in addition there is no doubt as to the country being covered adequately. It should be remembered, however, that such a method is unsound for small scale work (unless severely modified) and is wasteful of effort in mountainous country.

On the whole the advantages of the method outweigh its disadvantages, and the proof of the pudding being in the eating, the successful results produced at a rate above the normal for the type of country prove that its application was sound.

* See article, "A Colonial Survey Section in Malaya, 1923-1926," *R.E. Journal*, December, 1927.

PROPOSED NEW WAGON REPAIR DEPOT, EGYPTIAN STATE RAILWAYS, GABBARY, ALEXANDRIA.

By MAJOR D. J. MCMULLEN, R.E.

PREFACE.

THE scheme for a proposed new wagon repair depot set out on the following pages is a general scheme put forward from the point of view of the works manager.

Such details as have been found necessary from experience are specified, but, in general, the various departmental officials responsible for the provision of buildings, permanent way and track equipment, electrical equipment, and mechanical and machine tool equipment, will have to get out the details of their section of the project in accordance with the approved scheme.

Some details of the arrangement are directly due to the depot being schemed to employ Egyptian labour, but the main principles hold good for use in any country.

GENERAL NOTES.

The work that will have to be undertaken by these proposed shops is :—

(1) The 2-yearly overhaul of 8,250 equivalent 4-wheel vehicles per annum, *i.e.*, half the total wagon stock, which consists of approximately 12,570 4-wheel, 620 6-wheel, and 1,500 bogie vehicles. A 6-wheel vehicle has been taken as equal to one and a half 4-wheel vehicles, and a bogie vehicle as equal to two 4-wheel vehicles.

(2) Heavy repairs and rebuilds, such as fitting new steel floors, new steel bodies, new steel roofs, new frame members, and rebuilds after accidents to approximately 1,500 vehicles per annum, of which 1,000 are included under item (1), having come into shops for 2-yearly overhaul.

(3) Minor repairs due to accident and breakage in service, which cannot easily be carried out by outside staff, to approximately 1,750 vehicles per annum.

This gives a total 10,500 equivalent 4-wheel vehicles per annum. Allowing an average number of working days as 300, the output must be 35 vehicles per day.

Accommodation is provided in the wagon repair shops for 120 vehicles at comfortable spacing. This allows an average of just over three days per vehicle in shops.

Actually, the normal 2-yearly overhaul takes 2 days. This consists of completely stripping off all the running gear, draw and buffing gear, and renewal or replacement of same, straightening and repairing axleguards, renewing slack rivets, patching cracked frame members, repairs to doors, fastenings and fittings. Heavy repairs and rebuilds naturally take a longer period, in varying degrees, bringing the average up to 3 days per vehicle.

The shop has, however, been laid out with a view to dealing with the maintenance of an increased stock when the extension of the railway traffic makes this necessary. There is sufficient room, handling appliances, and auxiliaries to permit of the staff working on the normal 2-yearly overhaul to be increased, so that the time for this standard operation could eventually be reduced from 2 days to 1 day, by working up to 2 squads in the place of 1. This, however, should not be necessary for many years to come.

In addition to repairing actual vehicles, these proposed shops will have to manufacture and repair, for supply to outstations, all spare parts required for the maintenance of goods vehicles in service.

This supply being through Stores Dept., detail stores, except in the case of wheels and axles, are supplied in wagon loads direct to the districts concerned in exchange for worn ones.

In considering the work to be done, it has been assumed that, as at present, all drop stampings, including drawbars and buffers, would be supplied from the drop forging plant at Cairo, and that similarly all new cast steel axle boxes would be supplied from abroad finished ready for use.

No provision has been made for the manufacture in bulk of bolts and nuts, washers and rivets, as these can be more economically purchased in the open market.

The principles that have been adhered to in considering the general layout are, firstly, that all vehicles should be sorted into classes before entering shops; and that, secondly, as much as possible the movement of vehicles should be a forward progression without the necessity of frequent back shunting; and, thirdly, that ample provision must be made for dealing expeditiously and economically with the new and repaired materials and parts required daily, together with the disposal of the worn and scrap articles.

As vehicles with wooden floors and sides are gradually being scrapped and replaced by all-steel vehicles, the importance of the wood-working shops is steadily decreasing, and hence its somewhat unfavourable position in the layout.

In considering the general principles of the layout of a wagon repair depot there are 2 main systems that may be employed for collecting and sorting the vehicles for repairs, firstly by shunting and secondly by means of traversers and capstans.

The advantages of the latter method are :—

(1) That the yard can be very much shorter than that required when all the shop roads have to be fed by turnouts.

(2) That odd vehicles can be picked out of a rake and taken at once to any point, *i.e.*, a mixed rake of vehicles can be pushed or pulled on to a traverser one by one, without previous shunting, and can be delivered individually to any desired shop line.

These advantages make distribution by traversers very suitable for locomotive and carriage shops which are only handling a comparatively small number of units of widely varying types. But for wagon repair work a traverser is not at all suitable.

Firstly, wagon stock consists of a large number of units, the majority of which are exactly similar. To sort these units into similar groups with a locomotive is therefore a comparatively simple proposition.

Secondly, the majority of lines in the shops being filled with a rake of vehicles all requiring exactly similar repairs, probably on a time process basis, it follows that all these vehicles will be completed and ready for removal at the same time. One pull with a shunting locomotive and the whole rake is removed, to be followed at once by another complete rake for repairs, pushed in from the other side.

To remove these vehicles by traverser and electric capstan and replace them with others by this method would be a longish job, as only 2 or at the most 3 vehicles could be accommodated on the traverser at one time.

When a rake of vehicles is completed at mid-day, this change over must be carried out during the dinner hour, to avoid idle time, for which operation a traverser is certainly not suitable.

In addition, the use of traverser and capstans would not enable shunting locomotives to be dispensed with, as the large number of vehicles to be handled would still need shunting for feeding on to the traverser road and for removal from same.

Provided, therefore, the necessary length of site can be obtained, no traversers should be installed, and all wagon sorting will be carried out by two electric battery shunting locomotives, each driven by one man. An electric capstan should, however, be provided at the weighbridge for use when re-taring vehicles.

General Layout.

Referring to the plan, it will be seen that this gives a schematic layout which will of necessity have to be arranged to suit the final site chosen. The same principles of layout should be adhered to, but the tracks, etc., can be curved and rearranged as may be necessary.

The general principles of the flow of vehicles for repairs as given in this schematic layout are as follows :—

(1) A set of balloon sidings (not shown on the plan for want of space) capable of accommodating 400 vehicles plus a through road, are situated immediately outside the shops yard gate. All " cripple " vehicles for repairs will be placed in these reception and sorting sidings by the Traffic Dept., as sorted out from the incoming trains or from the various yards.

(2) The shops east yard electric shunting engine will pick up the desired number of " cripples " at the reception sidings, and after sorting them as required, will run round to the east and propel them into the shops east yard and further sort them out into the different lines of the different bays according to type of vehicle and nature of repairs.

When required these " cripples " will be propelled into their correct position in shops by this engine.

(3) It may here be mentioned that all 2-yearly overhauls will eventually be done on a time process basis.

(4) When repairs are finished, the vehicles will be withdrawn from shops by the west yard electric shunting engine, which, working up into the shunting neck provided, will sort them out into either the paint shop, the carpenters' shop, finishing shop, or straight through to the weighbridge.

Those vehicles requiring to go to the carpenters' shop will have to be pulled out again, this being the only back shunt in the system ; those passing into the paint shop and finishing shed are passed straight through to an automatic self-recording weighbridge for re-taring.

(5) After re-taring, vehicles will be collected by the east yard shunting engine and placed in the repaired vehicle departure sidings (these sidings being outside the shop gates are not shown on the plan), where they will be left at the disposal of the Traffic Dept. to withdraw at the latter's convenience.

SYSTEM OF REPAIRS.

The principle of the system of repair work is as follows :—

(1) In the wagon repair shop, which will consist of 4 wagon repair bays and 1 wheel bay, only work *actually on the vehicle* will be carried out. There will, therefore, be no fitters' benches in this shop, all bench work and manufacturing work, both fitting and machine work, will be carried out in a separate shop arranged to the north of the main building. A few vices only will be provided for holding items as may be necessary.

(2) The only exception to this principle is the wheel-bay work, which will be carried out in the centre bay of the repair shop in order to avoid unnecessary handling of such heavy articles as wheels and axles. Similarly the eastern third of this bay will form the bogie repair shop.

In addition, in the centre bay there will be a punching and shearing machine and drilling machines to deal with patches, roofing sheets, axleguards, solebars and other members of a similar nature, all of which have to be marked off on the individual wagon. The crane runways from this centre bay will run out over a wheel park and rubbish-collecting trucks to the west and over bosh tanks, scrap bins, and "rubbish" trucks to the east.

(3) The general principle of the movement of materials and spare parts will be, that new and repaired articles will enter the shops transversely across the centre, and will be distributed longitudinally. The scrap, dirty and damaged parts will be passed out of the ends of the shop to be loaded up, or cleaned or repaired in the manufacturing shop, and then returned for service through the centre of the repair shop, or passed into detail stores for stock.

(4) The position of the stores, auxiliary, machine and fitting, smiths', carpenters' and paint shops are self explanatory.

(5) The finishing shed alongside the paint shop is merely a roofed-over space with open side for dealing with such items as box truck door rollers, runner bars, door fastenings, and petroleum tank fittings, which have possibly not been able to be completed during the time process work or which may have been overlooked in the shops and have been checked by the examining fitters.

As far as possible all work will be completed in the shops.

(6) Shunting locomotives :—

3 electric-battery shunting locomotives (to handle up to 50 empty 10-ton wagons up to 8 miles per hour and 30 up to 12 miles per hour) will be required ; 2 for service and 1 for spare.

This type of shunting locomotive is considered the best for this particular work, as, firstly, it can be worked by one man ; secondly, it does not consume any coal (or other fuel) when standing stationary ; thirdly, there is no danger of fire due to sparks while working inside shops, nor is there any smoke or dirt to foul the overhead cranes and roof ; fourthly, there would be no need for water columns with consequent mess in the yards ; and fifthly, it can be charged up at night, after shops are closed down, when the power-house load is light.

(7) The time office will be arranged as a gate-house over the main gateway, with ticket issuing rooms to left and right below.

(8) No men's clothes cupboards will be allowed inside the shops, nor any washing. All these cupboards will be placed in two long buildings either side of the main gateway and time office, and provided with benches for taking meals and suitable washrooms. First-aid room will be provided alongside the time office.

(9) Unfiltered water will be laid on for the hydraulic system, bosh tanks, wheel press, low pressure fire hydrants, shop boilers and paint shop. Filtered water will be laid on for drinking and men's washing at the washrooms by the main gate, and for drinking purposes alongside the various lavatories, and also at the offices.

High pressure fire hydrants will be provided as necessary.

MATERIAL DISTRIBUTION SCHEME.

It is necessary, now, to consider the movement of materials, new and repaired spare parts, worn and unserviceable parts, scrap materials and rubbish, as the efficient and economical solution of this problem is the most important question to be studied.

On referring to the plan, it will be seen that the stores and manufacturing shops will be connected to the repair shop by a system of double line 18″-gauge tramways.

The modern practice in England is to replace tramways with either electric battery- or petrol-driven trolleys, either with or without trailers, and in lieu of rail tracks, suitable asphalt or concrete pathways are provided.

This method is more flexible than a rail system, but it is not considered that power-driven trolleys are so suitable for use with Egyptian workmen and labourers as is a properly-arranged tramway system.

Firstly, a trolley has to be steered as well as driven, which involves considerable skill, and of necessity a highly paid man, and even then frequent accidents.

Secondly, from experience at Gabbary, it would be very difficult to keep a clear pathway for a trolley route, as, without the ocular evidence of actual rails, the uneducated labourer and workman would be constantly dumping materials and parts on the trolley route.

Thirdly, power-driven trolleys, unless handled with great care, need considerable and expensive maintenance.

An 18″ gauge has been selected for the proposed tramway system as being more flexible than the 2-ft. gauge. The smaller gauge allows for small radius curves and shorter crossovers, and gives ample capacity for the work required.

The tramway trolleys will be of 1,000 kilos capacity, and be

fitted with double row self-aligning S.K.F. cage ball bearings packed with grease. The trolleys will normally have a flat loading floor, but should be provided with detachable steel bins for carriage of small parts. They should also be provided with suitable detachable push handles.

Materials and parts for delivery to the repair shops will normally be taken from either the stores or the manufacturing shops by trolley through the centre of the repair shop with alternative delivery lines along the east and west ends.

Parts for repairs and second-hand materials for further use will be loaded on trolleys for return to the manufacturing shop by the return lines either from the end tracks or from the centre.

Normally, the greater portion will be brought back by the return line tramway from the east end of the repair shop, but the system is sufficiently flexible with its double line tracks and crossovers to allow for variations as may be most expedient.

The longitudinal distribution of material and parts (other than wheels and heavy items) throughout the repair shop will be effected by Morris 1-ton electric hoist blocks, with push travel, running suspended from Morris overhead runways carried from the shop columns.

Along the centre 4 rows of columns these runways will be double line, one line each side of the columns, with suitable crossovers.

Along the outer rows of columns there will be a single line runway which will be provided with suitable lie-by branches.

All these runways will be extended over the tramway tracks at the east and west ends of the repair shops.

The new material and parts will be distributed down the bays by the hoist blocks, either the individual items being slung several at a time, or the trolley bin, or possibly the complete trolley with a light load (750 kilos load, 250 kilos trolley).

Except for the outer lines the blocks will run on an up and down line system to prevent delay to one another.

The worn materials and scrap resulting from the wagons will be collected by the hoist blocks and delivered to the trolleys for disposal; if dirty or scrap, to be taken to the east end to the bosh or scrap bins; or if clean and useful, to be taken direct to the manufacturing shop either by the centre tramway or the west end line.

The reason for the necessity of the provision of longitudinal runways for the distribution and collection of materials and parts is that the repair shop will be half as long again as our existing shop, and therefore to avoid delay the overhead cranes must be used entirely for their legitimate work of lifting wagons, bogies, wheels and axles and heavy members.

All distribution of smaller articles must be carried out by the runways, thus allowing 2 cranes to suffice in each lifting bay.

Disposal of scrap will be undertaken by the east 5-ton overhead travelling crane in the centre bay, which will work out on girders over the scrap bins and "rubbish" trucks. This crane will be provided with a magnetic grab for picking up, sorting and loading scrap, a small rotary converter being carried on the crane itself.

The west 2½-ton overhead travelling crane in the centre bay will work out on girders over the wheel park to deal with all wheels and axles. This crane will also load scrap tyres and axles into the respective "rubbish" trucks.

Rubbish and ash trucks will be provided throughout the depot on suitable dead ends to collect sweepings and ashes.

Wagon wheels and axles will be rolled by hand down the centre wheel tracks in the repair bays and the wheel bay on to special 18"-gauge wheel trolleys, and will then be pushed across transversely to the desired position, where they will be rolled off on to the wheel track concerned. Two special 18"-gauge transverse tracks will be provided across the centre of each half-bay for this service.

Complete bogies will be lifted by the overhead cranes on to the special standard-gauge transverse track provided, and then pulled across to and from the bogie repair shop by an electric capstan and suitable snatch blocks.

OUTLINE SPECIFICATIONS FOR THE VARIOUS SHOP BUILDINGS AND ACCESSORIES.

(1) *General.*

In order to use economically existing steel work from Gabbary and the old Cairo locomotive shops, the buildings have been laid out with standard bays of 52 ft. span, taking overhead cranes 49' 6" span where these are to be installed.

This enables all existing cranes, shop columns, roof trusses and steel work to be used in the proposed new depot.

All rails used for standard-gauge tracks inside any of the shop buildings will be heavy tramway type section (say 90-lb. rails) bedded on concrete foundations, and all crossings, both with wheel tracks and tramway tracks, will be of the solid cast manganese steel type as used in road tramway track.

The 18"-gauge tramway track will be laid with 35-lb. rails, and where this track is inside shops or stores or runs along paved routes, these rails will be of the tramway type bedded on concrete foundations. Ordinary light Decauville tramway track is quite unsuitable for permanent shop work.

For all shops, stores and paved routes the floor-level will be ¼" below the top of the rails.

The top of rails being ¼" above floor-level prevents worn tyres crushing the paving blocks, but at the same time is not enough to prevent the floor being practically flush. Floor-level also will be

½ metre above the surrounding ground-level in order to prevent flooding during heavy rainstorms.

All roof lighting proposed will be by frosted glass to prevent entrance of direct sun rays.

(2) *Wagon Repair Shop.*

This shop will consist of 5 bays of standard shop roofing, totalling 660 ft. long by 260 ft. wide. No. 1 bay will carry one 20-ton and one 10-ton overhead travelling crane. The 20-ton crane is used for lifting coaches in case of emergency, and also loaded wagons and heavy brake vans. It has a 5-ton quick lift. No. 2 bay will carry two 10-ton cranes and the west half of this bay will be fitted with fixed hydraulic jacks for lifting the standard 23-ft. underframe 4-wheel stock.

No. 3 bay will carry at the east end a 5-ton crane, and at the centre and west end 2½-ton overhead cranes. The crane runway girders of this bay No. 3 will be extended on steel columns out over the yards as shown on the plan, 260 ft. to the east and 180 ft. to the west, suitable for running the 2½-ton crane and 5-ton crane. No. 4 bay will carry two 10-ton cranes. The whole of this bay will be fitted with fixed hydraulic jacks for lifting standard 23-ft. under-frame stock. No. 5 bay will carry two 10-ton cranes.

All cranes over the wagon repair bays, including the 20-ton, travel, traverse, and for the same maximum loading, lift at the same speeds. Thus any pair can work together lifting or carrying a wagon down the bay, and traversing vehicles on to different lines. All these cranes are provided with 5-ton quick lifts, and normally use this power. The speeds are, travel 250 ft. per min., traverse 100 ft. per min., 5-ton lift 30 ft. per min., 10-ton lift 15 ft. per min., 20-ton lift 7½ ft. per min. The 2½-ton cranes lift at 33 ft. per min.

The floor of the wagon repair shop will consist of a reinforced concrete foundation faced with treated hard wood block paving, or, as an alternative, compressed asphalt paving blocks, set in bitumen.

This wood block or asphalt block paving will be supplied and laid by experts under guarantee, as is done with street paving.

The roof of the wagon repair shop, while using the existing steel work, will be modified to give much more light and better ventilation.

Additional light will be arranged for, by installing throughout the length of each bay a band of frosted armoured glass as shown on the cross-section. The remainder of the roofing will be of corrugated asbestos cement sheeting. Continuous large armoured glass lights also will be provided on a high level along the full length of both sides of this shop. Low-level windows are useless, as the glass is always being broken by flying rivet heads, when old rivets are being cut out.

Additional ventilation during the summer will be arranged for by making 50% of the existing vertical glass lights to pivot open. These movable lights need not be controllable from below, as they will be

definitely opened for the summer season and closed for the winter season. Efficient eaves ventilation will be provided along the sides.

Bays Nos. 1 and 2 and 4 and 5 will not end with the heavy crane girder columns, but will be carried out by a lean-to extension 16 ft. over the tramway lines.

It will be noted that only 2 wagon repair lines will be provided in each repair bay, with a central wheel track. The reason for this arrangement is that the span of the existing roof trusses does not allow of sufficient width to work satisfactorily on more than 2 lines of vehicles.

(3) *Manufacturing Machine and Fitting Shop.*

To be 2 bays of standard shop roofing 52 ft. span, 300 ft. long, with a 2½-ton overhead crane running throughout both bays.

Floor to be of wood block or compressed asphalt block paving set on concrete, as specified for the wagon repair shop.

Armoured glass windows to outer walls and suitable roof lighting and ventilation to be provided as specified for wagon repair shop.

To be divided from the smiths' shop with corrugated galvanized sheeting up to level of crane rails (behind the line of smiths' fires only).

(4) *Smiths' Shop, Spring Shop and Forge.*

To consist of one bay of standard shop roofing, 52 ft. span and 300 ft. long, separated from the machine shop as detailed above.

A cinder floor to be used and suitable eaves ventilation to be provided, also rolling doors to shut out wind and weather.

All smiths' fire hoods to exhaust into an underground flue from which the gases will be withdrawn by suction (Blackman system), thus leaving the space above the hoods free for a 2½-ton overhead travelling crane.

(5) *The remaining Shops*, not being equipped with cage controlled travelling cranes, do not need the height of the wagon repair shop, and will therefore consist of standard 52-ft. span roofing carried on steel columns, giving a clear height to the underside of the roof truss of 28 ft.

The walls, roof lighting and ventilation, will be similar to that specified for the wagon repair shop.

The second stores bay will have a 2-ton electric hoist, floor controlled, with hand travel and traverse.

The crane rails for this hoist will be extended out over the track in the stores yard to allow for loading and unloading heavy items.

The sawmill will be provided with suitable pits for underground shafting.

(6) *The Offices* will be a 2-storey brick or stone building with a plan measurement of 30 ft. by 100 ft. The shop offices will be on the ground floor, with the main office above.

(7) *Paved Routes* with a smooth surface (asphalt or concrete) will be provided for the entrance way and along the tramway tracks.

These routes will be used for all hand barrow or trolley work, and will be available for use of electric battery or petrol trucks, should these be introduced later to facilitate handling of materials.

(8) *Boundary Walls.*

The whole depot will be enclosed by a concrete slab boundary wall, with gates over the tracks as well as at the main entrance. The storage, reception, and departure sidings are outside this boundary wall. Thus, closing the shops gates does not interfere with Traffic Dept. delivering and collecting "cripples" and repaired vehicles. The stores yard to be independently closed by an additional boundary wall.

(9) *Hydraulic Lifting Jack Installation.*

All types of E.S.R. design 10-ton 4-wheel stock (except the very old stock now being scrapped), whether the older type with angle solebars, or the later type with channel solebars, have a standard length of underframe of 23 ft., and a standard width of headstock of 8′ 9″ to 8′ 10″. As there are a total of 10,000 of these vehicles in service, they are eminently suitable for being lifted in the wagon shop repair bays by a hydraulic jack installation.

This installation should consist of duplicate electric driven pumps and accumulators feeding the jacks by suitable hydraulic mains and branches. (Pumps should have sufficient reserve capacity to supply hydraulic power to small presses, etc., as may be required in future.)

The jacks should be set in groups of 4, arranged to lift on the ends of the headstocks of the standard 10-ton 4-wheel vehicle.

The control valves should be capable of controlling all 4 jacks together or either pair independently.

There are two alternative systems available, one system has a fixed cylinder and a long ram which lowers almost to floor level when not in use, to allow vehicles to be shunted. The other system has a cylinder with its ram set above floor-level, the cylinder being hinged at its base, so that it can be laid back on to the floor about this hinge to allow vehicles to be shunted. This system involves flexible connections to the cylinder.

The actual system to be adopted should be decided after consultation with the manufacturers of these types of hydraulic plant.

As this standard 4-wheel stock is the type that in particular will be dealt with on a time process basis, it is essential that every facility should be provided in the shop to prevent any delay occurring to upset the time-table. This can be insured by using jacks for lifting the vehicles, while the runways deal with light articles of supply, and the overhead cranes deal with the heavier items. These cranes will also be available to pick up off the jacks any vehicle which may be

found to need special repairs, and remove it to the end of the shop for shunting to the heavy repairs bay, thus not delaying the pulling out of the rake of repaired vehicles at the set time.

(10) *Electric Power* from the central Gabbary power house, 200 volts, 3 phase, 50 cycles, etc., will be laid on to all shops and offices.

Lighting of the wagon repair shop will be by gas-filled incandescent electric lamps, in parabolic enamelled reflectors, suspended from the roof trusses as shown on the cross-section.

This roof lighting will be arranged to give an intensity of illumination at floor-level of 3 to 4 foot-candles. Similar roof lighting will be employed in the other shops, and in addition each machine will have its own swivelling, shaded, 50-watt lamp.

Wall plugs for the 3-phase 12 h.p. portable electric welding plant will be provided on every 4th column in the wagon repair shop, and on every 2nd column for portable hand lamps.

(11) *Compressed Air* at 100 lb. pressure will be laid on throughout the shops to provide power for pneumatic drills, riveting and chipping hammers.

The way the air mains and branch pipes will be carried through the shops is shown on the cross-section.

It is essential that an efficient form of instantaneous coupling, of the Westinghouse type, be used between the flexible hoses and the shop air supply pipes, which coupling should be automatically air-tight without the necessity of using a spanner to screw up union nuts.

All air mains will be carried on a slight slope to a drainage point provided with a reservoir which can be periodically tapped.

The branch air pipes will be taken from the top of the air mains to ensure a supply of dry air to the pneumatic tools.

Three 75 h.p. motor-driven compressors will be installed with suitable reservoirs. Two compressors will normally be in service, with one compressor standing reserve.

SCHEDULE OF THE MACHINE TOOLS AND PLANT TO BE INSTALLED IN THE VARIOUS SHOPS.

[The details showing the principal work to be performed on these tools have been omitted for want of space. Such information, if required, can be obtained from the writer of the article direct.—ED., *R.E. Journal.*]

(1) *Machine and Fitting Shop.*

- 2 26″ vertical drilling machines to take up to $2\frac{3}{4}$″ diam. H.S. drills.
- 1 36″ radial drilling machine to take up to $2\frac{3}{4}$″ diam. H.S. drills.
- 1 Sensitive drilling machine to drill up to 3/16″.
- 1 12″ general purpose engine lathe.
- 1 18″ double-ended millwrights' lathe, that can be used single-ended when necessary to turn a 24-ft. wheel lathe shaft.

3 12″ hexagon turret lathes.
1 12″ Herbert combination hexagon turret lathe.
1 Auto-lathe for making, from the bar, door rollers, door roller pins, drawbar pins and various pins, bolts and studs.
1 Plane-miller, 30″ × 30″.
1 No. 3 Parkinson horizontal miller with vertical attachment.
1 Vertical miller with 30″ diam. universal table, to take 18″ under the head.
1 36″ duplex boring and turning mill.
1 Double-headed 18″ shaper.
1 Single-headed 24″ shaper.
1 18″ slotter.
1 8″ slotter.
1 2′ 6″ Stirk planer.
3 Landis tangential screwing machines to take up to 2½″.
1 Cameron punching and shearing machine, 36″ gap.
1 Cold steel band saw.

(2) *Tool Room.*

1 Electric pyrometer furnace for hardening and tempering super high speed and high speed lathe tools up to 3″ × 1½″ section.
1 10″ precision tool room lathe.
1 Vertical drilling machine to take up to 1½″ diam. H.S. drills.
1 Universal milling cutter grinder of the latest type.
1 Oscillating Lumsden tool grinder to take up to 1″ sq. H.S. tools.
1 Heavy duty twist drill grinder to take up to 2½″ diam. drills.
1 Light twist drill grinder to take up to ¾″.
1 Heavy duty emery wheel rough tool grinder.

(3) *Smiths' Shop.*

1 Hydraulic spring buckling and stripping press.
1 Forging machine to forge rivets and bolts up to 1¼″ diam. of shank.
1 Buckton 20-ton scragging machine for testing springs for temper.
1 20-ton spring load-testing machine for testing springs for load carrying capacity and deflection.
1 36″ diam. hot saw.
2 10-cwt. Rigby type steam hammers.
1 2-ton steam hammer with oil fired furnaces for heavy forging work, and die work, for all the system and not only for the wagon repair depot. This already exists, together with waste heat boiler.
2 Boilers arranged with destructor furnaces for burning shop sweepings, sawmill scrap, and old wagon floorboards complete—1 for use and 1 spare.
3 Oil-fired furnaces for spring work, and for heating bent wagon members requiring straightening, each in conjunction with a waste heat boiler. 2 for use and 1 spare.

(4) *Sawmill.*

1 Small general joiner and mortising machine.
1 10″ wood lathe.
1 Grit shield borer.
1 Tenoning machine.
1 36″ circular cross-cut saw.
1 36″ circular rip saw.
1 24″ circular saw with cutter attachment.
1 Band saw to take up to 2″ saws.
1 Heavy 4-cutter planing machine to take deals and baulks up to 12″ × 6″.
1 Screwing machine for re-threading old floor bolts and similar work.
1 Automatic band saw sharpening machine with circular saw attachment.
1 Circular saw gulleting machine.

(5) *Wagon Repair Shop.*

Ref. No. on plan.	
1 to 5	5 Heavy duty latest type motor-driven high production wagon wheel lathes.
6 and 7	2 Existing light Hetherington wagon wheel lathes for cutting out the tyre retaining rings.
8, 9 and 10	3 Journal lathes for re-turning and burnishing journals of axles mounted in wheels.
11	1 Axle lathe.
12	3 Tyre boring machines, 2 for use and 1 spare.
13	1 300-ton hydraulic wheel press.
14	1 " Rapidor " hack-sawing machine.
15	1 48″ heavy duty " Pels " armour-plate frame punching and shearing machine.
16	1 48″ radial drilling machine.
17 and 18	2 26″ vertical drilling machines to take up to $2\frac{3}{4}$″ H.S. drills.
—	1 Sensitive drilling machine to take up to $\frac{3}{8}$″.

(6) *Electrical Repair Shop.*

1 Vertical drilling machine to take from $\frac{1}{16}$″ to $\frac{3}{4}$″ H.S. twist drills.
1 8″ general purpose precision lathe.
1 6″ shaper.
(Heavy work for this shop will be done in the main machine shop.)

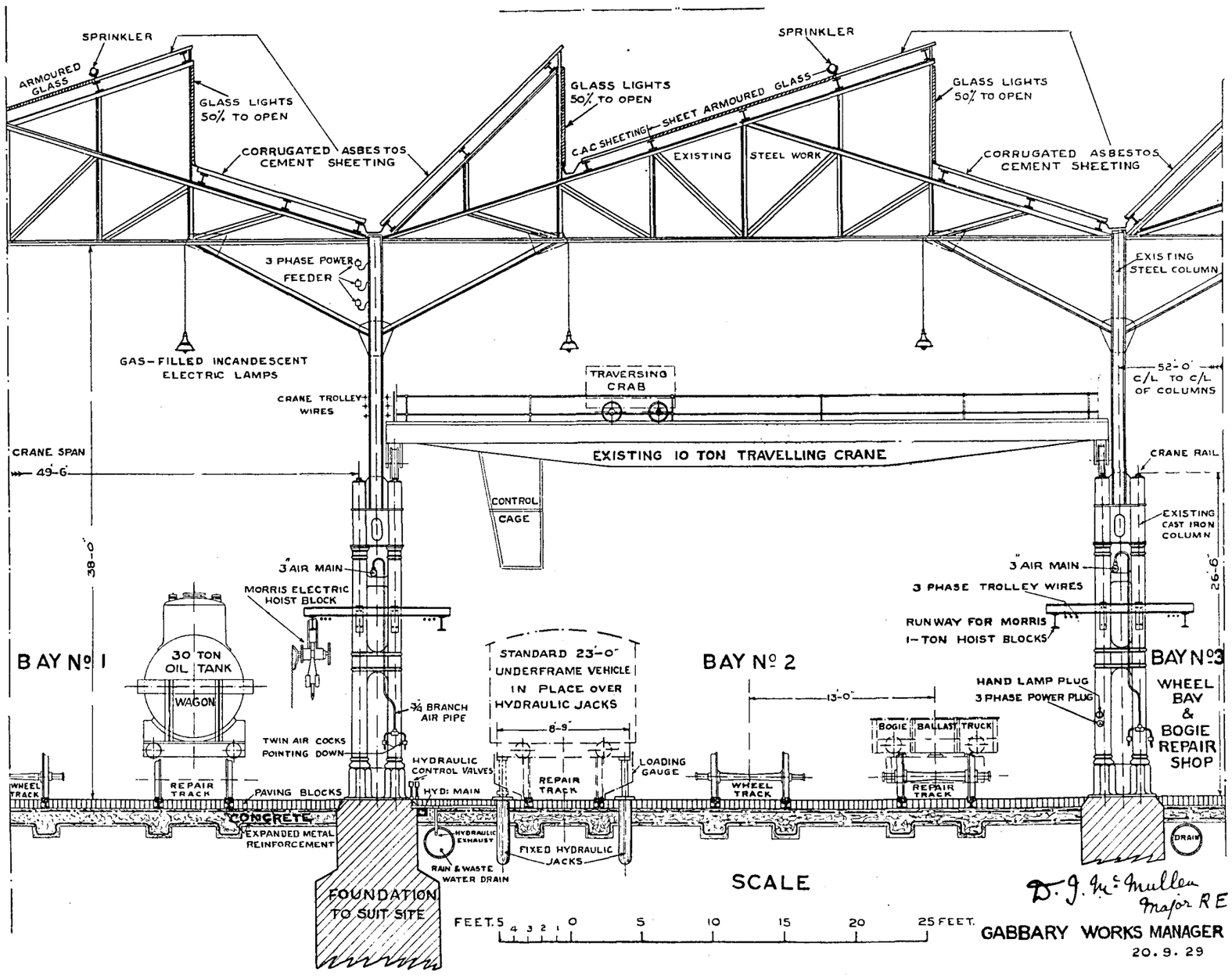
(7) *Welding Shop.*

2 Fixed acetylene generators, each capable of feeding 4 blowpipes in simultaneous use.
2 Portable acetylene generators, each capable of feeding one blowpipe.
1 Portable 12 h.p. electric welding plant driven by an A.C. motor.

(8) *Yard.*

1 10-ton locomotive steam crane.

PROPOSED NEW WACON REPAIR SHOP
ECYPTIAN STATE RAILWAYS CABBARY ALEXANDRIA
TYPICAL DIAGRAMMATIC CROSS SECTION

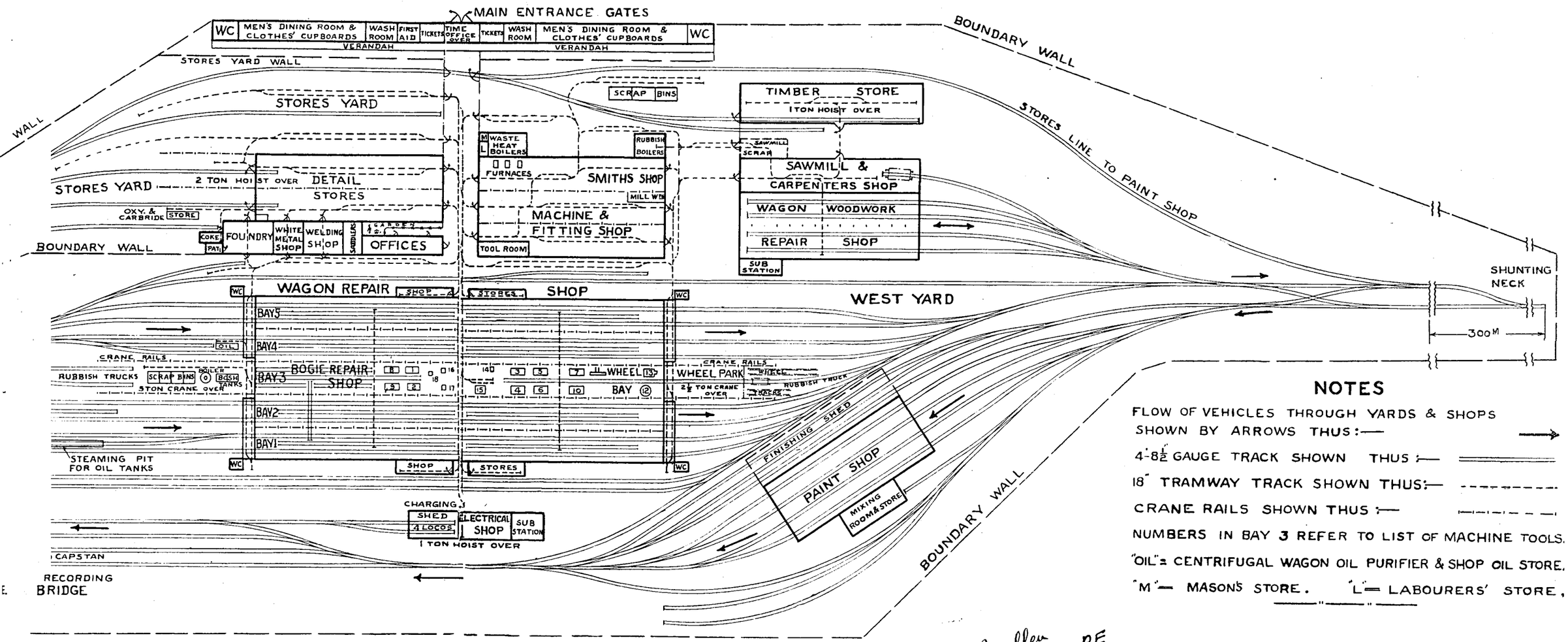


D. J. Mc Mullen
Major RE
GABBARY WORKS MANAGER
20.9.29

PROPOSED NEW WAGON REPAIR DEPOT

E.S.R., CABBARY, ALEXANDRIA

DIAGRAMMATIC PLAN



NOTES

FLOW OF VEHICLES THROUGH YARDS & SHOPS SHOWN BY ARROWS THUS :—

4'-8½" GAUGE TRACK SHOWN THUS :—

18" TRAMWAY TRACK SHOWN THUS :—

CRANE RAILS SHOWN THUS :—

NUMBERS IN BAY 3 REFER TO LIST OF MACHINE TOOLS.

"OIL" = CENTRIFUGAL WAGON OIL PURIFIER & SHOP OIL STORE.

"M" — MASON'S STORE. "L" — LABOURERS' STORE.

SCALE

METRES 50 40 30 20 10 0 50 100 150 200 250 300 METRES

D. J. McMullen Major RE

GABBARY WORKS MANAGER 20. 9. 29

APPENDIX.

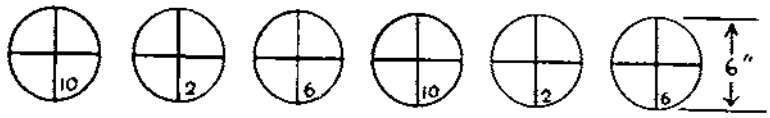
The Egyptian State Railway.

System of maintenance and lubrication of goods vehicles.

The principle on which the maintenance of goods vehicles is based is the conclusion, from experience, that a wagon should normally run for two years in service without requiring a general overhaul or any heavy repairs. While in service it must, however, be regularly oiled and examined.

Thus, on leaving shops after general overhaul, all wagons are provided with a set of six quartered 6" diam. circles preceded by the date of completion of the overhaul and initial of shop thus :—

G. 20.6.29



Each quarter represents one month, and the month of the year to which it refers is shown in the fourth quarter of each circle for reference.

On the completion of each month in service (*i.e.*, on the 20th, in the example given above), the wagon is oiled by the outside staff in the district it may happen to be in, and the initial of the district is stencilled in the quarter concerned, to show that the oiling has been done, and where.

On the completion of every fourth month in service, in addition to being oiled, the vehicle is periodically examined at the same time. This examination consists of removing the axle box covers and taking out the oiling pad and examining the journal and cleaning the axle box. The running gear and draw and buffing gear are also examined..

The initial of the district carrying out this examination is stencilled in the 4th quarter of the circle alongside the number of the month.

When the last quarter of the last circle is due to be marked off, the vehicle will have completed 2 years in service, and is then labelled to shops for general overhaul.

During these 2 years, all minor and light repairs required will be carried out by the various district loco. centres, the wagon being labelled as required by the examiner with a light repairs label marked to the nearest loco. centre.

In practice, it also frequently happens that vehicles are found requiring heavy repairs that cannot be carried out in the districts, and it is then necessary to send them specially to shops for these to be done, although the 2 years have not been completed. These repairs are chiefly structural either from accidents, or from the failure of old frame members due to fatigue. In addition, box trucks have to be sent to shops to be made weather-tight when roof or sides are found defective, either due to corrosion, or the effects of vibration in service.

This system of periodical oiling, examination, and repairs, ensures that each vehicle on the system gets regular and equal attention.

THE PERSONAL CARD INDEX, OR MODERATED METHODISM.

By LIEUT. G. V. MICKLAM, R.E.

MAD we may possibly appear. Undoubtedly we are becoming more and more married. But what is wrong with our methodists? So long as we do not let our methodism run mad, we should be grateful to an unknown wit for the derisive compliment.

Far be it from us, being methodist, to suggest that we shirk work. At the same time the " in " tray of our office table is depressing to the spirit. Like the tower of Pisa, it shrieks unstable equilibrium. An ill-timed opening of the door admitting " ambient air "—in the famous words of a certain D.F.W. specification—and behold the office floor carpeted with flying fidgety feuilletons. To work, then, and reduce the pile forthwith.

Almost at once we are up against it.

" Please give full particulars of Lance-Corporal Snooks, R.E., and assess his qualifications as a bootblack, with a view to his employment with Messrs. Nugget Blossom, of Shoe Lane, Bootle."

" How many of Z Company, R.E., are recommended for instruction as officers' batmen during the field works course commencing 1/4/30?"

" Please forward the names of any men who should report sick before the General's inspection next month, if humanly possible."

Now if only we had all the details about these men at our finger tips, here and now, how quickly we could scribble off terse, well-informed, judicious recommendations. As it is, we shall have to send the papers out to the office, for Serjeant Ink to enter the rank, age, etc., of certain men, and resubmit to us. If Serjeant Ink had been cunning and helpful, like Serjeant Smart, of Q Company, he would have already tapped the vast experience of the Serjeant-Major, and have entered the names on an attached pencilled slip, ready for our humble acquiescence or scathing repudiation, according to our natures. But Ink is only a Lance of tender years—unaccustomed to handling Company Commanders.

Now supposing we had a little box on our desk, about six inches by six by four; and we could nonchalantly turn back the lid, and flick some scores of little postcards therein until we came to an alphabetical index card S; and supposing we glanced rapidly through a dozen, or less, cards immediately behind S; we could in a very few seconds have a large amount of concentrated information about

SNOOKS, A., at our finger tips. You will remember that this was the pious hope at the beginning of the preceding paragraph.

The card might look like this :—

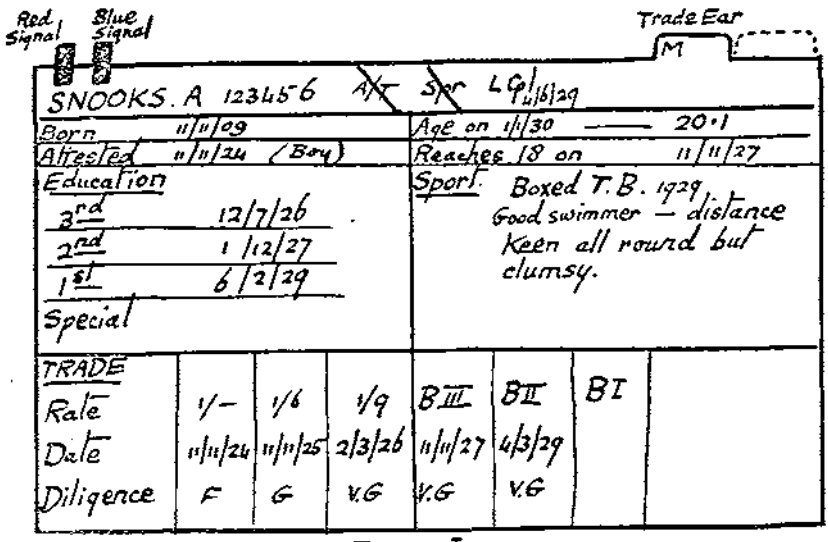


Figure I

and the Company Commander makes notes about the man's character etc., on the back of the card, if required.

The writing on the card gives certain information about the individual. The little gadgets at the top of the card fulfil the additional object of registering general information about the Company, apart from individuals. Let us introduce them.

Trade Ear. These are projections from the card itself, and bear the initial letter of the man's trade. We know at once that Snooks is one of our masons. The ears of the bricklayers stick out a little further towards the side of the card, and are labelled B. They are shown dotted in the sketch. Owing to their geographical position they form two lines of ears from back to front of the box—one line of masons, and one line of bricklayers. Consequently, by simply running a finger along the cards from back to front of the box, we can discover the numbers of each trade on the strength of the Company at any particular moment. In a school of instruction where one officer deals with, say, only five trades, this might be the best system. In a Field Company, where trades are numerous, the system needs modification. The principle holds good in all cases, but it rests with the officer to apply it to his best advantage.

Signals. These are commercial articles, consisting of small coloured metal clips, which can be attached to the top edge of a card, and stand out like guides. They occupy a width of approximately $\frac{1}{8}$" on the card.

Now supposing we want to record a set of data such as the following :—

1. Men overdue on their trade tests.
2. Men due in current month for discharge.
3. Men who should come up to the office at the first opportunity.
4. Men who are sick.
5. Men who are married.

These details might be indicated as follows.—

1. A red signal fixed to their trade tab.
2. A blue signal at the right corner of the card.
3. A red signal at the centre.
4. A red signal at the left corner.
5. A blue signal between the centre and the left corner.

Or, instead of using many colours, a monochromatic system may suffice, relying on the geographical positions of the signals only. There is no need to memorize these. The first card of the index should be a reference card, explaining the whole system, so that any stranger can see the index for the first time, and a few moments later be able to pick out all the data as skilfully as the owner. A specimen reference card is sketched below, with all its signals in position.

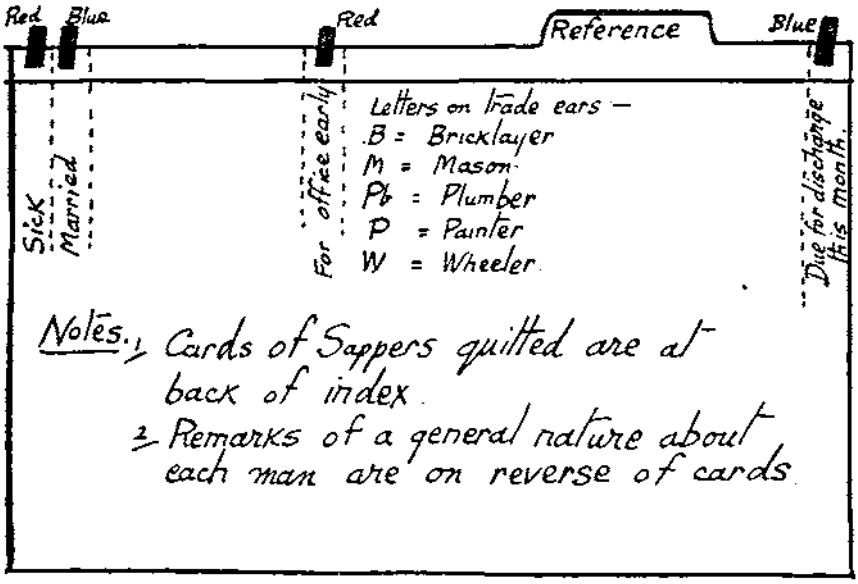


Figure II

Let it be emphasized that the preparation of such an index of 200 cards is not very laborious. We can buy enough postcards for a shilling to form a considerable encyclopædia of our company, class,

school, or even platoon. Our nephew, fresh from his geometry at St. Wellingchester's, will draw all the requisite lines nearly in the right places, for the humble half-crown. And we are perfectly justified in arranging for Serjeant Ink to fill in most of the particulars, in Government time, because this index will, we know, save incalculably more Government time in the future. Yes, bearing this in mind, we might perhaps ask for next Thursday off, after all. The open meeting is always a great success, and we have a shining new brassie—one with a heavy head, but beautifully balanced. One might even carry that tree at the tenth, and the moat will not cause us the slightest—er—as we were saying, it is a good idea, this card index business. Once it is completed, further alterations, promotions, etc., are quickly and easily recorded, for all time. Well then, what are the disadvantages of our system? When these are propounded, we can pass on with a clear conscience to tabulate the advantages.

Disadvantages.

1. A certain amount of initial labour.
2. A few shillings of private expenditure.
3. The compilation must be careful and accurate.
4. The index must be kept up-to-date. This, however, is an easy matter, and occupies only a very few minutes each day, which must not be grudged.
5. Loose cards may be lost.

Advantages.

1. Details of any individual are available at very short notice—as in a telephone call.
2. General information about the whole unit can be quickly seen, without scrutinizing the detail of each card, *e.g.*, how many men sick, how many married, how many masons can be spared to-day.
3. Any fresh information about anyone can be recorded for all time, before the correspondence is filed away and forgotten.
4. Infinite expandibility.
5. Making up a suitable card only requires common sense, and no specialized business training whatever.
6. Handing over to a newcomer is simplified.
7. No disorganization if the O.C. is a sudden casualty, as the next senior can take over all the information at once, and need not delay the office by countless questions.
8. Cards not wanted can be relegated to the "dead" part of the index, yet they can be resurrected, as when a Sapper rejoins a unit after absence. "Live" information is not mixed with "dead."

The whole attribute of a sound card index scheme is simplicity. And therefore a word of warning to the enthusiastic "signaller" would not be out of place. Let him put this question to himself before the little coloured signals lure him on to complexity. "Am I putting in relevant information which is likely to be of constant use to me? Or am I letting my methodism run riot? Shall I need this information once a day, once a month, once a year, or once in a blue moon?" When blue moons come into the question, the index is his master, not his servant.

Let him remember the next owner of his little box, and not make it a box of tricks. For here is the card of a Sapper

who is a bricklayer,
who is overdue on his trade test,
who has a third-class certificate,
whose boots do not fit,
who has had lockjaw,
who is undersize and overweight,
who cannot swim,
who is in No. 1 Section,
and No 3 Barrack Room,
who is a chess champion,
and whose greatcoat is due for condemning.

In fact, his card betrays him fully as a remarkable fellow. Heaven eserve us from having him as our C.S.M. one day.

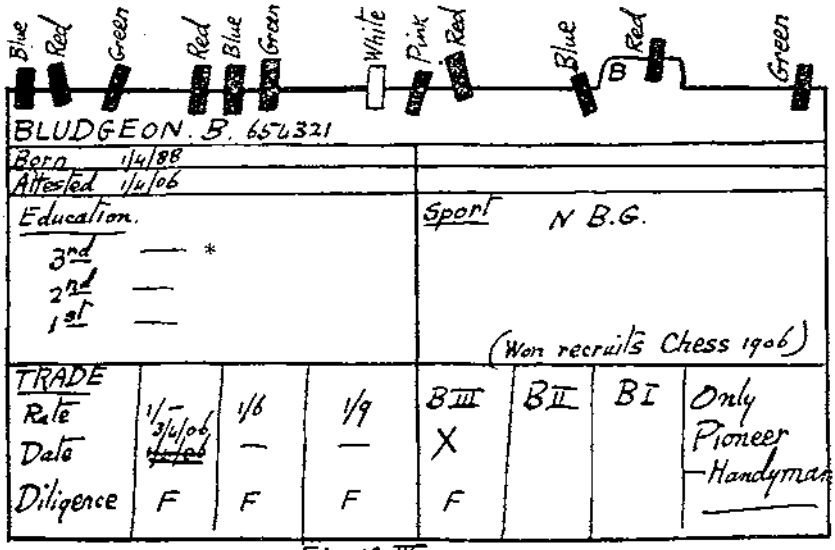


Figure III.

* 5/12/29.

REINFORCED CONCRETE SWIMMING POOL, SHANGHAI.

By LIEUT. J. E. C. MCCANDLISH, R.E.

THE moist heat of Shanghai makes facilities for bathing very desirable. No sane person, having once inspected the local river, the Whangpoo, or creeks, would dream of immersing himself voluntarily in any of them, and, as the existing resources in the way of swimming baths for troops were inadequate, permission was received from the War Office at the end of March, 1928, to construct a bath at a cost of £650.

There are in Shanghai a number of baths, owned by the Municipality and various clubs. Arrangements were made in 1927 for the former to be allotted at certain hours to the troops. In addition, the British Forces Recreation Centres, a voluntary organization which ran canteens, built a small bath which was very popular.

The site chosen for the bath now described is on municipal property, in a corner of Yu Yuen Road Camp, which is built on ground earmarked for a school for boys and close to a girls' school. The funds available proved the deciding factor as to size, and a bath 70 ft. by 30 ft. was designed. A depth of water ranging from 6 ft. 6 in. at one end to 4 ft. at the other was considered sufficient to allow for a certain amount of high diving and for water polo. The level of the water is 6 in. below the edge of the bath; this figure might have been increased with advantage, as there is a good deal of spilling when the bath is full of men.

In the words of the journalists, Shanghai is a city built on a swamp, and while that is not strictly true, in that the ground was all cultivated before it was built over, there is very little rise from the sea-level; in this case water was found about 3 ft. below ground-level. (See Fig. 1). The creek into which the bath drains is tidal, in which respect it conforms to nearly all the creeks by which Shanghai is intersected; many of them are culverted and have roads built over them. Draining into this creek was found more practicable than laying a longer line into a road drain at the same level, or cutting up asphalted tennis courts in the girls' school grounds.

This question of drainage necessitated the top of the bath being raised above ground-level; it was found possible, after giving our drain a drop of 12 inches in its length (350 feet), approximately to balance the cut and fill. In rainy weather, or when the river is in flood, this 12-inch drop will be reduced by about a half.

The design of reinforced concrete bath to meet these conditions, where the whole of the surrounding earth may be at times waterlogged, presented some difficulty to one who lays no claim to be an expert. The *S.M.E. Manual*, which in most reinforced construction work supplies the correct answer to anyone who will follow the sequence of calculations, did not serve quite as well the special requirements of the case.

The design is admittedly too strong, but it was preferred to err on the lavish side in view of the uncertainty of the behaviour of the ground and the lack of knowledge of the efficiency of the contractor, the cement, and the reinforcing steel. The floor was doubly reinforced in view of the probability of the surrounding ground sometimes becoming completely waterlogged. This did happen in 1927, and the occupants of the camp had to wade to and from their meals.

The embankment walls are not to be relied on to support the walls of the bath to any appreciable extent, as it will be months before the made ground will set.

The contractor, after an initial reluctance to space his reinforcing meshes in the floor slab, which had to be corrected somewhat forcibly by the A.E. at an unholy hour on a Sunday morning, proved himself able and efficient.

The methods of contracting and sub-contracting in the city are complicated. We placed three orders, one on a European firm for the water supply (the Chinese are neither adept nor competent at this work), one for the matshed covering and bamboo fencing (contractors for this work being a special race), and one for the remainder of the work with a Chinese contractor.

The latter then let out to separate sub-contractors the drainage, the excavation, the steelwork, the concrete, the supply of carpenters, the timber, and the painting. This ensures experts at every particular trade, but provides the contractor with an excellent excuse for " passing the buck " if anything goes wrong.

The excavation was done somewhat slowly, the day's work of a coolie (9 hours) being only about 75 cubic feet, the soil being exceedingly easy, the excavating tool universally employed is as shown in Fig. 2.

Water was found where anticipated, and drains leading to a sump were dug, a pump was produced and, being Chinese, it is needless to say it would not, at first, work.

The network for both the floors and walls were tied together quite neatly, but great difficulty was experienced in making the contractor understand that it mattered where the steelwork should be placed in the concrete.

The concrete was mixed entirely by hand and provided an astonishing example of the efficiency of gang labour well organized. A batch of 1 : 2 : 4 concrete with four feet of stones averaged just

under six minutes for mixing and pouring; this speed was kept up indefinitely.

The gang was composed of eighteen men. Four men (in two pairs) carried the sand and the stone, two other men filling their measures at the dumps, two more uncrated, sieved and carried the cement, four men mixed and poured, and two men watered. Two men rammed

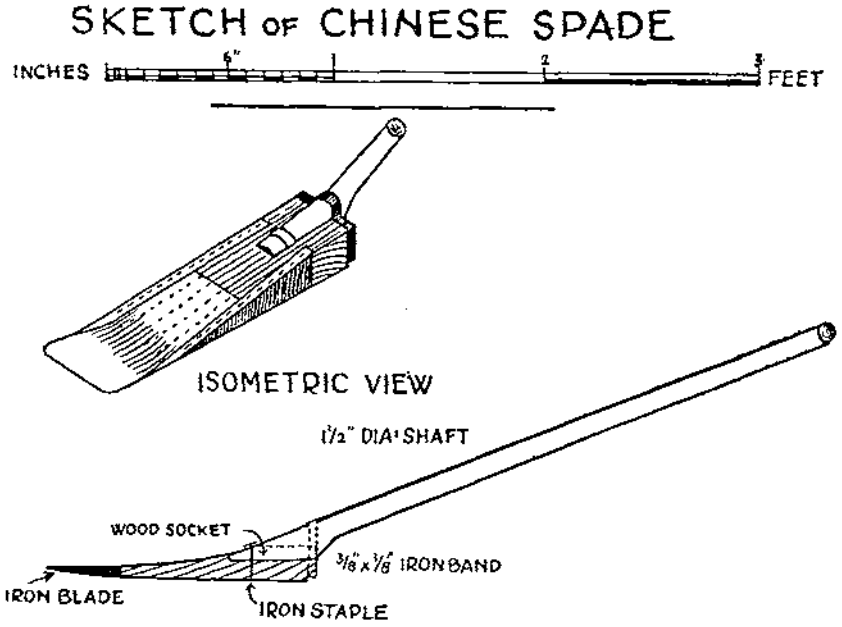


FIG.2

and shovelled the concrete into place; there were at least two men spare. Each man could take any other man's place, and the gang worked up to 12 hours a day without any break, except for one man at a time sitting out smoking a cigarette.

Carpentry was as usual well done, for with few tools the Chinese can work wonders. The only peculiarities are that nearly all planing is done with a short-handled axe, and all sawing with a fretsaw.

It is impossible to get seasoned timber in any quantity in Shanghai; practically all the wood is newly imported American. Except for special work, we have used Oregon pine for all our hutting, and have

had considerable difficulty in getting reasonably sound material. The writer has made a rule that any rejected timber must be taken off the work immediately; if found next day a large wedge is cut out of it, thus reducing the contractor's chance of using it elsewhere.

We have found Solignum excellent as a preservative, and stain for wood; it will be necessary to give all exposed woodwork one coat every year. The drawback is that when applied in hot weather it takes a long time to dry. The material is not very satisfactory in any but the natural brown colours.

The design of changing-rooms was adopted to ensure men having a shower before going into the bath, to keep the water from dirtying too quickly. A springboard and a small high-diving platform have been added, and electric lighting installed over the bath and in the changing-room.

The construction of matsheds which form the roof of the bath and changing-room is a fascinating art. In all but the very biggest of them (*e.g.*, our hangars, which were 70 feet wide) bamboos form the only support. Men engaged on the construction are specialists all their lives, and know by instinct the size of bamboo required and the design of truss needed. All that is required is to give the ground dimensions and the height you want, and the matshed contractor does the rest; barring a typhoon they never fail.

The joints are tied with approximately square lashings of dried reed about 1/8 in. by 1/32 in., and the covering is of mats made of the same material laced together; usually a roof consists of two layers of these mats with a sheet of oiled paper between them. The roof will need repairs after about six months, and renewal before a year, but the framework, including the reed joints, seems to stand indefinitely.

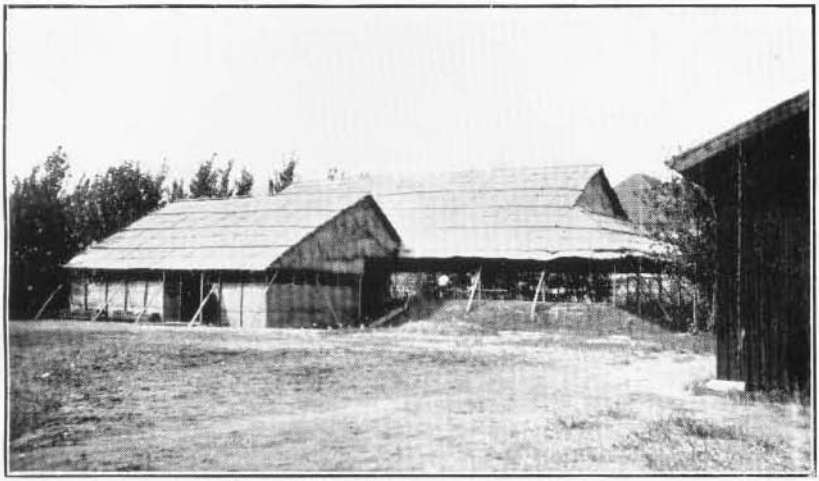
The usual practice is for the contractor to remain the owner of the material and either to remove it, or be given an order to renew the roof, after about six months. With these conditions, they cost little over 1½d. per foot super for small sheds, and about 6d. for very large ones.

The diary of the work is as follows: the contract was placed on April 24th, for completion within six weeks. Four days later, after the outline of the bath had been marked in powdered lime, the excavation was started. This took five days, on one of which there was considerable rain. Rain stops work almost entirely, as the labourer, having but one suit of clothes, prefers to stay at home and earn no money rather than get it wet.

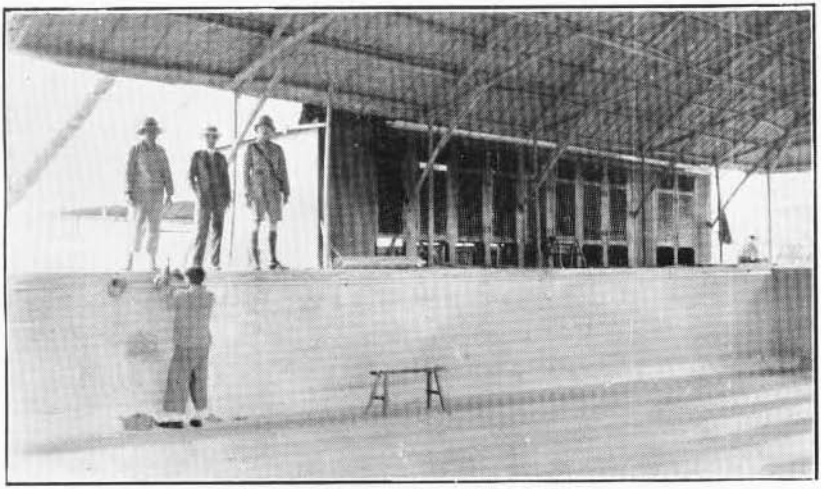
At the same time that the excavation was going on, the matshed over the bath was constructed, so making work possible during showers.

On the thirteenth day, concreting the floor started, the interval having been occupied with placing shuttering and steel mesh. The

REINFORCED CONCRETE SWIMMING POOL, SHANGHAI.



Mat Sheds Forming Roof of Bath.



Interior, Showing Dressing Rooms.

Reinforced Swimming Pool

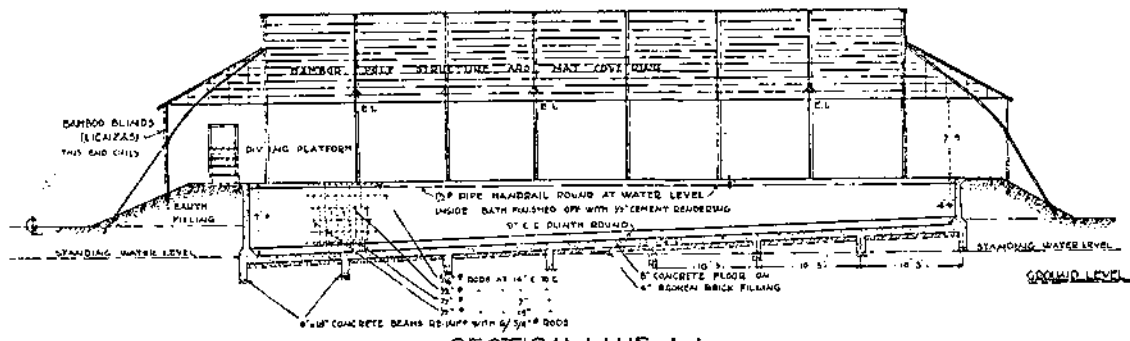
FIG 1.

SHANGHAI
YU YUEN ROAD CAMP
RE-INFORCED CONCRETE SWIMMING POOL

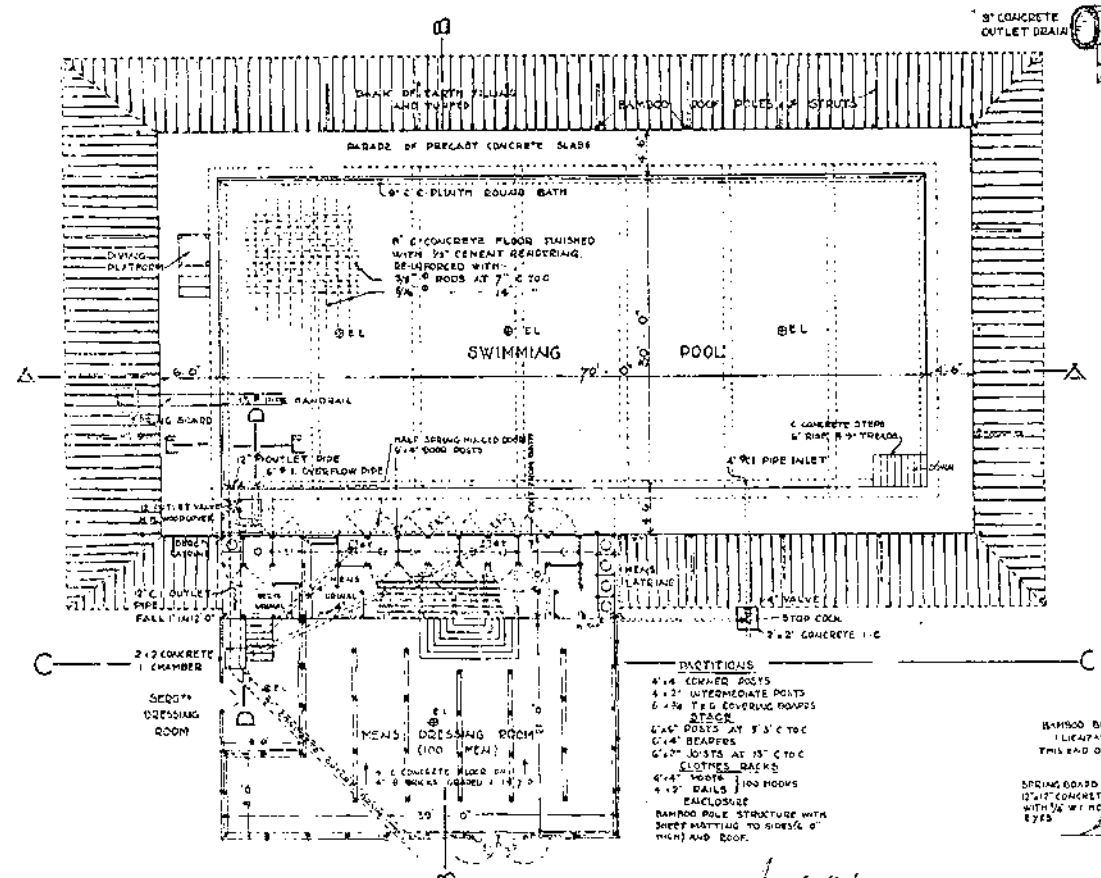
REFERENCE	
ACTUAL CAPACITY	12075 CUBIC FEET
WATER CAPACITY	0000 GALLONS
ESTIMATED COST	$ [illegible]
ACTUAL COST	$ [illegible]
DATE OF CONTRACT	[illegible]
WORK COMMENCED	[illegible]
WORK COMPLETED	[illegible]
CONTRACTOR	[illegible]

SCALE FOR PLAN. INCHES FEET

SCALE FOR DETAILS.

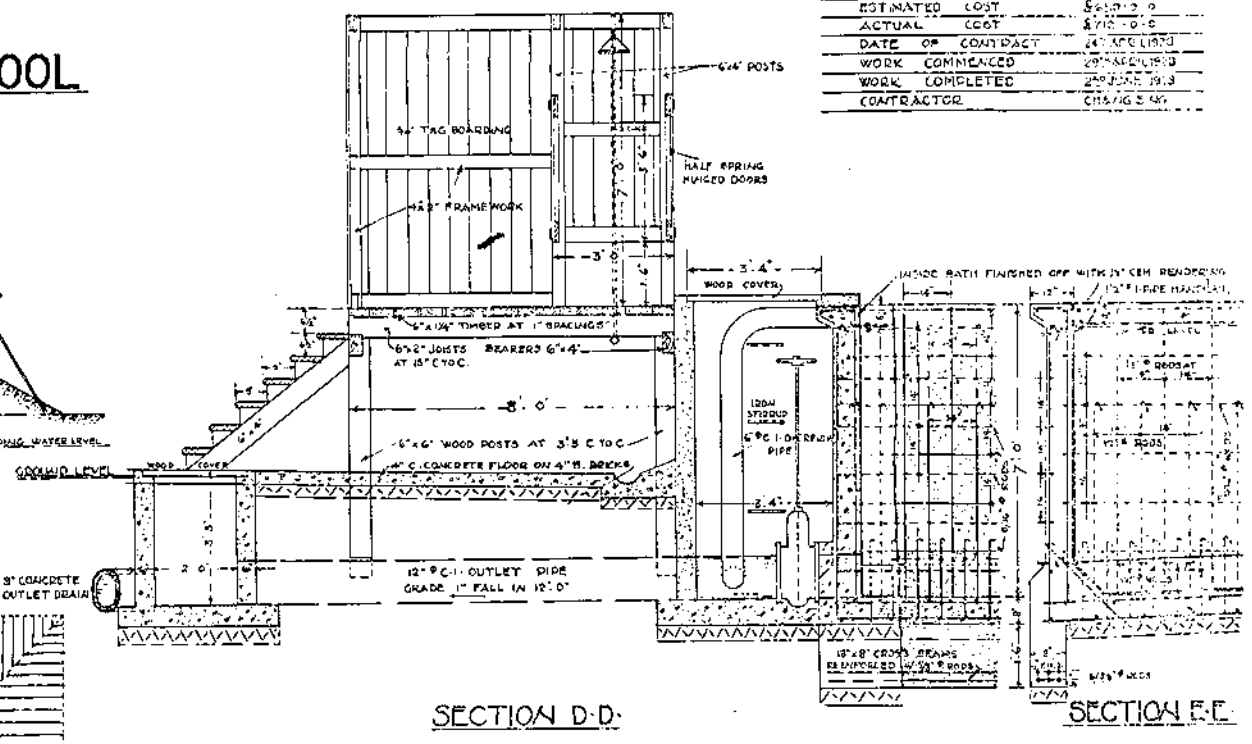


SECTION LINE A-A.



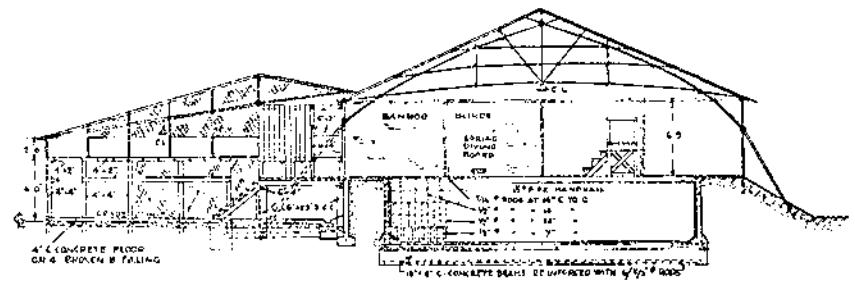
PLAN

LIEUT R.E.
A.E. WEST

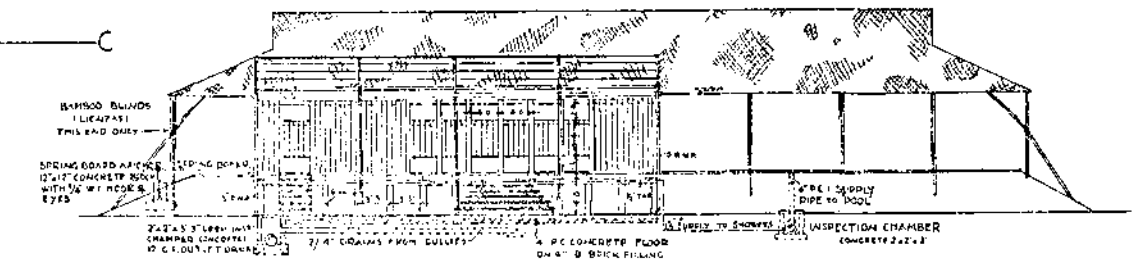


SECTION D-D.

SECTION E-E.



SECTION B-B.



LT COLONEL R.E.
C.R.E. SHANGHAI AREA

SECTION C-C.

floor, which contained 55 cubic yards, was poured in two days, each of 12 hours' work, with one gang mixing. In four more days the sides of the bath were finished, and the shuttering was left in place for a week.

The carpentry work for the dressing-rooms was started when the carpenters had finished work on the shuttering, and progressed without incidents other than the fury of the A.E. on discovering timber with large knots.

The drainage was laid out with great difficulty by means of a highly inaccurate level. This instrument was sent out with the Shanghai Defence Force.' The accuracy thereof has not been improved by its use for trade tests of instrument makers, for whom it is deliberately thrown out of adjustment, and through whose efforts confusion is worse confounded.

Salt-glazed pipes are almost unknown, and for this job, as for all other of our drainage works, concrete pipes were used. The Public Works Department manufacture very good concrete pipes and gullies, etc., and these are copied in an inferior manner by the Chinese. Drainage work is consequently, if not nasty, at any rate indifferent, but it is cheap, the 9-in. drain for this bath laid on, and bedded in hard core costing 23s. per chang, *i.e.*, ten foot run.

In this case, the operation was prolonged by the drainage contractor being " difficult," and the drains were not tested until the thirty-second day. The floor of the dressing-rooms, which had been held up, was laid three days later. The G.O.C. visited the work that day, much to the joy of the contractor, who turned on a special demonstration gang of concrete mixers for his benefit. The contractor finally cleared off the site on the fortieth day, two days early.

The water supply was started on the twenty-third day, and the main pipe line was tested on the thirtieth day. The job was a very simple one, and calls for no comment except the number of joints which had to be remade. It is rather curious to note that most of the plumbers in Shanghai come from Canton, and the South of China. The pressure at the main rarely exceeds 30 lb., and the line was tested to 140 lb. The main pressure is obtained by pumping, and the problem of filling the bath in permitted hours, between 9 p.m. and 5 a.m., was somewhat urgent. In order to reduce loss of head, a six-inch meter was installed on the 4-in. main.

It has been found that the delivery at the bath varies between 300 and 190 gallons per minute, according to the other demand on the main.

The original liability for the bath was £470, excluding drainage, the matshed cover £36, and the water supply £100 extra, but the movement in exchange between the tael (the currency in which all works are done) and sterling went the wrong way to the extent of about 12 %, so that the final cost was just over £700.

MAP READING RACES.

By LIEUT. W. L. ROLLESTON, R.E.

IN the event of war a great many sappers would at once become N.C.O.s, and perhaps more in our Corps than elsewhere, the junior N.C.O. would have to be able to read a map accurately and quickly. Map reading is, therefore, an important part of the military training of the sapper, but it is a difficult subject to teach, especially by word of mouth.

This is a short account of a method of teaching practical map reading, which has been used with some success in a small unit this training season. It has no claim to originality—many of us have done wild schemes of the same kind on bicycles at the Shop—but it does not seem to be in very general use at present. The idea has been adopted by some of the local infantry, who have become quite keen about it.

The scheme is run on the lines of a " treasure hunt," the men being divided into about four parties, each with a serial number. It was found better not to include senior N.C.O.s, so as to make sure that the younger men could air their views. A one-inch gridded map, protractor, and prismatic compass if possible, should be carried by the N.C.O. or sapper in charge of each party. Envelopes containing the first clue are given out in barracks, and all are started off together.

The first point is usually indicated by a simple four-figure map reference, each squad, of course, getting a different place to find. The next clue is there, hidden in a fairly large envelope. As a four-figure reference indicates only a square of 100-metre sides, this square has to be accurately located and thoroughly searched. The second clue may be a magnetic bearing with a distance in yards, and the syndicate can either try their luck with compass marching, or set out the bearing with a protractor and locate the spot on the map. The latter is more accurate for a distance greater than a few hundred yards, but the compass provides a useful check.

The next envelope when found may contain a straightforward map reference, or possibly a grid bearing with a distance ; and again the search continues. The final point should be the same for all, and made fairly difficult to find. The time of arrival of each party should be noted, and all clues handed in and checked to avoid " short cuts." The first lot to finish are suitably rewarded, perhaps excused the next

marching order parade, and all are made to complete the course before being allowed to return to barracks.

The preparation requires some care, as details may easily go wrong. Four or five suitable points should be chosen on the map and lettered. They should be roughly on a circle which includes the starting point. The parties should be sent round in opposite directions with different first points for each. The points can then be juggled about till all the routes are of about the same length. Large envelopes for each point and the finish should have their distinguishing letter outside, and the clues can then be worked out and put in smaller envelopes inside the large ones. Each small envelope must bear the serial number of the party clearly written on it. It is a good plan to get someone to follow each route round on paper as a check, especially of the bearings. On the morning of the scheme the circle must be followed round by car or bicycle, and the big envelopes hidden at the various points. They should be well concealed, both to make the scheme more difficult, and to evade the curiosity of village children.

The schemes can be made progressively harder, and various interesting features added as the standard of map reading increases. Conventional signs make useful clues with just enough surrounding detail to identify them, and considerable amusement can be got by thinking out tricky places of this nature.

The actual points can be well concealed, and may call for ingenuity as well as map-reading skill. One finishing point given as a map reference was the window sill of an old passage window ; the passage ran along the inner side of a grass moat, and was about twenty feet from the ground. The entrance to the passage was locked, and a ladder concealed some distance away. It was a close finish, and two parties arrived at the point almost together. One lot located the envelope, found the ladder, and got the envelope down in under four minutes from their arrival, which was fast going.

The sappers got extremely keen about these " races," and learnt a good deal without knowing it. The much-discussed quality of individuality was apparently also developed as the following incident shows. A party was leading comfortably on one occasion near the finish, when they were passed by another lot who had adopted the simple expedient of taking a bus !

It is probable that this kind of scheme is in use in a great many units with variations and improvements, but to those which have not already adopted it, it can be strongly recommended, both for training and amusement.

"ILEX" IN THE FASTNET RACE.

By ONE OF THE CREW.

IN the year 1926, one of the crew made his way round the Fastnet course for the second time, and for the second time vowed it was his last race. As he stood on Mizzen Head in August, 1927, watching the great white-crested Atlantic rollers smothering the Fastnet Rock with spray, he vowed that his luck was in. As he read the account of the 1928 race, prepared to gloat over the tribulations of his brother officer, he was troubled. *Ilex's* luck was unquestionably out. It must be restored, and that necessitated a mascot. One of the crew must produce a mascot. There followed correspondence, persuasive on one side, almost illegible on the other, between himself on the one hand and the oldest R.E. ocean racer on the other. Josh must go—too old—nonsense—too busy—nonsense—not enough olives—nonsense—I have to take a cure—You won't need it after the race—Alright, I'll go, but by heck you will go, too, one of the crew, that when the waters are troubled and ocean racing gives me a pain I may feast my eyes upon your physical infirmities and my spirit may be gladdened by the spectacle. And so it came to pass.

On August 13th, after listening to a fortnight of (apparently) howling gales and meditating what excuse I could produce for going sick at the last moment, I leapt in a smart and seaman-like manner on to *Ilex's* deck from Cowes pier. *Ilex* left the pier immediately, leaving my curiously assorted baggage thereon surrounded by the inquiring offspring of innumerable trippers. The result was a re-disembarkation *via* the dinghy with the Mascot, who was only too pleased to get ashore to supplement what he considered to be the inadequate victualling of the ship for the voyage. The Mascot did us well. An enormous melon he bought from a smooth-tongued widow, who assured him that it was ready for immediate consumption. It was over-ready. It was bad. A goodly supply of hot-house grapes we bought and other delicacies. 1929 was going to be a bumper year. We came to the more solid items remaining to be purchased. Kippers, salted silverside of beef, onions. The Mascot paused. "We must be returning to the ship," he murmured. "Can't let the others do all the work. What about *you* sleeping ashore, and collecting these remaining items to-morrow?" It is no use arguing with a mascot. We returned.

Ilex had been anchored in a most masterly fashion. We were

obviously foul of not one but two smart motor cruisers. As we swung on our chain, first we threatened one of them, whereat the apparently deserted vessel sprang to life and a hand appeared with a fender and a scowl. Then we came round, making as if to board the second, and a chef thereon would look threatening. On *Ilex* no one moved. It was too obvious that we would have to move vigorously in the near future, so why budge until we had to? Francis, who had spent the last three-quarters of an hour coiling down and putting the sail covers on, was below. He was obviously the person to take them all off again. At last—"Up mizzen and staysail, break out the anchor." Slowly we moved off, looking for a berth. When we were just beginning to wonder when we would find one, a good samaritan on *Avocet* sent his launch to tell us of a vacant mooring and tow us to it. Once more peace reigned—except for Francis quietly coiling up all the ropes and putting the sail covers on again.

The Mascot and I then had leisure to count the crew. One, two, three, four, five, plus the cook. We started tactful enquiries. Yes, the crew had dwindled to five. Five, one of whom had not pulled a rope for two years, to represent the Corps in the big cruiser event of the year, against a highly enthusiastic band of experienced cruising yachtsmen. Leave difficulties, alas, had reduced us to this sorry plight. Luckily there was a ray of hope, or rather two distinct rays. The immediate ray was directed towards the neighbouring yacht *Avocet*, which was supposed to be crawling with Sapper subalterns probably at this moment reclining in deck chairs in comfort, pitying the poor victims on *Ilex*. An attempt must undoubtedly be made to shanghai them. Wilks and I were deputed to make the attempt, the former presumably with an eye to the possible use of physical force. We rowed off to *Avocet*, where we were most hospitably received, and returned half an hour later considerably cheered internally but without any additions to our crew. *Avocet* was about to sail on a shaking down cruise prior to the Santander race.

The second ray of hope was that Fryer and Gibson, who had been wired to, might obtain the necessary leave and join us before the race started. Fryer arrived by the last boat on Tuesday night. There was just a hope that Gibson, who was returning home from Belgium that night, would join us before the start on Wednesday morning.

After our unsuccessful visit to *Avocet* we adjourned ashore for dinner, thence to the hospitality of the Royal London Yacht Club, where those who indulge in Fastnet racing are wont to foregather and get their sailing instructions. It is becoming an unwritten law of the R.E.Y.C. in the Fastnet race that the crew of *Ilex* obtain the handicaps by hailing one of our rivals after the start—they never seem to be obtainable with the sailing instructions.

On Wednesday morning Gibson arrived. Under the circumstances

we had hardly expected to see him, but thanks to the sporting action of the authorities in providing the necessary leave at a moment's notice and his own great keenness, he had achieved the apparently impossible.

Ten a.m., therefore, saw us cruising about before the start in a light breeze under jib, main and jackyarder, with the jib topsail in stops and spinnaker and reaching foresail ready to hoist.

We got a very fair start at 11.30 a.m. with the wind dead aft and ran for the Spithead forts. It is curious that the order of start has given a very fair indication of the order of finish in the three races I have been on. In this race we were close astern of *Neptune*, *Jolie Brise* and *Maitenes II* as we crossed the line, with *Saladin* abeam and close inshore. The rest of the fleet were tailing out astern. *Neptune* gave up, *Jolie Brise* won, and *Maitenes*, *Saladin* and *Ilex* kept reasonably close company throughout the race. The rest of the fleet we lost sight of after the first day.

The crew had not begun to settle down yet. Watches had not been fixed and all those members of the crew not actively occupied lay on deck watching the fleet. The sole exception was the indefatigable Francis, immediately nicknamed the Busy Bee, who had taken on the duty of wireless operator. This duty included that of getting one or both of our two sets to work, prior to our getting time signals and light music. Francis started by taking exception to our horizontally-wired frame aerial. In this he was unquestionably correct, as the results with it were *nil*. He immediately proceeded with the manufacture of a frame and the winding thereon of two hundred feet of wire in some thirty coils, each being threaded through four holes in the frame. After the first gybe he was found looking at some wreckage which had apparently been hit by a shell, but which actually had felt the weight of either the boom or Wilkinson's foot. In a disgust too deep for words, he disappeared below, to re-emerge with a new frame and restart the winding of the aerial. His patience was rewarded by obtaining time signals and weather reports throughout most of the race.

Close to the forts we ran into the " twelves " racing close-hauled, and *Neptune* obliged with the first touch of humour of the race in the form of a nice gybe all standing, while trying to avoid them. Luckily there was little weight in the wind. Spinnakers were taken in rounding the forts, and the long spell of tide dodging and beating in light and fluky winds which lasted from Spithead to the Longships began. Under such conditions Chance plays too great a part in relation to skill. Luck, in the shape of a patch of breeze, took the tail of the fleet past us shortly after rounding the forts. Lucky breezes enabled *Maitenes* and ourselves to pass and repass each other more than once *en route* for the Longships. Luck enabled us to catch a faint breeze across Mount's Bay which took us up to the leaders at the Runnel-

stone, and luck gave *Saladin* a fair wind into Plymouth which died away to leave *Maitenes* on the doormat. However, it is all in the game, and without the element of luck a race like the Fastnet race for yachts of an infinite variety of design would probably lose its chief charm.

Near St. Catherines, *Saladin*, tired of tide dodging, headed a large contingent out to sea, leaving *Neptune*, *Jolie Brise*, *Maitenes* and *Ilex* dodging along the coast in that order. About two miles separated *Neptune* and *Ilex*.

During Wednesday night the wind shifted northerly and freshened slightly. *Ilex* hoisted yankee jib and reaching foresail and bowled along merrily. By dawn on Thursday, *Maitenes* was astern and *Neptune* and *Jolie Brise* were still in view ahead.

Thursday was a repetition of Wednesday, with light airs from varying directions, all four boats hugging the shore. *Maitenes* passed *Ilex*, was in turn repassed, and passed us again to end the day about a mile ahead. The two leading yachts continued to open out a lead, but were still in sight. Of the *Saladin* contingent there was no sign. At nightfall, the Eddystone Light was about a mile away on the starboard bow.

Thursday night was a good illustration of ocean racing in light airs. The wind shifting astern spinnaker was set to port at 1 a.m. The 2–8 a.m. watch (we kept two watches of three) gybed ship in the pitch dark at 3 a.m. and in all took in spinnaker, gybed and reset spinnaker three times to catch the varying airs.

At dawn on Friday we approached the Lizard with the three leading yachts rather closer as a reward for the night's exertions. As the visibility improved we sighted a stranger under spinnaker on the port quarter, which proved to be *Saladin*. Thus the much debated question as to whether the fuss and bother of tide dodging down the coast in light airs pays against the bold policy of getting right out into the channel remains a very open one. In 1926, *Ilex* made for open water, and it paid handsomely. This year we tide dodged. Did it pay? *Quien sabe?* At any rate we did not lose much by it. Heading for the Runnelstone Hunt greatly improved our position by keeping out of Mount's Bay, while the three leading ships went in and lost the breeze. Passing the Longships we were close astern of *Neptune* and *Jolie Brise*, and had opened out a lead of about a mile on *Maitenes*.

The second phase of the race begins here with a leg N.W. to the Fastnet Rock, tide dodging behind us *pro tem.*, and a breeze freshening and veering rapidly. By 10 a.m. we were nearly close-hauled and thumping into a troublesome short sea *en route* for Ireland. The ship was getting thoroughly wet and the lee rail was awash. She was being hard driven in the endeavour to prevent *Jolie* and *Neptune* getting away, but weight was bound to tell under the existing con-

ditions. We stuck to our jackyarder yankee jib and reaching foresail to the bitter end, the crested tops of the waves sweeping the decks from end to end, sheets of spray drumming on our oilskins. *Jolie Brise* made the first move in reducing sail. Down came her yankee jib and up went a small jib topsail. We followed suit. The next move was also by *Jolie Brise*. She handed reaching foresail, set staysail and stood out to windward close-hauled on the port tack, We in *Ilex* substituted staysail for reaching foresail, and got down the jackyarder before it knew what we were about and could raise its usual objections to that operation. I must really raise my hat to our jackyarder and its unimpeachable behaviour in the race. Our jackyarder is a sail of truly feminine perverseness. In the normal way when most wanted up it jams: when most wanted down it fouls something and some luckless wight has to go aloft to clear the foul. During the race, knowing what to expect, the crew tried shock tactics. Manning the halliards sheet and downhaul stealthily and making noises about getting the jib in, we got that unsuspecting jackyarder down across the deck and stowed before it could manage one foul in protest. After getting in jackyarder we stowed mizzen, which is a hindrance rather than a help close-hauled in a sea, and attempted to follow in the wake of *Jolie Brise* whom we could still see between squalls. In this, unfortunately, we were not successful, the head-on sea stopping our weigh and sagging us off to leeward.

Down below, *Ilex* was getting into ocean racing trim. Unable to get her own back on the watch on deck who were driving her in this ruthless fashion, she wreaked an ample revenge on the watch below. In fury she hurled any loose articles off the racks on to the floor, and on to the occupants of the floor seeking sleep. Occasionally a playful wavelet rushing aft along the deck and lifting the hatch cover would drop a cupful or so of cold water on to the blankets of the sleepers. Lockers came adrift and dropped on to the occupant of the cabin floor aft. This individual became a species of tell-tale whose reproachful cries would inform the watch on deck when the bilge needed pumping. Withal the glass remained high and steady, the breeze never freshened to reefing point, and the long Atlantic rollers, which usually one expects underlying the boisterous short seas, never got up.

The fresh breeze had brought about a radical change in the situation. The big yachts, *Neptune* and *Jolie Brise*, forged steadily ahead and to windward, and we were powerless to prevent them. In turn, we were pulling right away from *Saladin* and *Maitenes*. The danger point had shifted from *Saladin* and *Maitenes*, to whom we had to give an inordinate amount of time (about seven hours), to *Jolie Brise*, who was giving us under an hour. *Neptune* we were not frightened of. She had to give us ten hours, and we were still reasonably close on her heels. All Friday we thrashed to windward. By Friday

ILEX IN THE FASTNET RACE.

D. N. B. Hunt, Skipper

Ocean Racing.

ILEX in the Fastnet race

Fryer.

The Red Watch.

The Red Watch

night, the wind freshening, we had to ease the ship by lowering jib topsail and staysail in the early hours. At dawn on Saturday, we managed to get staysail and mizzen on her again, followed by jib topsail and jibheader as the wind eased about 8 a.m. We made our Irish landfall about 1 p.m., when we sighted the Old Head of Kinsale and went about at 2 p.m. on the starboard tack, running parallel with the Irish Coast and about six miles from it. Nearing Cape Clear the wind dropped light amid the united groans of the crew. Had the wind held we would have rounded the Fastnet not so very much outside our time astern of *Jolie Brise*. As it turned out, that last sixteen miles dead to windward in negligible airs gave *Jolie Brise* a clear nine hours lead—she rounded the Fastnet at 9 p.m. on Saturday, and we drifted round at 6 a.m. on Sunday morning. Rounding the Fastnet is always the event of the race, and can usually be guaranteed to provide the chronicler of the voyage with some comic relief. This race was no exception to the rule, and professional pride must not make me conceal the fact that our signals left something to be desired. As we approached the rock, our distinguishing flag hoisted, we fired a Verey light. A black dot appeared on the balcony of the lighthouse, placed himself where we could only see one of his arms and guess at the other and started to semaphore. All available brain on *Ilex* was turned on to reading, and good guesswork filled in the gaps in a string of letters and turned it into *Jolie Brise*. So far, so good, but all the crew of *Ilex* could not read the rest, and we gave it up. Undeterred, Black Dot continued to work himself up to a peak of signalling frenzy and eventually collapsed against the balcony rail, registering disapproval. Meanwhile one member of the crew was having a pleasurable morning. Hoot, having roped in a suitable assistant, had got out the signal flags and a book of the words and was looking like an advertisement for a flag day. Up went a vast string of flags to the crosstrees. No sooner were they up than up fluttered the answering pennant from the lighthouse. Black Dot had recovered. Things were looking up. The only beings who appeared at all disconcerted with the rapidity of the reply were our signalmen, who were now burrowing like moles into the book of words again. The ship drifted placidly towards the rock: "What kind of shock will we get as to our position from the lighthouse?" I wondered: "this flag business seems a slow process: however, our message must be nearly through by the length of the hoist." At this moment someone inquired what message we had hoisted. "I have just sent the general signal 'What,'" explained Hoot, still rushing anxiously through the pages of the code book.

There is no doubt that such a signal is a great temptation to a lighthouse keeper who has had nobody to talk to for the last two months. Black Dot reacted with energy and goodwill, but with complete lack of success. He might as well have burst into

Gaelic. Perhaps he did. With the rock abeam we had gleaned nothing.

"But," began the Busy Bee, and that was as far as he got. A hoarse noise from the lighthouse silenced him and startled the gulls. It sounded like "Hullo!" It *was* hullo. We had established communication. As the one who talked most and did least I was deputed to shout back. Our conversation ran something as follows. (The reader must picture the yacht drifting past the light, minimum distance two hundred yards, gradually increasing.) "Hullo," from the lighthouse. "Hullo" (me). Pause—"hullo"—pause—"hullo"—pause—"*Jolie Brise* passed 9 p.m." (rest of sentence lost). "What?" (me)—"Hullo" (lighthouse)—"Hullo" (me): "You are next"—"When did *Neptune* pass?" (me, strain on larynx getting severe). "Try semaphore" (lighthouse)—"Can't read your semaphore" (me). "Wow" (tone of deep disgust from lighthouse). At this point my larynx threatened rupture and vocal communication was suspended *sine die*.

As we foregathered to discuss the news a voice was heard from our signal halliards. "Has he answered yet?" it said. There flaunted from the crosstrees a string of flags. Slightly flushed, our signalman was preparing another signal. "No, he has not answered" we said without enthusiasm. "What have you asked him with that little lot?" "They mean 'When,'" said our signalman proudly.

After rounding the rock we got a light breeze from the N.W. and set spinnaker to port. *Jolie Brise* had a clear nine hours lead. To drop that lead to under one was a bit of a problem. *Neptune* had evidently not rounded. Anyhow, why worry? We got all our soaked gear on deck in the pleasant sun, and with every stitch of canvas set prepared to enjoy what the sea had to offer us. Sitting aft on the counter we whiled away the time with the gramophone and revolver practice, and with idle guesses as to how the rest of the fleet were faring. At 8 a.m. our guesses began coming home to roost when we passed *Saladin* outward bound, followed an hour later by *Maitenes*. The latter looked rather the worse for wear, as if she had been well reefed down. It seemed fairly clear that *Jolie Brise* was, barring accidents, beyond catching, while *Saladin* and possibly *Maitenes* were still within their time of us.

We averaged about six knots to the Longships, with a maximum of seven and a half, a run all the way. As we neared the English coast the wind dropped lighter and lighter. Pendeen and Bishop's light were picked up at 3 a.m. on Monday and light breezes took us peacefully past the Runnelstone at 5 p.m. and into the middle of the fishing fleet from Penzance. It is surprising what an interest the fisher folk take in the race. One by one as they passed they waved or asked questions. "How are you getting on?"—"Are you leading?"—"You must have had it fresh by the Fastnet"—and so on.

The same old light breezes took us to the Lizard and left us kedging at 11 p.m. on Monday night. It was painfully slow progress with the monotony relieved only by a flirtation with rocks off the Lizard by the watch on deck, who quite obviously thought that the watch below had had enough sleep. They started their watch with the gramophone until quelled with harsh words from below. This was followed up by much sail shifting and other indiscriminate noises "off." Then came the operation of kedging, followed by the breaking out of the kedge in an apparently flat calm. Scraps of conversation of which the following are samples drifted in the still air through the skylights—just enough to keep the watch below stirring in their bunks. "I think it's a seal"—"It isn't moving and there is a nasty swirl round it"—"Anyway we will know soon as we *must* hit it." "Seal be blowed. It's a rock, bear away. No can do, no steerage way." When the watch below took over at 2 a.m. the ship had drifted through, round, or over the seal and its *confrères* off the Lizard. By this time we were all experts at sail handling on moonless nights. On this Tuesday morning before dawn, we set spinnaker and reaching foresail and gybed twice before dawn. We had not seen *Saladin* or *Maitenes* since Sunday morning. In the meanwhile, on we drifted. I have an impression that we of the Red watch were not at our brightest at dawn on Tuesday. We would all have been the better for something fizzy out of a glass. The Mascot talked gloomily about running on the Manacles; the Busy Bee did not talk, but as he coiled up ropes he had the hiccups. The only note in my diary for Tuesday morning is a rude remark about the hiccups. I remember hoping that the hiccups would wake the watch below and that the watch below would brain the producer of the hiccups, when the smell of breakfast banished thoughts of hiccups, the Manacles, and our lost beauty sleep of the previous night.

If the wind remained light, it seemed fairly certain to save our time and get a second. If a breeze came up from the south or west, the situation was very open. Unfortunately, the wind freshened, and by noon we were racing along with a fresh following breeze, which must have reached our pursuers hours before. We had not much hope now of saving our time, though *Saladin* and *Maitenes* were not in sight. As we crossed the finishing line we learned that *Saladin* and *Maitenes* were $7\frac{1}{2}$ hours behind us at the Start. Such a lead in time was, however, of not much value now the wind had freshened. So it proved. *Saladin* saved her time and we had to be content with third place. *C'est la guerre.*

In conclusion a few general impressions of the race. All on board were agreed that *Ilex* had never been better found and victualled than in this race. We had no trouble of any description with the gear. The wireless set, though not working properly, was persuaded to yield up the time signals and weather forecasts without trouble,

when required, and when adjusted will be a great asset to the ship. Hunt combined the duties of skipper and navigator, and very excellently he did both. Our landfalls were beyond reproach. Francis, who distinguished himself last year as ship's carpenter when he spliced the broken topmast during the race, was indefatigable again this year on all kinds of odd jobs, usually performed in his watch below, ranging from the manufacture of bamboo gramophone needles and the stripping (and correct re-assembly!) of the ship's stopwatch to winding frame aerials. The yacht hand excelled himself in the culinary line. After his fifth ocean race he must have few rivals as a cook in a sea.

We were a little unfortunate, firstly, in being almost becalmed with a dead beat before us sixteen miles off the Fastnet, and secondly in the freshening of the wind at the most inopportune moment as we neared Plymouth.

It is becoming increasingly clear that *Ilex* is very ill-served by the special O.R.C. handicap formula. This year, although the smallest yacht in the fleet, we gave half the fleet time. *Jolie Brise*, a big powerful yacht twice our size, gave us 40 minutes. To *Saladin*, almost as large, we gave over five hours. Luck and hard sailing alone can give us another winning flag. We will not get any assistance from the formula.

The starters were as follows :—

Yacht.	*Rig.*	*Tons.*	*Handicap.*	*Owner.*
Guerveur ...	Yawl	48	Scr. ...	Baron A. de Neufville.
Maitenes II ...	Ber cutter	25	15 hr. 22 min. 30 sec.	Lt. L. B. Luard.
Ilex	Yawl	20	10 hr. 35 min. 40 sec.	R.E.Y.C.
Jolie Brise ...	Cutter	44	9 hr. 54 min. 30 sec.	Mr. R. Somerset.
Neptune ...	Cutter	46	30 min. 45 sec. ...	Lt.-Col. G. L. Chambers.
Vega	Ber schooner	—	13 hr. 9 min. 15 sec.	M. Balderweek
Amaryllis ...	Yawl	37	3 hr. 45 min. 30 sec.	R.N.C., Dartmouth.
Grey Fox ...	Ketch	33	5 hr. 38 min. 15 sec.	Mr. N. Newgass.
Saladin ...	Cutter	34	17 hr. 15 min. 15 sec.	Mr. Jugo Simon.
Cariad ...	Cutter	34	16 hr. 54 min. 45 sec.	R.N.E.C., Devonport.

Order of finish on corrected times :—*Jolie Brise, Saladin, Ilex, Maitenes II.*

MEMOIR.

MAJOR-GENERAL ARTHUR EDMUND SANDBACH, C.B., D.S.O.

THE subject of this Memoir, Arthur Edmund Sandbach, was born on July 30th, 1859, at Hafodunos, in Denbighshire. He was the third son of Henry Robertson Sandbach, D.L., J.P., of Hafodunos. His mother was daughter of Captain Martin Williams, of Bryn Gwyn, Montgomeryshire, and to her sister, Miss Katherine Williams, this family property descended; subsequently Miss Williams made the place over to her nephew, Major Martin Sandbach, R.A., and, on his death in 1895, his younger brother, Arthur Sandbach, became the owner of Bryn Gwyn.

He followed his two elder brothers to Eton (Durnford's House) when he was twelve years old, was placed in the IV Form, and, as the youngest of three contemporary brothers, was termed Minimus, a title which stuck to him all his life with his old schoolfellows. Among his contemporaries at Eton in the Corps we find Hawker, Hussey, Anstruther and Mills; in the rest of the Army, Sir William Pulteney and many others. Amongst statesmen and diplomatists, Lord Curzon and Sir Arthur Lawley, whilst the Church and Literature are adequately represented by the present Dean of St. Paul's.

He was six years at Eton, and passed direct from the VI Form into Woolwich in 1877, when he was fifteenth on the list. He was a "wet bob" at school, and also an ardent member of the school Volunteer Corps, in which he became a serjeant. We may be sure that even then he was a very efficient drill; legend has it that he was rudely rebuffed at Woolwich by his Division Officer when he pleaded his status in the School Corps as a ground for being excused some of the preliminary drills which "last joined" underwent. From the first he was unusually smart as a cadet, and as a result was specially made an Under Officer out of his turn, with the general approval of his fellow cadets. One of his Woolwich contemporaries, and subsequently a comrade in the Soudan, now General Sir Reginald Wingate tells the writer that Sandbach went by the name at Woolwich of "the lordly stag," which is curious in view of the fact that twenty years later, when serving with the Egyptian Army, where everyone had a nickname, Sandbach was christened "the stately stag," which was held to describe very well his carriage and his walk. The nick-

name in his own batch and obvious to the Corps was "Sandbags," which was perhaps the most lasting of his different sobriquets.

He was gazetted to the Corps on 6th April, 1879, being the eleventh out of a batch of twelve, of which John Winn was the head and S. G. Burrard second. At Chatham, he took up rowing again, and induced the batch to follow his example. He was stroke and best oarsman in the batch Four. He taught the others how to row, and his crew were head of the river whilst the batch was at the S.M.E.

He was also chief whip of the Beagles whilst at Chatham, kept a horse, and hunted. One of his batch, referring to Sandbach at this period, writes: "He was a true gentleman, he never did or said a mean thing, never said a word against anyone or to hurt anyone's feelings. He was a very upright and straight-living young fellow, he had high ambitions and was a hard worker; among his own batch he was decidedly popular, and never made an enemy."

Sandbach must have given satisfaction to the authorities as a young officer, because at the conclusion of his S.M.E. Course he was at once appointed to "A" Troop (Pontoons), and then made his first acquaintance with Aldershot, where so much of his subsequent Home Service was spent. Colonel Fitzroy Somerset was C.R.E., with Sir Howard Elphinstone as O.C. Troops and Companies. Major Robert Bond commanded "A" Troop, with Godsal, Pemberton and Irvine as the other three subalterns. The "C" or Telegraph Troop was commanded by Major Hamilton, one of whose subalterns, Sir Ralph Anstruther, was an Eton friend of Sandbach's, and writes of him at this period: "I can recall him to-day as he was then, a tall slim lad with very fair curly hair, intensely keen on his duties, with a happy ingratiating manner and a pleasant smile for all and sundry."

Colonel Pemberton, a fellow subaltern in "A" Troop, tells of Sandbach's efficiency as an officer, his attention to duty, and the good work which he did on active service in Egypt; "with an easy assurance, pleasant manners and *joie de vivre*, he was an attractive personality, we were always the best of friends and I admired his forceful character and his ambition to push himself to the front."

In 1882, Sandbach had his first experience of active service in the Egyptian Campaign, when "A" Troop, "C" Troop and the Field Park all went to Egypt together and back in the same ship, the *Oxenholme*.

The Pontoon Troop did useful service in the Sweetwater Canal, and was in close support at Tel-el-Kebir, but in view of the course which the campaign followed, and of its early conclusion, the Troop had no opportunity of any very important action.

Sandbach remained in "A" Troop for three years, and enjoyed his service with it, and life at Aldershot immensely. The Troop in those days used always to send a bridging detachment to the Royal Military Tournament at Islington, and Sandbach was in charge of it

Major - General Auther Edmund Sandbach.

Egyptian Army, 1897-1898.

Egyptian Army

on at least one occasion, when he rode his chestnut trooper "Ascot" in the tent-pegging competition, and was third in the whole Army. Then in the winters he used to hunt with the Garth, the H.H., and sometimes with "The Vine."

He was a very attractive fellow in those days; the writer remembers so well the impression made on General Fred. Willis, then commanding a Brigade at Aldershot, and for some time a dining member in the R.E. Mess: he thought Arthur Sandbach the ideal of what a young officer and gentleman should be, and tried ever so hard to secure him for his A.D.C.

In the summer of 1884, after three years' service in "A" Troop, Sandbach came up for foreign service, and on September 3rd embarked to join the 11th Field Company, which had just arrived at Cairo and was expecting to go up the Nile as part of the expedition in relief of General Gordon. Only a section of the Company, however, ascended the river, and Sandbach, the junior subaltern, had to stay in Lower Egypt; later on, however, his opportunity came, and he grasped it. After the fall of Khartoum it was settled to send a force to Suakim, and as part of the preparations Colonel Hutton organized and trained a Mounted Infantry Battalion at Cairo of which Colonel H. F. Grant, 6th D.G., was ultimately to have command. Sandbach describes as follows what happened:—

"I had known Col. Hutton when he was a Brigade Major at Aldershot; so one day I asked him why he did not have an R.E. Section with his M.I. battalion. He took the idea to the General in Cairo and got his sanction, and then asked Col. Maitland (the C.R.E.) to nominate me, and very soon I found myself at Abbassiyeh with an R.E. Section of 28 all told, drawing saddles, mounted equipment and Arab horses. The Section was selected from the 11th Field Co., which was still quartered in Cairo. A telegram was sent to the War Office asking for my replacement by another officer, as I was proceeding to Suakim with Mounted Infantry. A reply came 'Stop Sandbach—no R.E. officers can be spared for Mounted Infantry.' My Section was duly ordered back from Abbassiyeh to Kasr-el-nil, the breeches and puttees of the men were returned to store, and there was some friendly chaff in the Company about the cavalry soldiers of the R.E. who thought they were off to Suakim. I was naturally bitterly disappointed after all that Col. Hutton had done to get my Section organized. I sat down in the Orderly Room at Kasr-el-nil on our return there and wrote off two letters to London, worded in much the same way, one to Sir John Stokes, D.A.G.R.E., and another to Sir Andrew Clarke, Inspector-General of Fortifications. I explained the circumstances and what had been intended to be our work with R.E. tools and explosives, of cavalry pioneer equipment carried on our saddles, and told both these R.E. Generals that I felt sure that the nature of the organization of the R.E. Mounted Section

and its proposed duties had not been understood in the War Office. To my intense joy in five days time a telegram arrived from the War Office saying: 'Sandbach and Mounted R.E. Section approved.' I had replies by letter from each of the Generals; Sir Andrew Clarke merely said he was sorry for my disappointment; he, too, had had his disappointment about active service, and so on. Sir John Stokes replied that he showed my letter to the Duke, and that, as soon as H.R.H. understood the details of the proposal, he gave his approval at once, and a telegram to that effect had been sent to Cairo. Accordingly we went back to Abbassiyeh, had some more riding instruction with the men with Colonel Hutton, embarked at Suez to join the M.I., and reached Suakim early in April, a few days after the fight at McNeil's Zareba. I reported to Col. Grant, my new C.O., and my R.E. Section was posted to a Company of Coldstream Guards M.I., commanded by Captain John Ross, of Bladensburg, whom afterwards we knew so well in Dublin."

Sandbach goes on to describe some of the work which his detachment did whilst at Suakim; the story has been told at length because it was from this beginning that later sprung first of all the R.E. Mounted Detachment, and then the Field Troop R.E.; the incident illustrates Sandbach's persistence in a good cause, whilst it shows that Sir John Stokes and H.R.H. were not so conservative as they have been sometimes painted, though, on the other hand, Sir Andrew Clarke on this occasion belied his usual reputation of a reformer.

In Colonel Grant's M.I. Battalion was serving the future General Sir Horace Smith-Dorrien, who, in reference to these days, writes: "At Suakim, 1885, Sandbach and I served in a battalion of Mounted Infantry together, and a very remarkable battalion it was, for it was made up of sections from many units of the British Army, even Marines, proving that horse-marines are a possibility. Sandbach commanded the R.E. Section, and was popular with all, as he was always cheerful and ready to help anyone. The Corps was about 800 strong, and had on its rolls representatives of 35 units."

In May, 1885, owing to complications with Russia, the Suakim Expedition was stopped, and most of the troops were withdrawn, Sandbach with his detachment rejoining the Headquarters of the 11th Field Co., R.E. At Suakim he had made the acquaintance of Col. E. P. Leach, V.C., R.E., then commanding the 24th Company, R.E., and from him he received advice to go to India for his foreign service. Colonel Bindon Blood, whose acquaintance Sandbach also made about the same time, gave the same advice, and asked him to join the Bengal Sappers and Miners, to the command of which Blood was about to succeed.

Sandbach accordingly volunteered for service in India, was ordered home and given leave before embarkation. However, shortly after his arrival home, in July, 1885, he was laid up with malarial fever,

and had to take sick leave for the winter of 1885–6. In the following spring he was posted to the 12th Field Co. at Chatham, pending embarkation for India in the autumn. This Company was commanded by Major J. C. Tyler, then the exponent and pioneer in Field Company development, and the inventor of the tool cart which bears his name.

One of the subalterns of the Company, now Major-General Sir Hugh Bruce-Williams, writes of Sandbach's sympathy to the young officers at Chatham, and how constantly he was on the look-out for keen youngsters who would be likely to do well in the troops and companies of the Corps. "It was he certainly who put the idea of going into a Field Company into my head, and it is thanks to his advice that I eventually went to the Staff College."

In September, 1886, Sandbach sailed in the Indian troopship *Jumna* for Bombay, *en route* for the Bengal Sappers and Miners at Roorkee. In some interesting notes regarding his earlier experiences he tells us that Colonel Blood and the Adjutant (W. A. Cairnes) met him at Roorkee Station and informed him he was to go on at once to Upper Burma, and join there the 5th Company of the Bengal Sappers and Miners, then commanded by Captain M. C. Barton, whom 19 years later Sandbach was to succeed in command of the Sappers at Roorkee. In regard to his Burma experiences, Sandbach was at first handicapped by his complete ignorance of Hindustani and of Indian methods. The country itself was very unsettled, and bands of decoits still infested Upper Burma and entrenched themselves in stockaded villages, which small flying columns had to attack and capture. There was plenty of work and much experience to be gained by young officers, together with the spice of danger, and, on one occasion, Sandbach, if not wounded, at any rate had the experience of having his horse shot under him. After five months of this hard campaigning in a feverish area, Sandbach was ordered back to Roorkee, whence he made a short visit to Simla to shake off a fever attack. He tells us in his notes of the then Viceroy, Lord Dufferin, and his Military Secretary, Lord William Beresford, and how he saw for the first time "the paraphernalia of the Viceregal Court in India, in which I was destined later to take a personal part."

The next two years Sandbach spent at Roorkee; he managed, however, to make two visits to Cashmere, and on the second occasion had a four months' trip, going from Srinagar to Leh, and thence to Haulé, in Thibet, whence, after crossing passes over 17,000 feet, he reached Simla from the north; for three months after leaving Leh he had not seen a white man, and had only spoken in Hindustani to his servant.

He had now the good fortune to drop in for the Sikkim Expedition of 1888–9; the fighting was soon over, but a fortified position was

held all through the winter of 1888–9 by the troops of the column, and the Sappers had plenty of work in road-making and hutting. In the summer of 1889 the fever from which Sandbach had suffered at intervals became worse, and in August he was sent home on a year's sick leave, having become a Captain on the 15th of April previously. On the ship going home was General W. K. Elles, then Adjutant-General in India, and the two made friends over some problems and conundrums which the General gave Sandbach to work out; thus it came about that later on Sandbach became the General's A.D.C. in India on the completion of his sick leave. Sandbach was two years A.D.C. to Sir William Elles at Rawalpindi; during this period Sir William was given command of the Hazara or Black Mountain Expedition, which lasted from March to June, 1891; Sandbach acted as principal A.D.C., with Lieut. Wilberforce (now Sir Herbert Wilberforce) and the late Prince Christian Victor to assist. In his final dispatch published in the *London Gazette* in October, 1891, Sir William referred to Sandbach as "having already seen considerable and varied service in the Field, and as having been specially useful."

On completion of two years as A.D.C., Sandbach rejoined the Bengal Sappers and Miners in January, 1892, when he was sent on special duty to Gilgit, where he took the place of Captain Aylmer; Aylmer had gone to Gilgit directly after the Black Mountain Expedition, and in the interval had helped to make history and to earn for himself a V.C. in the romantic fighting at Nilt and Hunza Nagar, so well described in Knight's *Where Three Empires Meet.*

To be chosen to succeed Aylmer at this most important frontier post was a compliment, and reports all say how well Sandbach did during his seven months at Gilgit.

At Gilgit, Sandbach was a Special Service Officer on the British Agency, and had only a small detachment of Bengal Sappers with him. His duties generally were to improve the communications throughout the district and act as adviser to the British Agent on all engineering matters. As Sir Fenton Aylmer writes: "To look after R.E. matters in the Gilgit district was a heavy business, and entailed endless riding of long distances over vile roads. Most things had to be done with local labour (coolies) totally untrained, and it was always a case of making bricks without straw."

One incident of these times deserves recording.

It happened that Sandbach, smartly costumed and well retinued, was riding out one day from Gilgit along a bridle path which led towards the frontier. There appeared coming to meet him along the path a tattered looking individual, perhaps a pedlar, his clothing in rags, astride a pony, with a native of Central Asia following in rear.

The path was narrow, and the ragged one endeavoured to clear the way for *Huzoor;* in the effort, the roped stirrups slipped, and after a momentary struggle the rider bit the dust. The kindly Captain halted and scanned the fallen one as he rose. Surely no pedlar this,

the face despite the dirt seemed to grow familiar. "No, it can't be; but yes, yes, it is, Pembo."* Last met when a fellow subaltern in "A" Troop, and now on his way back to civilization from one of his adventurous explorations of Central Asia.

A curious meeting that, and one over which they both often laughed in years to come.

His service at Gilgit ended Sandbach's Indian tour, and he came home in the summer of 1893 and joined the Depot at Aldershot on the 6th August.

It was fitting that Sandbach's first home appointment should be to the command of the Mounted Detachment of which he had been the first exponent in 1885. A Mounted Detachment had been in existence as part of the R.E. Field Depot since 1888, but so far had not been formerly recognized in Army Establishments; it had been commanded since its formation by Captain Kincaid, who vacated it in August, 1893, on being appointed to the Egyptian Army.

In the spring after Sandbach assumed command, the Mounted Detachment became a separate unit under Sandbach, with H. A. Micklem as his subaltern. The new unit attended the Cavalry Manœuvres of 1894 at Churn, and its Commander received high commendation from the Inspector-General of Cavalry, Major-Gen. Keith Fraser.

Sandbach commenced to work for the Staff College directly he joined at Aldershot, and most of his off duty hours were spent in study at the upright desk at which he always worked; he went up for the examination in 1894, and although he failed to qualify he did sufficiently well to be placed on the list of Special Officers for nomination kept by H.R.H. the Commander-in-Chief.

In April, 1895, Sir Arthur Mackworth, who had been O.C. T. and C., succeeded Colonel Bruce Brine as C.R.E., whilst Lieut.-Col. A. Dorward became O.C. T. and C. The Adjutancy became vacant at the same time, and was offered to and accepted by Sandbach, who took up his new duties on the 25th April, 1895. He was not destined, however, to hold this coveted post for long, for in the autumn of the same year he was one of the Commander-in-Chief's nominations to join the Staff College Course of 1896, and he accordingly vacated the Adjutancy and joined at Camberley on 15th January, 1896.

He found himself one of a course which, judged by subsequent events, was a very remarkable one. Among the nine nominations was the future Earl Haig.

Captain E. H. Allenby, 6th D.G., the future Field-Marshal, was Master of the Drag; Sir George Macdonogh and Sir James Edmonds represented the Corps; we find in the list—in addition to General Sir Richard Haking and Lt.-General Sir William Furze—the names of eight future Major-Generals, including the brilliant "Tommy" Capper, and, with one of them, Sir George Forestier Walker, Sandbach was to be subsequently associated in Ireland and in France.

* Colonel E. St. C. Pemberton.

In this brilliant galaxy Sandbach held his own, and he got an excellent leaving report from Sir Henry Hildyard, a Commandant by no means easy to please.

His services were already in request, and within a fortnight of the conclusion of the Course, Sandbach embarked for service with the Egyptian Army on the last day of 1897.

He arrived in Egypt at a very opportune moment, a few months before the Battle of the Atbara, and the subsequent advance on Omdurman.

He was employed during the eleven months he was with the Egyptian Army on Staff and L. of C. work; he was successively A.A.G., Dongola District, Commandant Wadi Halfa, and A.A.G. L. of C. He finally came to the front as A.A.G., Headquarter Staff, in time to be present at the last battle, that of Omdurman. He gave great satisfaction as evidenced by reports sent home about him, by his mention in dispatches, and by the award of a Brevet Lieut.-Colonelcy.

Sandbach's period of service with the Egyptian Army came to an end on the 30th November, 1898, but he was home in time to attend the banquet given at the Mansion House on November 4th to Lord Kitchener and to those of his officers who were within reach of London, and it was shortly before that date that his next form of employment was settled, viz., Military Secretary to the Viceroy of India, Lord Curzon. The future Viceroy apparently sounded his old schoolfellow on the subject when they met at the Eton dinner given to Lord Curzon on October 28th, but the appointment was actually suggested by Sir Walter Lawrence (Private Secretary to Lord Curzon), after the advice of both Lord Roberts and Lord Kitchener had been taken. Sandbach had already accepted the post of Military Secretary to Sir George Luck, then commanding one of the larger areas in India, but Sir George waived his claim when he heard of the future Viceroy's wishes.

Sandbach went to India at the same time as Lord Curzon, and took over his duties on arrival. The association between the Viceroy and his Military Secretary was not a happy one, and did not last long. Temperamentally they were unsuited to one another, and it was probably a relief to both when the outbreak of the South African War gave Sandbach the opportunity of proceeding to the scene of operations as a Special Service Officer on the Indian Establishment.

It is well to record that there was nothing in Sandbach's action at the time which could give his friends and well-wishers cause for regret. Among these friends Sir Walter Lawrence, who had formed a high opinion of his work in Gilgit, and had stayed with him at the Staff College, does regret that by his suggestion Sandbach should have joined an appointment where there was no scope for military ability. But when he and Sandbach reached India, it was soon evident that the latter's duties were those of a *major domo*, and that

neither the Viceroy nor the Military authorities had any use for his experience and professional knowledge. He was not fitted by inclination for domestic affairs, and estrangement from all but the ceremonial side of military life vexed him. When the war broke out in South Africa, Sir Walter suggested to Sandbach that there was a way out, and he took it.

He embarked for South Africa on November 7th, 1899, and on the 28th December was appointed A.A.G. Intelligence to the Natal Army. He held this position until the Natal Army was broken up in October, 1900, when Sir Redvers Buller, shortly to be followed by Sandbach, returned to England.

It so happens that the writer is in a position to speak with some knowledge as regards Sandbach's work in South Africa, because after being in Ladysmith he joined the staff of Sir Redvers as soon as the relief was effected; he found them full of the excellent work which Irvine and the Pontoons and Jelf with the Telegraphs, had done throughout the long and trying relief operations, whilst Sandbach and the Intelligence, and Rawson with his cloud signalling, had also made a great impression. The Engineers had indeed done their bit towards the relief of Ladysmith.

It is to be realized that at this period the Intelligence Division of the Staff was much more "on its own" than in later years; the Chief Intelligence Officer dealt direct with the G.O.C., and not through the intervention of the "A" Staff, which was the General Staff of those days. In this way Sandbach was in very close touch with Sir Redvers Buller, reported to him daily, and was much in his confidence, and Sir Redvers had the highest opinion of him. In the final stages of the relief operations, after the capture of Hlangwane and the subsequent failure to make ground to the west of it, it was largely Sandbach who persuaded Sir Redvers to change his plans and to attack the centre and left of the Boer position on Pieters Hill; Sandbach had found for this purpose a suitable crossing over the Tugela river where it was possible for Irvine and his Pontoons to construct a bridge protected from hostile fire. The plan was adopted with success, and the way into Ladysmith was found at last; Sandbach's share in the credit was admitted by all from Sir Redvers downwards, and the facts are brought out in the official as well as in *The Times* History of the South African War. He had been active in all the trying operations subsequent to the battle of Colenso; in *The Times* History we read of his having been on Spion Kop on the day of the fighting there, a very unpleasant place at the time, and having brought down a message from General Thornycroft to Sir Charles Warren.

When the writer joined the Natal Staff he well remembers Sandbach and his scallywag and picturesque following of white men, kaffirs and Cape boys, the wagons, Cape carts and quaint vehicles which carried their belongings, the strings of horses, donkeys and cattle. What

a show they made on the march, with Sandbach, irreproachably costumed, at their head, and how difficult sometimes they were to control. It was a large organization, and to help him there served under Sandbach, although senior to him in army rank, Colonel Seymour Munro, a great character, boisterous and delightful, and who always addressed and spoke of his Intelligence Chief as " the Czar."

We all liked Sandbach, and he did excellent work in the post-Ladysmith operations of the Natal Army. He was with the advance by Laing's Nek, the fighting at Alleman's Nek, the engagement at Bergendal, and the subsequent movement to Lydenberg and Pilgrim's Rest.

He was mentioned three times in dispatches by Sir Redvers : " Has been untiring and has been of the greatest assistance to me." " The Intelligence Department has been under Lt.-Colonel Sandbach ; this officer possesses energy, enterprise and system, and has devoted himself to the work. The Department has been highly successful."

The Natal Army came to an end when Sir Redvers was ordered home on 6th October, 1900 ; Sandbach was then sent to Pretoria for Intelligence work, and stayed there about a month, after which he was ordered home *en route* for India, landing in England on 8th December, 1900.

For his services in South Africa, he was awarded the D.S.O., and the Queen's Medal with six clasps.

After a couple of months' leave, Sandbach was employed for a few weeks in assisting his neighbour, Sir Watkin Wynn, at Wynnstay, in enlisting and training the 88th and 89th Montgomeryshire companies of the Imperial Yeomanry. He then passed on to the Mobilization Branch at the War Office, and was employed for nearly 18 months under Sir Percy Lake in revising the schemes connected with the defence of England.

It was during this period, on January 15th, 1902, that Sandbach married at St. Paul's, Knightsbridge, the Hon. Ina Douglas-Pennant, daughter of the second Baron Penrhyn.

On the 26th Sept., 1902, Sandbach, then a regimental Major and about two and a half years off attaining his regimental Lieut.-Colonelcy, embarked for India to complete the tour which he may be said to have commenced when he went to Lord Curzon as Military Secretary. His first appointment was C.R.E., Narbudda District, Jubbulpore, from Sept., 1902, to April, 1904. The only information the writer has gleaned about this period is from a brother officer then at Roorkee, who writes, " we used to hear characteristic stories of his ordering the Jubbulpore garrison out for some tactical exercises when he happened to be for some brief period in temporary command of the Station." It would appear, however, from official documents, that at one time during this period Sandbach acted as Commander of the Jubbulpore Brigade for five months.

In February, 1904, he became a Brevet-Colonel, and in May of the same year, with still a year to run, before becoming a Regimental Lieut.-Colonel, he was appointed to succeed Colonel M. C. Barton in command of the 1st Sappers and Miners, Roorkee.

For the benefit of readers who, like the writer, have never been to India, it is as well to give some idea of the command to which Sandbach had been appointed. It included about 22 British officers, 30 British N.C.O.s, and about 1,400 Indian ranks. It comprised six Field Companies, Balloon Section, Pontoon Section, Printing and Photograph Section, and later, due to Sandbach's incessant bombardment of Simla, a Mounted Detachment was added, to be followed afterwards by a Field Wireless Section. There were usually two of the Field Companies on detachment, one at Peshawar and one at Rawal Pindi. One who served under him, and to whom the writer is much indebted, states as follows :—

" He took over what we were pleased to think was a good show, and he most certainly improved it. He was a very live wire, especially in an administrative way ; he was closely in touch with A.H.Q. at Simla ; he knew all that was going on, and he kept the 1st S. and M. and their capabilities and possibilities well to the fore among the powers-that-be at A.H.Q. He was a great exponent of the science and art of military co-operation, and he was well ahead of his time in that essential outlook. He boomed the Corps in the eyes of the Army at large, he always strove to make the 1st Sappers and Miners the most soldierly of all soldiers ; any idea of an R.E. officer being anywhere except in the forefront of the battle was anathema to him ; the Corps could nowhere have found a more able and accomplished champion. He was, of course, constant in his help and encouragement to his officers to go to the Staff College and take up service on the Staff ; he instituted and obtained sanction for a system whereby the Commandant visited and inspected his outlying companies on detachment."

" In the great Rawalpindi manœuvres in December, 1905, under Lord Kitchener, with the present King (then Prince of Wales) as spectator, Sandbach saw to it that practically every possible field engineering activity was represented in the opposing forces by units from the 1st S. and M.

" He made, as a general training policy, continuous attempts that Sappers should, whenever and wherever possible, have some infantry with whom to work in co-operation in field training.

" His military qualities and his previous service made him a personality deeply respected by all his British officers and N.C.O.s, whilst his handsome appearance and irreproachable turnout made him highly admired by his Indian soldiers.

" His friendly and amiable characteristics endeared him to all ranks ; he was interested in all forms of sport, and much enjoyed the polo and shooting, for which Roorkee affords such good facilities."

Speaking of his nickname *Huzoor*, the same writer adds: "The term *Huzoor* (Your Honour) was used of him by his British officers when speaking of him amongst ourselves; it always seemed in a genial chaffing spirit to hit off his air of distinction."

The above is only one of a number of tributes as to Sandbach's work at Roorkee, which had been received from officers who served under him in the Sappers and Miners. A remarkably large proportion of them have since risen to high distinction, and are ready to admit how much they learnt from Sandbach and how much they owed to his inspiration and example.

An R.E. officer who held a high position in India at the time, writes of Sandbach as follows:—

"I know he was a great success as Commandant of the Bengal Sappers and Miners, and did a lot for that Corps, and his juniors always spoke highly of him. He had the courage of his opinion, and backed up the Corps bravely. Whilst Commandant he held and organized the centenary of the Bengal Sappers and Miners, a great success, to which Lord Kitchener went, enjoyed himself, and was generally very pleased."

His tenure of command was marked by the erection of the war memorial which commemorates the 50th anniversary of the blowing in of the Kashmir Gate at Delhi during the Mutiny of 1857. This memorial took the form of the Ghuznee tower, which was designed and built by the Bengal Sappers and Miners, and forms to-day the nucleus of the larger war memorial which has been built to commemorate the memory of those who fell in the Great War.

It was during Sandbach's time at Roorkee that the Corps was honoured by receiving the designation of Prince of Wales' Own (subsequently changed to King George's Own) Sappers and Miners.

In October, 1907, Sandbach relinquished command after holding it for three and one-third years, and, as one who served with him says, "he left the Corps in a very high state of efficiency, and to the great regret of all ranks, British and Indian, for whose good he was ever solicitous."

Probably no period in Sandbach's service was so successful and so instrumental for good as this, his last tour in India.

The Indian authorities recognized his good work, and in a most appreciative letter the G.O.C. Eastern Command informed the War Office of Sandbach's performances, whilst in January, 1907, he was recommended by the Commander-in-Chief for promotion to the rank of Major-General. On arrival home Sandbach, with still two and one-third years more to run as Regimental Lieut.-Colonel, was given the post of C.R.E., North Aldershot, on Dec. 2nd, 1907, and held this for eight months, at the end of which, on August 1st, 1908, he succeeded Irvine in the post of O.C. Troops and Companies.

General Sir Horace Smith-Dorrien commanded at Aldershot during the whole of Sandbach's stay there, and the Chief Engineers were,

first, Colonel P. T. Buston, and after him Colonel George Scott-Moncrieff.

Sandbach's time as Lieut.-Colonel came to an end on the 9th April, 1910, when he was placed on half-pay, nothing of great importance having occurred during the twenty months he commanded the Troops and Companies.

After six months on half-pay, on the 7th October, 1910, he took up the post of Chief Engineer in Ireland, which he held for close on four years, in fact, until the commencement of the Great War. General Sir Neville Lyttelton was in command at the commencement, and was succeeded later by General Sir Arthur Paget. Sandbach served under three M.G. i/c A., Generals Bunbury, Hadfield and Friend.

Whilst in the Irish Command, Sandbach lived at Ashtown Lodge, Castleknock, and in his responsible post he found full occupation.

It was at this time, however, that a great disappointment befell him; he had been a Brevet Colonel since February, 1904, and in July, 1911, reached the top of the Colonels' List; however, on the 24th of that month he was passed over for promotion, and between that date and the outbreak of war, thirty-five in all were promoted over his head. The cause of this supercession is not clear, but it did not lie with his immediate superiors in Ireland, who consistently recommended him for promotion. Sandbach, of course, felt this very keenly, but those who knew him at the time are aware of the fine spirit with which he met his chagrin and did his best at the work which lay at hand.

When the War broke out, Sandbach was given the post of Chief Engineer, Second Corps, under Lt.-General Sir James Grierson.

Shortly after the landing of the H.Q. of the 2nd Corps in France, the B.-G.G.S. of the Corps found on visiting Havré (No. 1 Base) that the Commandant had collapsed, and refused either to give orders or to sanction them being given by a subordinate. With the prospect of the immediate advent of troops something had to be done, so Sir James Grierson on the 16th August detailed Sandbach to be temporary Commandant of No. 1 Base, and reported the fact to the I.G.C.

Regarding this phase of Sandbach's war work, Major-General Sir F. S. Robb, who was I.G.C., writes as follows:—

"Important though the charge of this main Base was which had thus temporarily devolved on Sandbach, nobody could at that time have anticipated the far more important role which he was destined to play.

"The overwhelming pressure of the Germans forced the British Army back in a direction far eastward of the original L. of C., which had thus become open to an attack from the direction of Amiens, already in the enemy's possession. It was therefore decided, on the 29th August, to change the main base from the mouth of the Seine to that of the Loire.

"In view of the fact that the original L. of C. were practically without defensive troops, and that an attack on them was momentarily expected, the situation at Havre, where some 60,000 to 70,000 tons of warlike stores had already been unloaded, was one of extreme danger. Sandbach grasped the situation at once, and threw his whole energy into saving the stores and shipping, and he was further impressed with the gravity of affairs when Lord Kitchener, after visiting Sir John French at the Front, returned through Havre, giving him the latest information and emphasizing the paramount importance of sacrificing everything to speed.

"By 9.0 a.m. on the 5th September, the place was clear of stores, viz., in less than seven days of the receipt of the order to re-embark them, so that the clearance had been effected at the rate of from 9,000 to 10,000 tons a day. In order to appreciate what this means, it may be recorded that, even after the home ports had been expanded to meet the requirements of the world war, the average daily shipment from Southampton was 2,000 tons, from Richborough 3,000 tons, from Liverpool and Newhaven 3,700 tons each."

In the *Official History of the War* it is recorded that in four of the seven days in question 20,000 officers and men, 7,000 horses and 60,000 tons of stores were shipped from Havre to St. Nazaire.

Sandbach remained at Havre until 7th September, when he returned to his Corps, then on the Marne, just as the battle of that name was developing.

The following are some glimpses of Sandbach's work as Chief Engineer, Second Corps:

Sir Horace Smith-Dorrien in testifying to Sandbach's work, writes: "I found him a loyal and competent Chief Engineer. He always played the game and did his work well without ever being flurried; in fact he was always cool, calm and cheerful, and therefore an excellent comrade in trying circumstances. He joined me first in the neighbourhood of the Petit Morin River, just south of the Marne, as the battle of that name was developing."

Major-General Sir George Forestier Walker, who was B.-G.G.S. Second Corps at that time, pays him a warm tribute.

"His work during those strenuous early months of the War was always first-class, and no commander could have been better served in R.E. matters than was his Chief, whilst no Chief of the Staff could possibly have had a more devoted, considerate and able colleague—quick, cheerful and resourceful, his work on the rear and alternative positions which we had to construct in the early days in Flanders was very good, and he was a great asset to me and to the General Staff generally. Incidentally, he was the originator of the word 'switch' to indicate that type of alternative line of defence which ran into the original line at an oblique angle, and thereby had certain advantages. I remember so well his proposing it when we were struggling for a descriptive word."

Colonel D. M. Griffith, always a great admirer of Sandbach, writes: "I saw him at his best one day during the War—he was acting C.E. of the Second Army, and on March 15th, 1915, came up to see us in the 28th Division billeted in Ypres. He insisted on going round the front line with me, and I took him all round by Ypres, Commines, north of St. Eloi, and even up to the bluff opposite Hollebeke Château and back by Zillebeke Woods, a nasty, unhealthy spot. He did not seem to mind going anywhere, and it was only with some difficulty I got him to discard his red cap, or rather to cover it with a khaki handkerchief. We had few communication trenches in those days, and it meant dodging from cover to cover going up to the front in daylight.

"He was most helpful in getting us R.E. stores, plant, etc., and sent his S.O. by car down to Paris to get us electric torches and lamps to help our work in the mines. He was a splendid Chief Engineer."

In recognition of his work during the early stages of the War, he was promoted Major-General for Distinguished Service in the Field, dating from 26th October, 1914, an honour he received in company with nine other officers, whose names, like his, were brought to notice in Sir John French's dispatch of 8th October, 1914.

Sandbach was not made C.E. of the 2nd Army on its formation, and in May, 1915, was ordered home to be Inspector of Engineers, where he did a lot of useful work in helping the R.E. units of the new armies which were being raised all over England.

He, of course, wanted to get back to France again, and it was a step in that direction when he was given the command of the 68th (Welsh) Division, then belonging to the Central Force and located at Bedford. He held this command from November, 1915, to 13th February, 1916, when he took over the command of the 59th Division.

The 59th Division, which had been in existence for fourteen months, was the second-line North Midland Territorial Division, and was the first of the second-line divisions to be ready for training for overseas. The Division had its three brigades at St. Albans, Harpenden and Watford.

In April, 1916, when the Easter rebellion occurred in Dublin, the 59th Division was the mobile division for home defence purposes, liable to be sent at short notice to any threatened point, and for this purpose rolling stock was held ready in its vicinity.

Orders were received on Easter Monday (April 24th), directing one brigade to be entrained for an unnamed destination, and the 178th Brigade, under Brig.-General E. W. S. Maconchy, was selected; the Brigade was railed to Liverpool, where it embarked, and where the officers first heard of their destination; efforts were made at Liverpool to buy as many maps of Dublin and its vicinity as possible, but so hurried was the whole thing, that a large proportion of the Brigade were surprised to find themselves landing next day in Ireland, and not in France, and to hear English and not French spoken by the inhabitants.

The 178th Brigade reached Kingstown at dark on Tuesday, April 25th, and disembarked at 10.15 p.m. that night.

It is beyond the scope of this memoir to describe the happenings at Dublin in Easter Week, 1916, enough only will be said to explain the participation of the 59th Division.

Although there had been in existence for some time in Dublin armed organizations known as the Irish Volunteers, and the Citizen Army, which were wont to parade from time to time, the Civil Authorities and the Police never anticipated any rising.

It came, therefore, as a great surprise, when, at noon on the Easter Bank Holiday, armed bands of the Volunteers and the Citizen Army, parading as for a route march, took possession of important points in the city, whilst a provisional Government proclaimed an Irish Republic. The General Post Office and some of the railway stations were among the places seized, but an attempt to take possession of Dublin Castle failed: fortunately, too, the telephone system was left undisturbed, and by its means the military authorities were able at once to grapple with the situation, and to utilize to the full the few troops quartered in Dublin. There was a Reserve Dismounted Cavalry Brigade in proximity at the Curragh, and this was brought up to Dublin the same afternoon, and its Commander, Brig.-General Lowe, was placed in charge by the G.O.C.-in-C. of the active operations in the city.

The troops available, however, were small in number for the task in hand, and the arrival of the leading Brigade of the 59th Division at Kingstown, on the night of Easter Tuesday, April 25th, must have been very welcome to Irish Headquarters, which at once issued instructions to General Maconchy. He was to dispatch on Wednesday, April 26th, two battalions *via* Stillorgan, west of Dublin, to Kilmainham, where Headquarters were situated. The other two battalions were the same day to move direct on Dublin *via* Balls Bridge, Northumberland Avenue and Merrion Square. He was also to send a detachment to Arklow to guard the Munition Factory there. The Arklow Detachment and the two battalions directed on Kilmainham reached their destinations without opposition, and the same was the case with the other two battalions as far as Balls Bridge, which, situated on the S.E. outskirts of the city, is famous as giving its name to the grounds where the Dublin Horse Show is annually held.

As soon as a further advance, however, was made from Balls Bridge by Pembroke Road and Northumberland Road, in the direction of the bridge crossing over the canal which leads towards Merrion Square, it was resolutely opposed by riflemen in occupation of houses along the route. The fighting became severe, the locality was unfamiliar, and the troops were inevitably much exposed: the progress was necessarily slow, and it was not until after nightfall that possession was obtained of the required crossing over the canal.

The losses had been heavy, five officers and 150 other ranks, but

these previously untried and only partly-trained soldiers (only a small proportion of them had ever fired a service bullet) had shown great gallantry, and nothing could have been better than the way in which they had come through their baptism of fire.

Meanwhile, subsequent to the dispatch of the 178th Brigade, the G.O.C. 59th Division received orders that the remainder of his Division was to follow. The Staffordshire Brigade (No. 176), under Brigadier-General Carleton, was the next to move, and landed on the 26th (the day of the fighting), and moved on to Balls Bridge that afternoon, whilst the Brigadier, now the Senior Officer of the Division on the spot, got into touch with General Maconchy and Irish Headquarters. As a result, the freshly-arrived Brigade took over the positions occupied by the battalions of the 178th Brigade, which had been so heavily engaged, and these latter were directed the next day on Kilmainham to rejoin the two battalions of the Brigade already there. This movement was duly effected on the 27th, with some fighting *en route*.

The two Brigades now worked under the orders of Brigadier-General Lowe, and took an active and effective part in the fighting which terminated on Saturday, April 29th, when a surrender was enforced.

By this time the casualties of the Division reached a total of 207, including five officers killed and 19 officers wounded, figures which indicate the severity of the ordeal which these young troops successfully underwent.

The remainder of the Division landed at Kingstown on the 27th and 28th, and, on the morning of the 29th, the Divisional Headquarters moved on Balls Bridge just as the surrender was being arranged.

From Balls Bridge, the Headquarters of the Division moved to the Chief Secretary's Lodge in Phœnix Park, where the Division was collected. Sandbach took over the command of all troops in Dublin, and it fell to his lot to provide the courts-martial to try the prisoners and later to arrange for the execution of those that underwent the death penalty. He had also to administer martial law for a period, issue proclamations under the Defence of the Realm Act, and arrange for a special system of passes for controlling the movements of the civil population.

The Division was almost immediately split up again; early in May the 177th Brigade was sent to Fermoy, the 178th to the Curragh (whither D.H.Q. also went), whilst the 176th Brigade had two battalions at Dublin and two in Belfast. This scattered distribution was maintained all through the remainder of 1916, and, with the detachments under Local Area Commanders and largely removed from divisional guidance, it is easy to see how enhanced were the difficulties of preparing the Division for France—a task rendered still harder by the units having to furnish drafts for the first-line Division

at the front. Sandbach, we may be sure, did his best, but it came as a great relief when, in January, 1917, the Division was moved to Fovant, near Salisbury Plain ; every nerve was now strained to make the most of the time and opportunity : on February 13th the Division was inspected by H.M. The King, and ten days later it proceeded to France, landing at Havre on February 24th, and two days later the Headquarters were established at Mericourt sur Somme.

Special difficulties seem to have faced the Division in France, as at home. It was not possible to give it time to train at one of the rest areas, and early in March it was sent straight up into the line in the 3rd Corps, south of the Somme, near Estrees, with Headquarters at Foucaucourt, and here it experienced its initiation into the mysteries of trench warfare.

The Germans, however, suddenly retired across the Somme about 17th March, and, of course, the British troops at once pushed forward in pursuit. " General Sandbach had then to conduct ' above ground ' operations, the first of the kind since Mons, Le Cateau and the Marne. He tackled this with enthusiasm, and effectively, and, in order to keep his troops moving, he obtained a Second Divisional Train and an additional Ammunition Column.

" The Division now felt its lack of training, for it was engaged in a very difficult operation, necessitating ceaseless and bold patrolling and constant initiative on the part of Brigade and Battalion Commanders. Tactical situations were difficult enough, but in addition the utter absence of communications had to be contended with."

Jeancourt was captured after a fine attack on the 31st March, 1917, but a subsequent attack on Le Verguier on 2nd and 4th April, and another on the 5th and 6th, were repulsed.

These attacks were costly, and it was not perhaps realized when they were ordered that the position attacked was part of the Hindenberg Line. It was never captured until the final advance at the end of the War.

The difficulties which Sandbach and his Division had to face were immense, and they were tackled with courage and enthusiasm.

It seemed, however, to the Army and Corps Commanders that the public service would gain by the employment of a younger man, and one with more recent fighting experience, to command the 59th Division, and so, on 10th April, 1917, Sandbach handed over his charge to his successor, Major-General, now Lieut.-General, Sir C. F. Romer, and returned to England on half-pay.*

After his return from France, Sandbach, with plenty of younger men available, was not further employed, and he finally retired on the 19th August, 1919.

With the exception of a couple of years spent abroad, Sandbach

* For the account of Sandbach's connection with the 59th Division the compiler is largely indebted to the Records of that Division, supplemented by information kindly given by Lt.-Col. C. U. Bradbridge.

spent the remainder of his life at Bryn Gwyn, where he found plenty to do. For many years, despite his active military career, he had taken a keen interest in the affairs of Montgomeryshire. He had become the first Chairman of the Montgomeryshire Territorial Force Association after the passing of Lord Haldane's Act in 1908, and he retained the post until 1920. It was in no small measure due to the enthusiasm which he inspired that Montgomeryshire was one of the first counties in the country to recruit its Territorial units up to strength.

He was a Deputy Lieutenant for the county, and filled the office of High Sheriff in 1919. The following extract from a local newspaper gives some idea of his county activities :—

"After the War, General Sandbach threw himself unsparingly into work in the interests of ex-Service men. He was a member of the Disablements Committee of the Montgomeryshire War Pensions Committee, now disbanded, and was appointed as one of the Joint Pensions Committee set up for the combined counties of Denbigh, Flint and Montgomery. The Comrades movement in Montgomeryshire was largely kept in existence as an active organization through his zeal as Commandant. He took a leading part in the amalgamation of the various ex-Service men's organizations into the British Legion, and he acted as a member of the National Executive and as President of the Welsh area. He was also a leader in the Boy Scout movement. He acted as Commissioner for Montgomeryshire, and troops of Scouts which had the good fortune to train at Bryn Gwyn found in General Sandbach one who was a fine example for boy hero-worship. He was a zealous Churchman, and one of the original members of the Representative and the Governing Bodies of the Church in Wales. He was a Governor of the University College of North Wales, Bangor, a member of the Montgomeryshire Agricultural Committee, and a member of the Welsh Consultative Committee of the Forestry Commission."

His Grace the Archbishop of Wales has supplied the following appreciation of Sandbach's connection with the Church of Wales :—

"In any record of General Arthur Sandbach, there would be felt omission if some testimony, however inadequate, were not borne to the place and influence which were his in his own home and among his countrymen. He was a distinguished and much-respected figure in Wales. A Welsh soldier and neighbour described him as 'every inch a gentleman, and his very presence was enough to make him respected.' This description, so spontaneous and uninspired, was in simple words simply true. There was a charm of manner and address which attracted those who knew him, and his friends recall the generous kindling of his glance, and the fascination of his smile. His home lay amid a circle of mountains, and the valley through which it was reached was full of beauty and romance. At the foot

of the hill, upon which his home, 'Hafodunas,' stood, lay the village and church of Llangerniew, which, translated, means 'the Church of the Cornishman.' Whatever the link may be between it and Cornwall, Llangerniew, one of the oldest and most interesting churches in the country, dates from the middle of the fifth century.

"Arthur Sandbach took a lively and sustained interest in the well-being of the church and village, and it was in one of the many church gatherings there that I first saw him well nigh forty years ago. One evening on which we both met soon after his return from the South African War was spent in a vivid description of the passage of the Tugela, and then he passed to an enquiry about the doings of the Church in Wales, at that time on the edge of fortune. So it was during the Great War that he watched the struggles of the Church in Wales with undiminished concern. When he retired from active service, he took a foremost place in the wider field of ecclesiastical affairs in Wales. The first years of the disestablished and disendowed Welsh Church called for the loyalty and the active service of its sons. The task before Welsh Churchmen involved an almost intolerable strain upon resources depleted by the Great War, and upon an unequalled sacrifice in time and service. Even more arduous still was the reconstruction of the oldest Church in Britain, severed from its younger and far more powerful sister-church in England. The first step taken in this great task was the assemblage of a convention at Cardiff in October, 1917, constituted of representatives, lay and clerical, of the whole Church in Wales. Foremost among the representatives was General Sandbach. During the four days at Cardiff, the outlines of the task were clearly drawn. When details were reached, it soon began to be realized that the centre of gravity had shifted, and that undreamt of difficulties and problems of the utmost complexity daunted the stoutest hearts.

"Committees of clergy and laity were chosen to deal with these specialized problems. The work demanded regular attendance and careful study of the problems to be solved. This went on for five years. The toil bestowed upon it was beyond all praise. General Sandbach, from the day of the convention until the day of his death, never failed to take a leading part in this work. In the debates at the meetings of the governing body of the Church in Wales, and in the administration of the resolutions therein taken, his unfailing presence was an inspiring example. This distinguished soldier, trained in a school of order and discipline, never spoke in vain, and in the fewest possible words helped to clear obscurities or to bring to light important points that had escaped observation. The record of the part he took in Church matters resembled in character his activities in the general life of Wales."

Major-General Sir Hugh Elles, who, when a Captain, was his Adjutant at Aldershot, and who visited Sandbach at Bryn Gwyn, writes: "I stayed once with him at his place on the border of Wales;

a most delightful and assiduous host, and in his county held in high respect. He certainly was a devoted county man and worked tremendously hard at all the things for which the county magnate gets no pay and very little thanks."

The same writer goes on to say: "As a young soldier I always understood he was ambitious; I never saw much trace of that myself; if his ambition persisted, he certainly took the curtailment of his career with great philosophy."

The above is interesting as throwing a side-light on Sandbach's character.

Those of us who knew Sandbach in his younger as well as in his later years realize that an honourable ambition to succeed as a soldier was from first to last one of the keynotes of his outlook on life; he followed Robert Burns' advice:

> To win Dame Fortune's golden smile,
> Assiduous wait upon her
> And gather gear by every wile
> That's justified by Honour.

But in spite of this characteristic, there were things in life that had higher values for Sandbach than gratified ambition, and it was to this fact that he owed his unfailing dignity of character; for this reason he was never unduly cast down by failure or elated by success; he never adopted a complaining attitude, but, making the best of life, played the game to the end.

By the death of his eldest brother, which occurred early in 1928, Sandbach succeeded to the family place, Hafodunos in Denbighshire, a very fine property, where he had been brought up as a boy, and where he had learnt to hunt, shoot and fish.

Sandbach had one child, a daughter named Geraldine, to whom he was devoted, and for whose benefit he wrote the notes of events in his early life which have been utilized in this narrative; it was mainly on her behalf that her parents took a house in London for the season in 1927 and 1928.

On the second occasion Sandbach became unwell shortly after reaching London; he then contracted pneumonia, from which he seemed to be slowly recovering when his death occurred unexpectedly on June 25th, 1928, when he was within a month of completing his 69th year. He was buried three days later in the churchyard of Bwlchycibau Church, close to his home, and the large attendance of all classes in the neighbourhood bore testimony to the affection and respect entertained for him by those among whom the closing years of his life had been spent.

The Corps of Royal Engineers was represented by a senior officer, and a party of R.E. trumpeters from Aldershot attended and sounded the "Last Post."

H.M.L.

PROFESSIONAL NOTES.

A RECENT DEPARTURE IN THEODOLITE DESIGN.

THEODOLITES are of such general use in all branches of engineering that no excuse is made for describing a new type of these instruments. The majority of Sappers are probably most familiar with the type of instrument which had its circles divided on silver arcs and in which the micrometer or vernier arm clamped directly on to the accurately divided circle. The great disadvantage of these instruments was that they weighed a great deal and that the micrometer arm had to be levelled before making a vertical observation and that the clamp was likely to bend the vertical circle. In recent years the latter two defects have been overcome by re-adopting an obsolete design in British practice of clamping the telescope directly to one pillar of the instrument, and leaving the micrometer arm free to be levelled and clamped to the other pillar of the instrument after the setting of the telescope had been made. The former defect was not overcome until the introduction of what may be called the " glass " theodolites.

The " glass " theodolites are here so termed because their essential difference is in the fact that their arcs are divided on glass and the system of reading is by optical means brought to one eyepiece in proximity to the telescope eyepiece. Examples of these instruments are the " Wild Universal Theodolite," " Wild Precise Theodolite," " Zeiss Theodolite," " Watts-Zeiss Theodolite " and " $3\frac{1}{2}$" Double reading Theodolite (Cooke, Troughton and Simms, Ltd.)."

The characteristic features of these instruments are that they give similar magnification and light collecting power to the normal 6" or 8" theodolites with a smaller and lighter telescope, that the arcs are totally enclosed, that the mean of the readings on opposite sides of the arc can be read with one setting of a micrometer visible from the observation standpoint, that both arcs can be read from the same position and with the same micrometer, and that the bubble can be set after the telescope has been set, and viewed from the observation standpoint. These great simplifications in reading have been achieved by an elaborate system of lenses and prisms and in most cases a parallel plate micrometer, all incorporated in the body of the instrument and of fixed adjustment.

The advantages of these instruments over the latest patterns of the normal theodolites are :—

(i) much less weight and bulk for the same precision, and
(ii) observation and reading are possible from the same standpoint, resulting in a saving of time and less disturbance of the instrument during reading.

The disadvantages are that, with the exception of the bubble adjustment, all parts are fixed in maker's adjustment, with the result that in the event of a displacement of the optical arrangement the instrument is probably rendered useless. The precision of manufacture, however, renders this very unlikely. Further repetition readings on a subtense bar cannot be taken.

The following is a summary of the types of "glass" theodolites mentioned above :—

Wild Universal.—Weight of instrument about 9 lb.
Micrometer reading direct to 1 second horizontal arc.
Micrometer reading direct to 2 seconds vertical arc.
Bubble sensitivity, 16″ per millimetre.*
Range of 32 readings of one arc setting (vertical), 1·7″.
Probable error of single astronomical reading, including setting and stop-watching, 1·9″.

The telescope transits eyepiece up only. A diagonal eyepiece is fitted, but no star sights. Two lenses of the reading system are exposed to the atmosphere, rendering condensation possible. Only stars up to 60° elevation can be observed.

"*Wild Precise*" is a larger and more accurate instrument of the same type.

"*Zeiss.*"—Weight of instrument, about 10 lb.
Micrometer reading direct to 1 second both arcs.

The telescope transits eyepiece up only. An object glass prism is fitted for high star sights; this cannot be collimated. No star sights are fitted. The reading telescope does not travel with the sighting telescope. Only stars up to 60° elevation can be observed.

"*Watts-Zeiss*" *or* "*Monocular Micrometer.*"
Weight of instrument, 10 lb.
Micrometer reading to 1 second both arcs.
Bubble sensitivity, 9″ per millimetre.*
Range of 5 vertical readings, 4·2″.

The telescope transits object end up only. A diagonal eyepiece is fitted and also star sights. All altitudes of stars are observable. One end only of the bubble is set to a mark, the error from expansion of the bubble may thus rise to the order of 1 second in the tropics. The reading telescope does not travel with the sighting telescope.

"*Cooke, Troughton and Simms.*"—Weight of instrument, about 11 lb.
Diagonal scale reading direct to 10″ both arcs.
Bubble sensitivity, 5″ per millimetre.*
Range of a number of readings (no. unknown), 10″.

* N.B.—With the same accuracy of a single setting, a less sensitive bubble gives a greater rapidity in reading.

The telescope transits either end up. A diagonal eyepiece is fitted. The reading is by diagonal scale. All altitudes of stars are observable.

A new model of this theodolite is being made with a micrometer reading attachment designed by Capt. Baker, R.N., which should give readings comparable to the Continental instruments.

D. R. CRONE.

"EMERGENCY WATER SUPPLY IN WAR TIME."

IN the *Military Engineer* for May–June, 1929, appears an article entitled "Emergency Water Supply in War Time." This describes the application of a system of water supply which is in use for the irrigation of the Arkansas ricefields to the case of a training camp required in a hurry. The principles employed are the same as those used now in many cases for obtaining water for cantonments in Northern India, and a description of these principles and of the differences in their application in the two countries is of interest.

In Arkansas, the water is obtained from wells driven to an average depth of 140 feet. From the surface of the ground to a depth of about 80 feet there is an impervious stratum of clay. Below this comes the water-bearing stratum of some 40 feet of fine sand. In the first endeavours to obtain water from these sands, an eight-inch pipe was driven down into the water-bearing strata. A brass tube in which fine slots had been cut was then lowered inside the pipe and placed at the bottom: the pipe was then raised sufficiently to expose the brass tube to the sand, and a pump installed in the bottom and set to work. The object of the slots was to keep out the sand and admit the water, the slots being necessarily smaller than the grains of the sand. As long as only a small amount of water was required, things went all right. But when large quantities were wanted, the velocity of the water caused the sand to pack all round and in the slots. This reduced the yield to such an extent that the wells had to be abandoned.

In the next attempt the slots in the strainer were made wider, and the results were again unsuccessful. The sand came through with the water so much that cavities were formed round the strainer, and eventually, the support of the clay stratum above having been removed, this stratum caved in and the well was wrecked.

The final successful solution of the problem is the "gravel-wall well," and is described as follows:—

A large-diameter surface caisson is driven from the surface of the ground to the top of the water-bearing sand stratum, from which it is proposed to develop the water supply. A smaller-diameter perforated pipe of sufficient length to penetrate the water-bearing stratum is prepared. On the bottom of the pipe in question is

attached a large perforated cone. The bottom diameter of this cone is large enough to fit loosely inside the surface caisson.

This cone forms the cutting edge for the perforated pipe or strainer and also a footing for the gravel wall. The perforated pipe with cone attached is lowered inside of the surface caisson until its larger diameter rests on the top of the water-bearing stratum at the bottom of the surface caisson. To the top of this strainer are attached sufficient lengths of pipe to extend above the surface of the ground.

The annular space between the two casings is then filled with carefully screened coarse gravel, forming a wall of coarse gravel around the screen. The water-bearing sand beneath the bottom of the cone is then removed by means of a plunger bailer or sand pump, and, as the sand is removed, the screen with its surrounding gravel wall, settles down through the water-bearing stratum.

This process is continued until the strainer has entirely penetrated the water-bearing stratum. Additional lengths of pipe are added at the surface as the screen settles through the water-bearing stratum, and additional quantities of gravel are introduced in the annular space between the casings.

After the screen is installed a plunger, fitting the inner casing and screen closely, is operated, in order to wash the water back and forth through the openings in the screen, and thereby draw all loose, fine sand possible into the screen, from which it is removed by bailing. As this sand is removed, the coarse gravel feeds down between the casings, filling any voids which may be formed around the screen, and thereby preventing the caving in of the impervious stratum by reason of the removal of the support below.

After all possible sand is removed in this manner, high-capacity pumps are installed in the inner casing and the well is surged and pumped at a high rate of speed to remove additional sand, and secure the introduction of more gravel around the screen.

The openings in the inner strainer are quite large, because this strainer acts only as a support for the gravel wall—the separation of the sand and water occurring at the outer diameters of this gravel wall. The result of this is a greatly increased capacity of production of water, flowing through coarse openings in the screen at a low velocity. This method has revolutionized the production of water from underground sand strata, and is now being used quite extensively in municipal supply. An illustration is given in the article of such a well which gives a supply of 25,000,000 gallons daily.

In India a similar problem existed of obtaining from water-bearing sands underlying an impervious stratum a supply of either drinking water for cantonments and municipalities, or of water for irrigation purposes. The problem was tackled some twenty years ago by two engineers, Messrs. Brownlie and Ashford. Two different tubes or strainers were evolved; the Brownlie strainer is a

slotted brass tube similar to the American pattern, whilst the Ashford tube consists of a framework bound round with copper wire, the turns of which are spaced according to the quality of the sandy stratum. The method of sinking is as follows :—A four-inch plain tube is sunk as a bore to obtain samples of the strata passed through. If any of these are water-bearing, they are tested by the Kennedy method, and from the results obtained it is possible to give a fairly accurate idea of the amount of water it will be possible to obtain and to determine the size of the openings in the strainer. From the test bore it is calculated which of the two standard sizes of strainer, five-inch or ten-inch, it is necessary to use. Assuming that a ten-inch diameter strainer is needed to give the yield required, then a twelve-inch plain tube would be sunk to the necessary depth. This tube has flush joints inside and out, to facilitate sinking and withdrawal, and to avoid damage to the strainer whilst it is being lowered inside the tube. To standardize manufacture, the strainer in the case of the Ashford patent is wound with a standard spacing between the turns of the copper wire, so that if the samples show a sand of unusual fineness, it is necessary to take precautions against the fine sand being drawn into the well, cavities forming, and the well eventually failing. This is provided for on very similar lines to those adopted in America, in the "gravel wall." Coarse sand is poured down between the outer casing and the strainer. When the plain tube has reached the requisite depth, the strainer is lowered inside it and kept suspended until the plain tube has been withdrawn and the soil has closed in round the strainer and removed any danger of strain, and consequent distortion and disturbance of the copper wire turns. The tube well in its completed form consists of the strainer in the water-bearing strata, and a plain tube in the strata which are not water-bearing. At some point in the plain tube, depending upon the local water conditions, is placed the pump, of which special forms have been designed for use in these tube wells.

The principle that underlies all successful getting of water from water-bearing sands is that the critical velocity of the water for the sand in each case must not be exceeded. This critical velocity varies in accordance with the conditions of each well. In an open surface well in India, for instance, the critical velocity is reached when the well is working under a depression head of 5 to 7 feet. That is to say, when, the water in the well having been lowered to this extent, there is a difference in level of 5 to 7 feet between the water in the well and that immediately surrounding it. If this critical velocity is exceeded, the finer particles of sand will be carried along by the water into the well, and the well will "blow." If the process is continued long enough, a cavity will be formed under the curb of the well, the steining will crack and the well will be ruined. This is a point which should be well understood; an officer is sent

out to test the water supply from the village or other wells in a certain area ; unless he knows this principle, the first thing he will do probably will be to pump a well completely dry. What he should do, if he wishes to test the rate of yield of the well, is to lower the water in the well by not more than 7 feet. Under that head it will be found that the critical velocity is about one-half foot per minute. Normally, therefore, the yield of a surface well is comparatively small, and depends on the area of the bottom of the well.

In the case of a tube well under the usual conditions in India, the critical velocity may be as much as half a foot per second, or sixty times as much as in the case of the open well. The reason for this is that the conditions of supply differ widely. The supply in this case is what may be called sub-artesian and the water normally will rise to a point fairly high in the plain tube above the strainer. What are the conditions which exist when the well is being drawn upon to its full capacity ? Any cross-section of the strainer is the centre of a circle, from the circumference of which water flows towards the strainer at an ever-increasing velocity. On the circumference of this circle, the water is flowing towards the tube at a velocity which is just sufficient not to disturb the lightest grains of the sand ; as the water flows towards the tube the velocity gradually increases till it reaches its maximum at the entry to the tube itself. In the process the smaller grains of the soil are washed into the tube and pumped out, and when a state of stability has been reached in the maximum flow into the tube, the soil within the circle affected is arranged approximately with a state of increasing coarseness from the circumference inwards towards the tube at the centre.

It is interesting to observe that it has been demonstrated mathematically by Mr. F. Temple, an engineer in India, that by grading the material scientifically, it is possible to pack the bottom of an ordinary open infiltration well in such a way that the fine grains of sand cannot be washed into the well, however hard the water is pumped, and therefore the well cannot blow.

The practical side of tube well sinking as practised in India is fully set out in Volume IV of the *Military Engineer Services Handbook.*

P.H.K.

BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

OFFICIAL HISTORY OF AUSTRALIA IN THE WAR OF 1914-18.

VOL. III.—THE A.I.F. IN FRANCE, 1916.

By C. E. W. BEAN.

With 475 illustrations and maps. (Angus & Robertson, Ltd., Sydney, 1929. Price 21s.)

This work will eventually reach a total of twelve volumes, of which Vols. I, VII, IX, X, and XII have been published. We now have Vol. III, which deals with the reorganization of the Australian Forces in Egypt after Gallipoli, their early experiences in trench warfare in France, and the part taken by the 1st, 2nd, 3rd and 5th Australian Divisions in the Battle of the Somme. As indicated in the Preface, the latter, and larger, half of the volume is written somewhat in the style of a "divisional history." Mr. Bean goes in great detail into the incidents of the fighting on the Australian front, makes it interesting by the introduction of the personal touch, and builds up his story rather on diaries, letters, and personal interviews with participants in the fighting, than on official reports and dispatches. These interviews were obtained within a few weeks of the events that he describes, and the author claims that they enable him to produce a much truer and more accurate account of what actually happened in the front line than could possibly be gleaned from staff diaries and official documents. To a certain extent he may be right, but it would be useful to be able to refer to more of the operation orders, especially of the lower units. The result, however, is—despite its 967 pages—a very interesting and instructive narrative, which he hopes will assist military students to arrive at the causes which have made the Australian soldier what he is, and help them to understand his characteristics and appreciate his good qualities. Mr. Bean apologises for the method he has adopted. The book, he explains, is written for home consumption in Australia as well as for the world at large. Colonials, he says, are sceptical of official reports and dispatches. Well they may be when these are "written up," with the aid of the official newspaper correspondent, with one eye on the effect they will have on the Dominion concerned, but the truth is that the official reports of untrained staff officers are apt to be sketchy, if they exist at all. Mr. Bean devotes a dozen pages of his volume to a subject on which Australians are touchy—the question of discipline. Discipline depends on the officers from the highest to the lowest in rank. The Australians were exceptionally fortunate in the senior officers of the Regular Army, who, by reason of previous service in the Colonies, or by selection, were appointed to command them. British officers, he says, unaccustomed to dealing with the independent and well-hardened types which composed

a large part of the Australian Forces, were shocked at their behaviour, drunkenness, and rowdiness in Egypt. The trouble was not confined to the men. There was a large number of unsuitable officers who were gradually eliminated. There were, he admits, regular officers serving with the Australian troops who thoroughly understood them, but there were others who never would. To anyone who served with Australians in South Africa, there was no difficulty in dealing with them in France. There are many ways of enforcing discipline. Mr. Bean gives us an amusing example. "A large number of Australians were, after Gallipoli, "in camp at Tel el Kebir. They were somewhat disappointed at finding "themselves, on their return to the comforts of civilization, camped so "far from Cairo. Every day two per cent. of the men in each unit "were given two days' leave to Cairo. There occurred a certain amount "of breaking out of camp, and overstaying of leave was fairly common. "The latter offence did not argue any very criminal intent, most of the "men being quite ready and willing to pay for a slight extension of their "holiday. Wise commanders for the most part recognized this fact. "For example, Lt.-Col. (afterwards Major-General Sir John) Gellibrand, "then commanding the 12th Battalion, when some of these cases were "brought before him, used to surprise the truant by asking: 'Well, "'have you had a good time?' 'Yes, sir.' 'Did you enjoy yourself "'thoroughly?' 'Yes, sir.' 'Of course, you don't object to paying "'for it?' 'No, sir.' There would follow a fine or other punishment, "which, though sometimes moderately severe, was accepted in the spirit "in which it was given."

There would have been no difficulty about discipline had the Australian authorities been stronger in dealing with the bad characters. "At "Tel el Kebir," continues Mr. Bean, "it has become obvious that there "had been enlisted a certain number of criminals, some of whom had "entered the force with the intention of running gambling 'schools' or "of escaping from punishment in Australia. As time went on, it was "found that many of these men had no intention of reaching the firing "line. They were a mere handful in number, and gradually became well "known to their officers and their comrades; but their presence, now "first noted, was the cause of atrocities which occasionally blackened "the name of Australia. As the Australian Government about the "middle of 1916 indicated that its policy was against the return of men "to Australia for disciplinary reasons, the A.I.F. was forced as far as "possible to digest its own bad characters, and the existence of these "men afforded a problem increasing in difficulty as the war went on."

The Suspension of Sentences order did not help the Australians in dealing with these bad characters. Mr. Bean omits to mention this, nor does he refer to the fact that the Australian Government had abolished the death sentence for military crimes, except in the case of treason and desertion to the enemy.

As regards minor indiscipline, *e.g.*, the failure to salute officers, Mr. Bean devotes three whole pages to the subject, and after attributing the failure of the Australian to his democratic bringing up, concludes as follows: "The precise forms of discipline suited for a nation imbued "with the feudal tradition were not found to be, in their entirety, well "suited for such people as Australians, among whom the sharp social

"distinctions and inequalities of the older nations are practically non-existent." It is well to mention this subject, for it may help officers serving with colonial troops. Whether they will be convinced by Mr. Bean's explanation is doubtful, but they should read it.

It is impossible to say much in a short review as to the rest of the volume. The detailed accounts of the raids carried out in the course of normal trench warfare by the Australians, and by the Germans in retaliation, and the narrative of the Somme fighting, will serve for all time as a classic for military students. Illustrated as they are by numerous sketches in the letterpress, they are easy to follow, and afford, in a manner in which no other writer has been able to do, a real insight into the difficulties of modern warfare. The descriptions of the fighting at Fromelles, and for the Pozières ridge, are a remarkable testimony to the fighting qualities, the individual initiative, the resource, the tenacity and the courage of the Australian soldier. It is almost inconceivable that any troops could have gone through what the Australians did day after day for weeks without damaging their morale. That they felt it, Mr. Bean admits, but only temporarily, and by the end of 1916 the survivors had entirely recovered their cheerfulness and morale. We hear nothing of shell-shock and the lasting effects to which soldiers of a less virile type were victims. If the system of wearing down the enemy by attrition can be deemed to have been justified by success, full credit must be given to the Australians for their share in the Battle of the Somme. To anyone who served with the Australians in South Africa, their achievements in Gallipoli, in France, and in Palestine came as no surprise. The wonder is that, after losing so many of their best officers and men in Gallipoli—the 1st Australian Division lost half its strength—they were able to produce and train the large number of officers and N.C.O.s required for the expansion of the Australian Imperial Force (A.I.F.), which eventually reached the equivalent of seven divisions.

The volume is well illustrated, provided with numerous maps and sketches, and a very complete index. If any officer or man is mentioned in the narrative, a footnote is inserted giving his place of birth, age, profession and place and State of origin. Though many of the heroes came from the back-blocks, there were many from amongst the well-educated professional men of the cities.

H.B.-W.

THE DEFENCE OF BOWLER BRIDGE.

By H. E. GRAHAM.

(William Clowes & Sons, Ltd., 3s. 6d.)

This "study of minor tactics" is a worthy offspring of the *Defence of Duffers Drift*, a classic to which the author freely acknowledges his indebtedness.

Times change, however, and tactics should change with them, so here is *Duffers Drift* in modern dress, only with a new author, new management and the old charm.

Duffers Drift may be proud of its child.

When the *Defence of Duffers Drift* was first published, it aroused an interest (which took it into more than 10,000 copies) much in excess of that which might be expected from the study of the action of a subaltern and 50 rank and file holding a drift across the Silliaasvogel River.

That was due to the author's skill in " painting the picture," and so creating the atmosphere which surrounds any commander of an independent mission far from the comfort of being suitably *encadré*. In consequence, big lessons were learnt from a small story—and perhaps the biggest lesson was how a military problem should be approached in practice.

Now we have a new Duffers Drift. The Silliaasvogel River has become Rasberry River, Duffers Drift is Bowler Bridge, Incidentamba and Regrettable Mountain are transmuted into Fiddleton-Homburg and Topper (sinister civilian headwear suggestive of Stellenbosch to an older generation). But the atmosphere of doubt and perplexity remains, as does the " everlasting miracle " by which Augustus Sydney Smith—whose parents were almost as careless at the font as those of the defender of Duffers Drift—gets a second and a third and a fourth chance to rectify his earlier errors. Each failure equips him with fresh knowledge and the sum total produces success, as at Duffers Drift.

Though times and weapons have changed, Augustus Sydney Smith is not much better off than Backsight Forethought was nearly 30 years ago. He disposes of a somewhat greater fire power but fewer men. In addition, he has an A/T gun of a more efficient pattern than has yet appeared. He also has Serjeant Bass, D.C.M., M.M., whom to know is to love, but who, like the addition in the story, " makes it harder."

His enemy is just as numerous—just as aggressive, as mobile and as slim, but for the " hippo mobility " of 1900 has been replaced the automobility and armour of 1929. The progress of invention, at first seeming, has made things even more difficult for the B.F.s and A.S.S.s who still optimistically command infantry platoons. The author, however, proves that this optimism is not so unfounded as it would appear.

The story is admirably told. There is not a dull moment. All sorts of valuable hints and ideas slip in among the more outstanding tactical events and lessons. The diagrams are good and give a clear idea of the ground. The book is recommended to any soldier who is working for the Staff College or for a promotion examination, or to those who, with single-minded devotion, desire only to improve their knowledge of their profession. A young officer could leave it safely in the hands of his parents.

No reader can fail to find it at once amusing and instructive. The greatest amusement and the best instruction will be got if the reader prepares his private solution to A.S.S.'s problem before reading on after page 7 or looking further than Sketch No. 2. It is possible that the professional tactician may find that Bowler Bridge is a *pons asinorum*. Try it on your friends.

Finally, I suggest that *The Defence of Bowler Bridge* has a particular interest for Royal Engineers. The bridge must not be blown up, but equally it must not be used by the enemy's A.F.V.s. The problem of making road blocks against A.F.V.s., which arises out of those conditions,

is a baby which is frequently passed to the Army's professional nurse for unpleasant children which nobody else wants, the Corps of Royal Engineers.

E.E.D.-S.

RECORDS OF THE SURVEY OF INDIA, VOL. XXII.

"THE EXPLORATION OF THE SHAKSGAM VALLEY AND AGHIL RANGES. 1926."

It is probable that most of the professional papers (now called "Records") of the Survey of India have been published for the instruction, rather than for the entertainment of the public. This must not be taken to imply that entertainment is not to be found in them or that their contents are unintelligible to any but those already well instructed in the subjects of which they treat. Far from it. Nevertheless, it is probably true to say that such entertainment as may be found in them is incidental to the primary object.

In this volume this time-honoured practice seems to have been reversed, and we have an interesting account by Major Mason, quite in the popular style, of his recent expedition to the Shaksgam Valley. The fulfilment, he tells us, of a "long cherished personal ambition" to fill in the last considerable blank in the map of the Karakoram.

The book, however, is much more than a story of travel and adventure in high mountains. It includes appendices on rations, supplies, clothing, equipment and transport, as well as one on geographical names, and the account is made to form a peg on which to hang a proposal for the revision of the nomenclature of this famous region.

In his preface, Brigadier Tandy, the Surveyor-General of India, refers to this proposal, and says, "The proper name assigned to this area is thus a matter of considerable (*sic*) interest." He adds that "From these discussions it appears quite clear that the Karakoram range is really a misnomer which has arisen from a series of misunderstandings," and concludes with an appeal to the Royal Geographical Society to arrive at a decision as to what name should be placed on future Survey of India maps.

This appeal will come as rather a shock to those who consider that, for deciding controversial points in national nomenclature, the National Survey should be a better authority even than so distinguished and competent a body as the Royal Geographical Society. They will not be surprised that the proposals come in for severe criticism from Colonel Sir S. Burrard, a former Surveyor-General of India and a leading authority on Himalayan geography, who points out in the September number of the *R.G.S. Journal* that the present nomenclature, far from being due to any misunderstanding, was only adopted by the Survey of India after the most careful consideration by geographical experts whose familiarity with this region was many times greater than that of any man living at the present time.

The actual account of Major Mason's journeys (for which the R.G.S. awarded him its Founder's Medal), though embellished with occasional rhapsodies on the beauties of dawns or sunsets in these elevated regions,

is somewhat marred by the difficulty of following the route on the map, from which a great many of the names used in the text are omitted. Indeed, there is no map included on which the movements recorded in the first chapter may be followed at all.

The Shaksgam Valley lies immediately to the north of the high range, containing the peak K.2, the second highest mountain in the world. It had previously been entered from its western end by Sir Francis Younghusband forty years ago. This expedition entered the valley from its eastern and upper end, but, after proceeding about 15 miles down it, was held up by a large glacier coming down from the high range to the south and forming an impassable barrier right across the valley. Efforts to turn this obstacle opened up much new and interesting country to the north, but the shortness of the season compelled a return of the expedition before the Shaksgam Valley had been regained. There is thus a small area of unknown country still left to attract the adventurous.

As regards more technical matters, this expedition was of particular interest in that Major Mason took with him a stereo-photo-topographical outfit prepared by Messrs. Wild and purchased for the expedition by the Royal Geographical Society.

This, it is believed, is the first occasion on which stereo-graphic methods have been used for exploration on any considerable scale, and there may be some who had hoped to find in this paper technical details of the equipment, procedure, or results. If so, they will be disappointed. Some interesting general observations are made, and the text mentions a number of camera stations, but apparently it is necessary to refer to a map published in the *R.G.S. Journal* to discover where and how these were situated, and the areas which were surveyed from them. Perhaps this omission only means that the Survey of India are going to deal with this interesting subject in a subsequent paper.

M.N.MacL.

(*a*) 1915 CAMPAIGN IN FRANCE.

THE BATTLES OF AUBERS RIDGE, FESTUBERT AND LOOS.

Considered in relation to the *Field Service Regulations*.

(*b*) THE OPERATIONS IN EGYPT AND PALESTINE, 1914, TO JUNE, 1917.

Illustrating the *Field Service Regulations*.

Both by LIEUT.-COLONEL KEARSEY, D.S.O., O.B.E., *p.s.c.*, and published by Gale & Polden, Ltd.

(Price 3s. each.)

The lay-out of both these books is the same. The author produces appreciations of the situations, a diary of events, and descriptions of the battles, illustrating *Field Service Regulations*.

It cannot be said that these books achieve the author's aim, as he has tried to do either too much or too little: appreciations are very drawn out and are more like historical dissertations: diaries of events are abbreviated to a point where little of interest is left: and the lessons deduced from the history are very vague.

In the former book, too, one cannot help feeling that analysis of Aubers Ridge and Festubert, with an eye on *F.S.R.*, is almost a waste of time.

The most disappointing and misleading parts of these books are the appreciations. It is never clear whether they are being made from the point of view of a Cabinet, G.O.C., or local leader, and history of future events is often mixed up with the appreciations. In the appreciation of the situation in Palestine at the beginning of 1916, the plan, such as it is, is decided before considering the possible action of the enemy, and it would certainly not pass the acid test of analysis to see whether sufficient information were provided to enable orders to be written. In this particular appreciation the *object* is given as "to carry out an active defence and to reduce the number of troops in Egypt." The plan is "to carry out an active defence and reduce the number of troops in Egypt." Then the method is discussed.

The lessons deduced to illustrate *F.S.R.* are all too vague, and it is a pity that these books, based on the 1927 *F.S.R.*, should just be appearing at the same time as the new *F.S.R.*, although the principles of the lessons illustrated remain the same. It is irritating, in addition, to find that, presumably owing to financial restrictions, the sketches of battle areas, etc., cannot be read clear of the letterpress.

H.G.E.

ARMY HEALTH IN INDIA.—HYGIENE AND PATHOLOGY.

By LIEUT.-COLONEL JOHN MACKENZIE, M.A., etc., Royal Army Medical Corps.

(John Bale, Sons and Danielsson, Ltd., 10s. 6d. net.)

Thirty years cover a period during which a wonderful advance has been made in medical science, both in prevention and cure. The story of this advance, so far as the Army in India is concerned, is told in this volume of 158 pages, which is blessed in a foreword by the Director-General, Army Medical Services. It so happens that this period, 1899 to 1929, coincides almost exactly with your reviewer's service in India, a service that started with a drastic one-dose inoculation against enteric fever. In 1899, one heard still on all sides of the dreaded ravages of enteric amongst the young newcomers to the country, and the deaths from this cause in the South African War, which started in October, 1899, will be well remembered. Compare with those times the conditions as we know them now, both in peace and war, and the great advance in preventive medicine in this disease alone will be realized.

The earliest available statistics of the health of the Army in India show that, during 1800–1856, the average death rate was 69 per 1,000 of strength. In 1924, the death rate was 4.27 per 1,000. From 1838 to 1856, the average annual admission rate was 1968 per 1,000. Allowing for changes in the system of treating men in barracks, and "detaining" them instead of "admitting" them to hospital, the admission rate dropped below 1,000 per 1,000 for the first time in 1904, when it stood at 900. The year 1911 was a record year, the rate being 524.7 %, the lowest

figure that has ever been recorded. The situation in 1924 gives a comparison between the health of the Army at home and in India as follows :

	Average strength	Ratio per 1,000 of strength.					Average sick time to each soldier (days).	Average duration of each case of sickness (days).
		Admissions	Deaths	Invalids. Sent home.	Invalids. Finally discharged	Constantly sick.		
At Home ...	101,698	362·8	2·00		13·49	21·12	7·73	21·32
India	58,614	658·0	4·27	15·00	14·74	31·7	11·97	18·18

The position in 1924 in India is analysed as follows :—

Average strength of British troops	58,614
Of which 65.8 per cent. were admitted to hospital	38,569
Of which two-thirds were communicable and infectious diseases	25,000
Of which three-fifths were caused by biting insects	15,167
Of which :	
Malaria (mosquitoes) represented	12,120
Dengue (mosquitoes) represented	1,005
Sandfly fever (sandflies) represented	2,042

" Diseases caused by biting insects are, therefore, the most important problem that military hygiene in India has to deal with, and the first and foremost of all is malaria."

Chapter II deals with malaria, a Kali straddling the round world, the destroyer of past civilizations, who to-day in India attacks 100,000,000 of the inhabitants each year, and slays one and a half to two million victims. During the last decade of the nineteenth century, the definite responsibility of the mosquito for the spread of this disease was established by Major Ross. During the last thirty years, the campaign against this enemy has been waged with increasing knowledge and varying success. It is during the last five years that in India results have been definitely more hopeful, and the author states that this is due to the following measures :—

(1) " Cold storage " of troops, *i.e.*, withdrawal of as many as possible from malarious stations to the hills during the infective season (August to October).

(2) Mosquito-proofing of barracks for the troops that must stay down during this period.

(3) Fumigation of barracks at the end of the cold weather.

(4) Propaganda and education.

(5) Measures of interior economy and discipline in units, *e.g.*, proper care and use of mosquito nets, use of repellents and so on.

(6) Drainage schemes, closing of wells, oiling, etc.

(7) Efficient artificial lighting of barracks.

(8) Effective treatment of malaria cases.

(9) Co-ordination of all measures in each malarious station under a specially appointed officer.

Such places as Mian Mir (now Lahore Cantonment) and Amritsar are beginning to lose their evil reputations.

Further chapters deal with organization, research, and cantonments. The " cantonment " in India is a military phenomenon that is unique. Its history is interesting, but cannot be gone into in detail ; sufficient to say that a situation has been allowed to grow up in which the tail wags the dog, and in the " cantonment " which was originally to serve the interests of the troops and provide living accommodation for the officers, vested interests have reached such proportions that the Government felt itself obliged to meet the " progressive spirit of the age " here as elsewhere in India, with results that the enforced resident in cantonments can only deplore. " The spirit of the reforms " has created in an Indian cantonment a machinery of administration that does not make the enforcement of sanitary conditions any easier.

In a summary the author states that the health of the British Troops in India is on a lower level than that of the troops at home, mainly owing to the prevalence of certain " tropical diseases " that are largely insect-borne, and can be prevented by suitable measures.

This is a book which all officers should read, and especially engineer officers, who serve so largely in India. The work of the military engineer there brings him into close touch with the medical fraternity, and by co-operation between the two professions much could in former days be done quietly to improve sanitary conditions for the soldier. The engineer incidentally provided a useful check on the sometimes over-enthusiastic schemes of his medical *confrère ;* schemes which often changed their scope and character in a somewhat bewildering fashion with a change in M.O.

P.H.K.

FURTHER ASPECTS OF MECHANIZATION.

By BRIGADIER-GENERAL ROWAN-ROBINSON.

(Clowes, 6s.)

Brigadier-General Rowan-Robinson is not happy with the way things mechanized are moving. In his book, *Further Aspects of Mechanization,* he tells us about his misgivings, explains why he would recommend us to go "nap" with completely mechanized formations for our winning cards, and sketches out their design.

Brigadier-General Rowan-Robinson tells us what practical experience he has had of these matters, to which he has given much thought, and as a result he maintains that the tendency, which he discerns to-day towards " motorization," rather than towards " mechanization," will be to little purpose and will bring us in but a small return in comparison with the achievements that might be possible through further development of our recent Experimental Armoured Force.

In spite of all that has been said and done recently, the author contends " that success in the warfare of the future in average terrain in civilized countries lies in the purest form of mechanization." He is fully aware of the shortcomings of the medium tank as a machine on which an Armoured Force should be built, and he recommends in lieu the multiple-wheeled armoured car ; for reconnaissance work light scout cars are added ; no 18-pounders, a very few howitzers and something in

the nature of a 3-pounder as the main artillery weapon. A battalion of four companies of light infantry to the proposed brigade, the necessary engineers and the closest co-operation with the R.A.F.—so close should this be that eventual incorporation of R.A.F. units in the force is envisaged as a logical outcome for control, co-ordination and the air-borne maintenance.

These are the lines on which Brigadier-General Rowan-Robinson would see matters moving.

So little is known as yet, however, about the multiple-wheeled armoured car that one is not sure whether prospects of development in this direction are in fact as bright as the author considers; if he is correct, then his proposals would be attractive.

As regards the author's criticism of the disbanding of the experimental armoured force, many may wish that the experiment could have been continued, but as we have always to be ready for war in any theatre with resources immediately available, we probably cannot afford to practise solely with independent armoured forces.

Motorization appears to be inevitable, and we are endeavouring to compete with it, together with all its attendant intricacies of maintenance, etc., etc. Mechanization, however, is a much more ticklish affair, and although we may not at the moment be able to test out formations any further in this respect, the author can rest assured that the subject continues to receive considerable attention!

Further Aspects of Mechanization is well worth reading for the views, admittedly personal "and often, maybe, heretical," which the author holds on many aspects of mechanization. As regards Sappers in particular, it is indeed heartening to read that the author considers them "the most efficient and up-to-date part of our mechanized forces," and the reviewer heartily concurs with Brigadier-General Rowan-Robinson's statement that "Certainly there is now no such live job in the soldier's world as that of the Mechanized Engineer."

N.T.F.

PIPE AND TUBE BENDING AND JOINTING.

By STANLEY P. MARKS.

(Isaac Pitman & Sons, Ltd., price 6s.)

This book, of some 150 pages, is written primarily for the artisan, and is, consequently, in comparatively simple language, is not encumbered with a host of technical terms, whilst the information given is generally of a high standard. It covers quite a large field, including lead, copper, aluminium, zinc, tin, iron and steel tubings, both as to the methods of bending and jointing. There is, however, one notable omission—the jointing of cast-iron pipe, both by molten lead and blue wool, not being touched on at all; and the subject of screwed iron and steel tube joints is dismissed in a very few words. The value of the book to an apprentice learning the trade of plumber would be greatly increased by a chapter, or at least some paragraphs, on pipe-screwing and the various machines used for this purpose.

The chapter on iron and steel tubes is excellent (in so far as it goes), and the notes extracted from the publications of the British Aluminium Company on the difficult question of Aluminium Welding and Soldering, and given in Chapter VIII, are of great value.

The author also makes a rather doubtful remark on page 16, when he states in connection with sand loading for bending lead pipes, "it is a most convenient method for the amateur and novice, and for those who have no proper tools, as, for instance, colonial workers and army mechanics."

One hopes that he had in mind a Sapper in the Field, with a minimum of tools—otherwise it is feared that the general reader will gain a poor impression of the way in which Service workshops are equipped.

J.H.D.B.

THE UNIVERSE AROUND US.

SIR JAMES JEANS, M.A., D.SC., LL.D., F.R.S. (Camb. Univ. Press. 1929. Price 12s. 6d.)

Any attempt to review this book, in the sense of criticism, would be both foolish and impertinent. It is written by a master, and, unlike most such works, is comprehensible by any student of ordinary intelligence. More than that, it provides delightful reading for those who read rather for amusement than for study. For rigorous scientific argument and mathematical analysis, reference can be made to an earlier work of Dr. Jeans, *Astronomy and Cosmogony*, published in 1928. Those whose mathematical equipment is inadequate to deal with stellar dynamics and modern cosmical physics will find in the present volume a fascinating and up-to-date account of their achievements in astronomy. The clarity with which Dr. Jeans explains the most difficult problems is indeed remarkable; we take Einstein, so to speak, in our stride; and even the Quantum theory assumes an air of relative simplicity while we read. A book, in short, that can be warmly recommended to every R.E. officer, and that few, having once finished, will not want immediately to begin all over again.

G.H.A.

SURVEYING.

For Agricultural Students, Land Agents and Farmers.

By A. H. HAINES.

(Longmans, Green & Co., 12s. 6d.)

As its title implies, this book is primarily designed to give practical help to agricultural students and the like who are called upon to perform various tasks in which Survey is all-important.

For the most part, therefore, it deals with all the aspects of Surveying with the chain, but there are also chapters on the Theodolite, Plane Table, etc. It is rather abridged in places, but as the author states in his preface, this was part of his object, as most of the textbooks on Survey are too voluminous for the particular public for whom he has written this book.

The first chapter is a masterpiece on Mensuration, and tells you all there is to know on this subject, from "How to ascertain the weight of cattle" to "How to measure felled timber," besides a host of other interesting tables on weights and measures.

The next two chapters are devoted to Chain Survey. The methods of booking, etc., are different to those taught to the Young Officer on his Survey Course at Chatham. The diagram on page 33 and the specimen

Field Book on page 34 would have been much better if they had not been so cramped, and if they had been on the same page for ease in comparison. The Line Nos. on Fig. 17 are very poor.

Long chapters are devoted to Scales, Plotting and Plan Drawing, followed by specific descriptions of various survey instruments. There is nothing in this book which is not in the Surveyor's "bible," the *Textbook of Topographical Surveying*, except chain survey and a description of one or two instruments like the box sextant, etc., and these are dealt with by pamphlets compiled and issued by the Survey School at Chatham. For those for whom it was written it is doubtless an excellent book, but for the Sapper officer it cannot do more than supplement his existing books or pamphlets on the subject.

R.E.F.

MECHANICAL ENGINEERING.

By LIEUT.-COLONEL W. A. MITCHELL, U.S. Army.

(Chapman & Hall, 20s.)

The author, in his preface to this excellent little book, says:

"This textbook is prepared especially for the cadets of the United States Military Academy, who are being fitted for duty in the United States Army . . . Every Army officer must have a fair working knowledge of the principles and practice of mechanical engineering: he applies this in his work on army posts in time of peace, and with motor vehicles and shop machinery in time of war. In this book the cadet is taught enough of the branches of mechanical engineering, so that he may in future understand the practical mechanical engineering requirements of his profession."

Although this book, then, is written for every U.S. army officer, Sapper officers need have no fear that it is too elementary for them to read, for its contents are approximately what is taught about mechanical engineering to all young Sapper officers at the S.M.E., Chatham, and at Cambridge, with the notable exception of metal workshop materials and practice. We may deduce, however, that the mechanical education of officers generally has made more progress in the U.S. army than in our own. Whether or no all officers of a modern first-class army should know all that the book contains is open to debate, but it is certain he must know some of it. This is where this book is so good, for it may almost be said that it is readable by the general public: certainly by people educated as well as the average British infantry officer.

The headings of the chapters include: Thermodynamics, Fuels and Combustion, Steam Power, Gas Power, Water Power, Power Transmission, Electrical Power Systems, Compressed Air, Lubricants, Refrigeration, Heating and Ventilation.

The text is extremely well written and illustrated. Points that stand out in the editing are that paragraphs are numbered throughout and the illustrations are numbered to correspond with the appropriate paragraphs.

The book does not attempt to give practical information about the running and care of engines, etc., it simply tells how they work and what their ordinary applications are. In respect of application, mention must

be made of many extremely well-worked examples included in the texts and lists of problems at the ends of some of the chapters, all very practical and in connection with the employment of mechanical power, etc.

The omission of metal workshops' materials and practice is a pity. These subjects are part and parcel of mechanical engineering.

The book contains a few inaccuracies and somewhat bold statements which should not occur in a textbook of this type. For instance, we find the very high speed of a small de Lavel turbine twice given as 3,000 r.p.m. Under "Boiler Tests" we find "A simple safety test may be made by simply pumping water into a boiler until the desired testing pressure is obtained. If there are no leaks the boiler is considered safe." Or again, "The only commercially successful turbine of the reaction type, the Parsons turbine . . ." T.C.W.B.

WIRELESS TIME SIGNALS FOR THE USE OF SURVEYORS. Third Edition, by ARTHUR R. HINKS, C.B.E., M.A., F.R.S. (Published by the Royal Geographical Society, 3s.)

This new edition of Mr. Hinks' pamphlet on Time Signals can briefly be described as being quite as indispensable to any surveyor as his book of logarithms or his penknife. There is no other book which collects in this way all information as to existing time signal services. In addition to the ordinary explanations of their various forms, it gives a large number of essentially practical details which can only have been learnt by extensive listening-in to all the signals. Few for instance can have realized that there is a considerable difference as regards the precision with which the preliminary calls are sent from Bordeaux and from Nauen, or that the Rugby signal was imperfect no less than eight times in five months in 1928.

Any surveyor who has used wireless time signals has always in the past suffered from not knowing in what publication to look for details as to errors in transmission. Vaguely he has realized that the Bureau Internationale de L'heure issue some kind of error list for French stations, but where to get this publication has usually defeated him. He cannot buy it on a bookstall. Mr. Hinks has given the most useful practical help in stating the name and address of the agent for this publication, as also for the correction list published by the Admiralty. This latter list deals solely with Rugby, Annapolis, Bordeaux and Nauen, and the arrangement by which the Astronomer Royal undertook to record the errors of these four time signal stations only came into force in 1928, so that to most surveyors it will be news that such a valuable and easily procured list of corrections exists.

A summary of the first four months' results since this checking of time signals was undertaken by the Royal Observatory is given on page 6 of the pamphlet, and is most interesting. It is also flattering to our national station, Rugby, which quite easily leads the field for accuracy.

Page 14 has some interesting experiences as to call signs recorded. One cannot quite imagine the feelings of a surveyor or explorer returning to his base after many months, when he is told that he need not have rejected the signals beginning with the call sign FYL as being from some unknown station. Mr. Hinks records that the great Bordeaux trans-

mitting station, so well known and so popular with all who have practical experience of longitude determination by W/T time signals, solemnly changed its call sign from the familiar LY to FYL without any sort of warning or even prompt official notification.

On the subject of the reception of time signals other than by chronograph, the pamphlet wisely remarks that every observer has a method of his own which he considers better than any other. Cynical but true. It seems, however, a pity to dismiss all chronograph recording as being too elaborate for field use. Automatic recording surely is, but many surveyors would prefer a chronograph and press button to any system of coincidence judging. Taking the mean of fifty standard rhythmic dots by chronograph has, in fact, proved itself to be a very suitable field method, and the use of the same press button and chronograph for booking the star over the cross wires of the theodolite introduces that accord of method which Mr. Hinks emphasizes in his description of coincidence judging when the chronometer has no microphone.

The second part of the pamphlet is taken up by an immensely useful schedule of all suitable time signals, arranged in order of the time at which they are sent instead of by countries or alphabetically. This is a far more helpful arrangement than that adopted in the Admiralty List of Wireless Signals to which most surveyors are wont to refer.

Each signal is set out in diagrammatic form, and in addition the wave length and type of transmission is stated. Useful notes as to reliability and vagaries are also given.

Finally, there is a map showing the true bearing of Rugby from all parts of the world, which will save many a wearisome computation to those surveyors who are using that station for their longitude work.

Indeed, one cannot but repeat that Mr. Hinks' book is a piece of equipment which it would be quite stupid to leave behind when starting out upon a surveying expedition.

P.K.B.

CIVIL ENGINEERING: A TEXTBOOK FOR A SHORT COURSE.

By Lieut.-Colonel W. A. Mitchell, U.S. Army.

(Chapman & Hall, Ltd., 30s.)

There is a mass of heterogeneous information contained in the 700 pages of this book, covering an extremely wide range, and varying from broad panoramic views to minute examination of detail. It is undoubtedly an ambitious task to condense into one volume a textbook of all the various branches of civil engineering, any one of which is justly entitled to treatment on a scale equivalent to that devoted to the whole.

In order to appreciate the success of this monumental effort, it is essential to ask oneself the question—"For whom is the book intended?" That is, what class of the community is so situated as to require in its daily work, not only the broad outlines of knowledge conveyed by this work, but also the elaborated and incomplete details with which it is embellished?

The solution to these questions is apparently contained in the following passage of the preface :—

> "Every army officer must have a fair working knowledge of the principle and practice of engineering ; therefore, in this book the cadet is taught enough of all branches of civil engineering, so that he may in future understand the practical engineering requirements of his profession. For the engineering work of the army requiring great technical knowledge, this textbook is supplemented by additional courses given in army schools to officers of the engineering branches of the army."

This passage raises points of such interest and is of such basic importance in appreciating the value of the book, that a detailed examination is essential. From this, three questions immediately emerge :—

(*a*) Is it essential for "*every* army officer to have a fair working knowledge of the principles and practice of engineering ? "

(*b*) Does a textbook on civil, as opposed to military, engineering supply his need ?

(*c*) Does this textbook " teach enough of all branches of civil engineering, so that he may in future understand the practical engineering requirements of his profession ? "

To consider this seriatim :

Query (*a*) : The answer to this is admittedly a domestic matter, upon which our opinion would be superfluous to the West Point instructional staff. To our minds, it would appear that an infantry officer can be equally, if not more, efficient at his job if he is not an expert in, say, city planning, reinforced concrete design or sewage disposal methods.

Economy of force and concentration of effort are principles of life and not only of war, and an officer cannot concentrate on his own particular job if he is dispersing his efforts over such a vast field of enterprise.

The crucial point of the statement is admittedly the definition of what constitutes a " fair working knowledge," and this we can only infer from the problems in the book, which the reader is expected to solve.

It is not unjustifiable to state that, on this side of the Atlantic, the vast majority of these problems, although undoubtedly within the capacity of all officers, are yet equally undoubtedly within the specialized domains of the technical corps.

Query (*b*) : In appreciating this point, the nature of the subjects dealt with under the heading of civil engineering should be realized, and for this it is only fair to be guided by the contents of the book under review. It is divided into four parts :—

Part I : " Mechanics of Engineering "—Forces, Tension, Compression, Shearing, Torsion, Flexure ; Beams ; Moving loads ; Pressure and Flow of Water.

Part II : " Building Materials "—Timber ; Metals ; Natural and Artificial Stone ; Testing of Materials.

Part III : " Component Parts of Structures "—Framing ; Masonry ; Columns ; Foundations ; Metal Work.

Part IV : " Engineering Structures "—Buildings ; Bridges ; Dams and Retaining Walls ; Water Supply ; Sewerage and Sewage

Disposal; Railways; Highways; City Engineering; Construction Equipment; Specifications.

With such a comprehensive list of subjects and only 700 pages in which to deal with them, the marvel is that the author has been as successful as he has!

But to return to our query; an officer envisages two phases of his professional career—Peace and War.

In peace time, he has at his disposal the full resources of the civil and military engineering professions, and a knowledge of their work, although of interest, is no more essential to him than to any other citizen.

In war, he is faced with a full-time job of his own and, although a knowledge of the elements of field or military engineering is a necessity, few, if any, of the headings and sub-headings enumerated above will be of the slightest assistance to him in the execution of this job.

Query (*c*): The severest criticism of the book must inevitably be contained in the answer to this question. It is the old, old story of falling between two stools.

Unnecessarily precise for a cursory survey, it is at the same time insufficiently detailed for use as a technical textbook.

The layman would never face the calculations (including differential and integral calculus) presented to him. Why should he? What does he stand to gain if he does?

The engineer could carry through no work of any magnitude without additional recourse to a textbook devoted entirely, or, at any rate, in very much greater detail, to the operation in which he is involved.

In general, the author appears to presuppose an interest and a degree of mathematical knowledge which is unlikely in a layman, while the information imparted by him is of little value to the engineer who finds himself faced with a definite problem, in the solution of which he turns to a textbook for assistance.

It is a matter for regret that no answers are appended to the problems set at the end of each chapter. These are of a distinctly practical nature and would tend, with the suggested addition, to arouse more than anything else that interest which is so essential.

A.D.C.

(*a*) CANTERBURY AND ROCHESTER, WITH MINSTER IN SHEPPEY.

(*b*) GLOUCESTER AND WORCESTER, WITH TEWKESBURY, DEERHURST AND MALVERN.

(*c*) WELLS AND BRISTOL, WITH BATH, GLASTONBURY, MALMESBURY, ST. MARY, REDCLIFFE and BRADFORD-ON-AVON.

(Bell's Pocket Guides, Cathedral Towns and Neighbouring Churches, 2s. each.)

This new issue of small guides replaces Bell's well-known Cathedral series, which is largely out of print. The plan of this series is plain from the titles, two Cathedrals and neighbouring churches of interest being dealt with in each volume.

The architecture is clearly and interestingly described in each case, and the points of interest in the cathedral towns are also dealt with.

The books are well illustrated from photos, and as far as can be seen from the guide to Canterbury and Rochester, are as up-to-date as is possible. The activities of the Friends of Canterbury Cathedral in restoring the Water Tower, however, are not recorded, but the restoration of the wall-painting of the legend of St. Eustace finds a place.

This is a valuable series, and cheap for the price charged.

P.H.K.

MAGAZINES.

REVUE MILITAIRE FRANÇAISE.

(*July*, 1929.)—Lt.-Col. Grasset completes "*Montdidier, le 8 août, à la 42e division*," in this number. The final action of this day was the capture of Fresnoy-en-Chaussée by this division, helped by two battalions of the 1st Regiment of Moroccan Rifles. The attack was to take place with the help of French tanks, but, owing to the short time available, some of the troops advanced before the tanks and an excessive muddle of units ensued. However, the village was captured, and completed a wonderful day's work for the 42nd Division. Général Débeney's order after the attack reads :—

> "The 42nd Division has just opened the gates of victory. The 3rd Army is now about to attack. If the battle assumes an unexpected success, it is due to the rapid thrust of the 42nd Division."

Lieut.-Col. Grasset concludes with an appreciation of the splendid work done by the Moroccan battalions, who well deserved to share in the praise given to the 42nd Division.

Lieut.-Col. Vanthier continues "*La défense anti-aérienne des grandes unités*," in this number. He discusses articles written in the *Journal of the Royal Artillery*, by Capt. Loch and Major Cherry. Both writers agree that ground artillery cannot undertake anti-aircraft fire, unless they are back, out of action, and then they can only act as a support to the true anti-aircraft artillery. Lieut.-Col. Vanthier agrees with these conclusions, and also arrives at the following points :—

(*a*) All small arms, including infantry guns and machine-guns, must be designed so as to be able to attack low-flying aircraft and tanks.

(*b*) Every commander must be responsible for his own air defence, and so must have the necessary weapons, apart from general air defence provided from above.

In the second and final instalment of "*La VIIe armée allemande en converture en août*, 1914," Capitaine Marchal describes the successful attack of this army. The French 7th Corps was extended on a wide front, facing N.E. and S.E., when the German Army commander decided

to strike. After actions at Cernay and Mulhouse the French were driven back, but General von Heeringen, the 7th Army Commander, failed to maintain his grip on the operations, which were not as successful as they might have been. However, the German 7th Army fulfilled its task as a covering force completely.

Général Armengaud and Commandant Donnio complete "*La pacification de l'Afrique encore insoumise,*" in this number. It is suggested that now is the time to pacify the remaining stretches of N.E. Africa, where the tribes have still failed to come to hand, using a small but practically invulnerable force, viz., aircraft and a specially composed land force. There is little doubt that aircraft can effect a great deal in an area where water is infrequent and the tribes are drawn to the oases, and quite a small land force, if properly organized, can complete the work. The article is illustrated with some quite good air photographs of the area and two sketches.

In completing "*La genèse de Neufchâteau,*" Commandant Pugens describes the difficult situation of the German Fourth Army. Owing to bad weather and the wooded country, the Duke Albrecht, commanding the Fourth Army, had practically no knowledge of the movements of the French. The German Crown Prince, on his left, then decided to attack, against the wishes of Moltke, thereby exposing his right flank. A German staff officer from the right corps of the Fifth Army came to Duke Albrecht's headquarters in the middle of the night, to ask for the left corps of the Fourth Army to cover the attack of the Fifth Army. Duke Albrecht finally agreed, in spite of his ignorance of the situation on his front, and this brings us to the eve of the battle of Neufchâteau, on the Fourth Army front.

(*August*, 1929.)—Lieut.-Col. Desmazes begins an interesting series of articles, entitled "*De Liao-Yang à Moukden,*" in this number. The writing is free from details of units, at least in this instalment, and he describes clearly the situation at the outbreak of the Russo-Japanese War, and also shows how Japan lost her numerical superiority by the autumn of 1904. It is pointed out that Kuropatkin, in 1903, recommended that Russia should relinquish her hold on Port Arthur and give up any idea of occupying Korea, and it may be that the rejection of this advice in Russia led to the general defensive policy of Kuropatkin, when he was appointed as Commander-in-Chief. A very interesting point made is the Russian mania for producing "combined formations," in which units were detached from their proper formations and banded together without staffs. This custom had naturally a great deal to do with the general failure of the Russians.

In completing "*La défense anti-aérienne des grandes unités,*" Lieut.-Col. Vauthier gives mainly a technical discussion still based largely on writings by Major Cherry and Capt. Loch, of our own R.A. He arrives, however, at a suggestion for air protection by light artillery and infantry guns, namely, that they should be designed so that they can take on the three tasks of fire against tanks, aircraft and field objectives. One must agree that the normal anti-aircraft artillery cannot provide full protection, and although further training will be necessary, it does seem that Lieut.-Col. Vauthier's solution will probably be the correct one.

Yet another article, entitled "*Les mémoires de Napoléon*," by Général Camon, appears in this number. It is of little interest to anyone who is not actually studying Napoleon's writings, being concerned largely with the differences between his memoirs dictated to Les Cases and to Montholon at St. Helena.

"*Les confins sahariens de l'A.O.F. en* 1929," by Commandant Cornet, describes the methods adopted by pillaging bands in Northern Africa. Especially on account of areas belonging to Spain into which these bands can escape, the French find it still very difficult to "discourage" these robbers. The appearance, however, of mechanized vehicles, wireless telegraphy and aviation, have proved an enormous help, and it is to be hoped that in time the French will be able to produce real peace in this somewhat turbulent area.

Lieut.-Col. Aublet begins "*L'artillerie française de* 1914 *à* 1918," in this number. The first section deals with the actual material and is not of particular interest. In the second section, we recognize the same problems in the method of command of the artillery as were faced by ourselves. In this number, the writer explains how fresh commanders were provided to deal with the growing mass of artillery as the War proceeded.

(*September*, 1929.)—The second instalment of Lieut.-Col. Desmazes' "*De Liao-Yang à Moukden*," describes the battle of Liao-Yang, together with the events leading up to it. It is quite clear that Kuropatkin held the advantage more than once, but could not nerve himself to launch the necessary counter-attacks with a big reserve. As it was, the reserves were used piecemeal. A typical instance of command by the Russians before the battle is given. General Sassulitch said, "His Majesty has awarded me the order of Chevalier de Saint-Georges. A Chevalier de Saint-Georges never retires." Unfortunately, he followed this remark by a very brisk retirement, although he was commanding the Russian covering force at the time, and asked if he might go back to Liao-Yang. It is not surprising that the Japanese were always successful when opposed by commanders of this type.

Général Chédeville begins "*Motorisation des engins de combat rapproché*," in this number. He points out how, through the ages, efforts have been made to bring the fighting man up to close contact with his adversary, by the use of shields, armour, and the like. Since the appearance of petrol as a motive power, this has developed into the production of tanks. In this instalment the writer considers the various limiting factors for the present-day tank and gives his opinions regarding its design. The different arguments are familiar to any student of mechanization.

"*La prise de Neuville Saint-Vaast*," by Commandant Lefranc, describes the French attack of May, 1915, which was designed to break through into the open country. Actually, it took a month of fighting to capture this village, in spite of the enormous amount of infantry and artillery collected by the French. The result of the operations was a reconsideration by the higher command of both the Allies and the Germans, as it became clear that an attack on a narrow front had little chance of success. Général Foch was commanding the northern group

of armies with Général D'Urbal, a real fighting army commander, directing the attack, but in spite of the gallant efforts of the French, the result was comparatively insignificant.

Lieut.-Col. Aublet completes "*L'artillerie française de* 1914 *à* 1918," with a description of the different tactics employed throughout the War. At the outset, the French artillery failed to support the infantry. This was quickly remedied, but the development of defensive positions produced the necessity for destruction by the artillery. The method of this period definitely failed, partly owing to the enormous expenditure of ammunition, and so surprise was attempted, combined with neutralization, instead of destruction. We all know how successful this last method was, but as the writer points out, it will be by watching developments in a future war, not by sticking to existing successful methods, that success will again be attained.

A short article, entitled "*La guerre en haute montagne*," by Capitaine Tourret, describes the conflict between the Italians and the Austrians in two sections of the mountain front. Clearly, little was gained on either side, in spite of casualties which varied from a small to a large percentage of those employed. Capitaine Tourret points out, however, that mountains cannot be neglected in a long war. The Italians have, all the same, practically given up their wire railways, by which supplies were mainly delivered, which makes us wonder whether they have already forgotten the lessons of the Great War.

H.A.J.P.

REVUE DU GÉNIE MILITAIRE.

(*May*, 1929.)—In an article, entitled "The Engineers of the 133rd Division in Belgium," a description is given of a pile bridge for heavy loads, constructed over the Yser Canal in August 1917, by two companies of Engineers. The bridge has seven piers, each of five piles.

In "The Engineers in Cochin China," Lieut. Botrel gives an account of work carried out in the shape of river crossings by native companies of engineers who, for the first time, took part in manœuvres. Owing to their breadth and frequency, the waterways can only be crossed by means of rafts.

There is a translation of Lieut. L. T. Grove's article in the March number of the *R.E. Journal*, called "The Use of Power Tools in a Field Company R.E."

(*June*, 1929.)—"A Story of Mine Warfare," by Col. Bailly, is an account of the mining carried out on the 28th Divisional front in the Proyart region of the Somme. In October, 1914, the General commanding the Division conceived the idea of attacking the village of Dompierre, by means of sapping and mining. The Lieutenant commanding the 14/2 Company of Engineers, pointed out that the distance of the village—about 300 metres—and the absence of all mining material would make the operation a very lengthy one, in which opinion he was supported by the Chief Engineer of the Corps. Nevertheless, the General persisted, and towards the end of October, mining was started by two companies. A detailed account is given of the operations and the varying fortunes of the combatants on either side—for the Germans

naturally started mining as well. Mine warfare gradually extended along the whole divisional front; it lasted for ten months, but the results were such as to justify the belief that the sappers would have been better employed in their normal manner.

There is a short article on the narrow-gauge railways in Morocco, by Lt.-Col. Suchet, and an account of a semi-rigid suspension bridge over the Rance, between Port St. Jean and Port St. Hubert, by M. Lebrun. The span is 173·65 metres between the piers. The two steel cables are eight-fold. The attachment of the vertical ties is to the upper part of the main girders (*poutres de rive*), an innovation whereby secondary stresses are to a great extent eliminated. The supporting joists for the roadway, which consists of a ferro-concrete slab, 12 cm. thick, are of **I** pattern, 400 mm. deep. The roadway and the main girders together form a channel ⊔ capable of resisting the most violent wind-pressure.

(*July*, 1929.)—Captain of Cavalry Gazin contributes a long article on the use of narrow-gauge railways in the war of movement in France and Germany, with special reference to the advance of the 1st Army, in 1918.

Lieut. Botel, in "The Use of Habert Bags," describes how, by means of a framework, these waterproof bags can be joined together to form rafts of various sizes. A raft made of five bags can carry twenty fully-equipped men, whereas a single bag can only carry three.

A.H.B.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1929. TOME II.—NOS. 1 TO 3 INCLUSIVE.)

"*Les opérations de l'Armée belge*, 1914–1918." An account is given of the events of a part of the period during which the Belgian Army held the section of the line Nieuport Canal–Furnes–Steenstraat. The portion of it appearing in No. 1, deals with the events which took place between March 11th and April 22nd, 1915. The general situation at the beginning of March, 1915, is briefly reviewed. In the middle of December, 1914, after the Battle of Lodz, the Eastern Front had become stabilized; however, the enrolment of the 1914 class of recruits enabled the Germans to create four new corps (XXXVIII to XLI) and a new Bavarian Division. Three of the new divisions were sent to the Western Front, and nine of them to the Eastern Front; at the end of January, 1915, the German XXI Corps was also transferred from the French to the Russian Front. At the beginning of February, 1915, the Germans resumed offensive operations in E. Prussia, and severely defeated the Russians in the region of the Masurian Marshes. However, in spite of the disaster which had overtaken their forces, the Russians soon returned to the attack; the Battle of Prasnyz (February 22nd to 27th) took place, and the enemy's advance was definitely checked. About the same time, the Germans had resumed active operations in the Carpathians; they succeeded in re-occupying the Bukovina.

In view of the fact that the Germans were now concentrating all their efforts for the purpose of bringing about the complete overthrow of the

Russian armies, Joffre hoped to take advantage of the numerical superiority of the Anglo-French armies and proceeded to make arrangements for an offensive on a big scale on the Western Front, with a view to holding a maximum of enemy troops in Belgium and France: for this purpose, the operations of the French 4th Army in Champagne were continued, and a new attack was to be launched in Artois by the French 10th Army. Owing to Sir J. French's inability to take over the section of the front in the Ypres Salient held by French troops, the proposed stroke in Artois had to be abandoned. The B.E.F., however, attacked to the N. of La Bassée on March 10th, and succeeded in capturing Neuve Chapelle; heavy losses and shortage of ammunition led to these operations being abandoned four days later.

It was now felt that the chances of success in the Champagne were small; in consequence, the operations of the French 4th Army also came to an end.

On February 27th, whilst plans for the proposed offensive of the French 10th Army were being worked out, Joffre enquired whether the Belgian High Command could take over a part of the line in the neighbourhood of Steenstraat, held by the French 8th Army. The proposal having been agreed to, subject to the French becoming responsible for the defence of the Nieuport Sector, the Belgian 6th Division relieved the French troops near Steenstraat, on the night of March 10th-11th; the French took over the Nieuport Sector on the evening of April 22nd. The measures taken in effecting the reliefs mentioned above are described in some detail in No. 1; the evolution in tactics during the early days of the stabilization period are also discussed.

The actions fought in the neighbourhood of Steenstraat, between April 22nd and May 25th, are dealt with in No. 2; they form a part of the operations known officially as the Battle of Ypres, 1915. The main object of the German attack in this locality was to try out the value of chemical warfare in the field, and to test the efficacy of the poison gas with which German chemists had been experimenting in their laboratories.

A brief review of these operations is given. On the evening of April 22nd, the French, holding the section of the line between Steenstraat and Poelcappelle, were completely taken by surprise and, large numbers of them having been put out of action by the poisonous fumes, had to fall back; in consequence, the Germans were able to cross the Yser Canal at Steenstraat and Het Sas. The Canadian and other British divisions lent timely support and by dawn on the morning of April 23rd, the breach in the Allied line was partially closed. French and British reinforcements were poured into this area. In the meantime, the enemy continued his offensive and succeeded in penetrating deeper and deeper into the Ypres Salient. The part played by the Belgians during the period of these operations is dealt with. Sketch maps indicating the position of affairs at various dates are provided.

The events of the period May–December, 1915, are dealt with in No. 3. The military situation in Europe during the period in question is briefly described. The Germans were now determined to annihilate, if possible, the Czar's armies. For this purpose, a new and powerful German army was constituted and placed under von Mackensen, who advanced on

Cracow on May 2nd; at the same time, a general offensive of the Austro-German forces on the Eastern Front was launched. The Russians were compelled to retreat and abandoned Galicia, Poland, Lithuania and Courland; they succeeded, eventually, in stemming the advance of the invaders, on a front extending from the Gulf of Riga to the Bukovina District. Trench warfare now began on the Russian Front and lasted until January, 1916.

The Germans having assumed a defensive attitude on the Western Front, owing to the depletion of their forces, the French High Command launched a series of attacks against the Germans in Artois and Champagne. In the meantime, on May 23rd, Italy joined the Entente Powers as a belligerent. Although the French attacks did not produce any decisive results, these operations and the Italian menace lessened to some extent the enemy's pressure on the Eastern Front, and proved of assistance to the Russians. On the other hand, the intervention of Bulgaria, as a belligerent on the side of the Central Powers, on October 5th, resulted in Serbia being completely crushed before the end of 1915. It is further pointed out that the Gallipoli Campaign (April 25th, 1915—January 8th, 1918), and the occupation of Salonica in October, 1915, created a drain on the forces of the Entente; the value of these diversions cannot be assessed with certainty.

"*La tactique des renseignements.*" The first three parts of an article under this title, by Colonel Tasnier, of the Belgian General Staff, appear successively in the numbers of the *Bulletin* under notice; they deal with the intelligence service. General principles are dealt with and discussed under various heads in Part I. The several sources from which intelligence is obtained are briefly reviewed: the "organs of discovery" are touched upon; the successive stages by which intelligence is collected and distributed are stated; the specific purposes for which intelligence may, on particular occasions, be required, are discussed and the importance of planning suitable schemes for the collection of intelligence is emphasized; matters connected with the recording of information, its distribution, analysis and utilization, are each separately treated.

Part II deals with the work of the intelligence department; the organization and functions of the *2e bureau* of a Belgian Army Corps are examined in some detail; the methods employed in obtaining intelligence and in transmitting it to the proper quarter are described at some length.

Part III is devoted to matters connected with the centralization of the intelligence services and the analysis of information. Tables are given which set out in summarized form the important points in relation to which information should be obtained, and the particulars that should be recorded.

"*La survie d'un peuple.*" Three parts of an article under this title, by Major F. Delvaux, appear successively in the numbers of the *Bulletin* under notice; the article deals with the military history of Serbia. In a short introduction, Major Delvaux points out that the histories of Belgium and of Serbia indicate that there are many resemblances in the experiences through which their peoples have passed in times gone by; in both these small territories, the inhabitants have, from time to time, had to submit to the temporary domination of a foreign overlord,

and have, in consequence, been subjected to oppression and the loss of their liberty.

In Part I, the migration of the Slav tribes from Russia to the banks of the Vistula and the Danube, in the fifth century of our era, is traced; the territory occupied by the Serbs in the seventh century and its military features are briefly described; the anarchy which reigned in the Balkans and the Islamic domination in that region during the fourteenth century, are commented upon. The history of the Serbs shows that a traditional enmity has existed for centuries between them and the Turks and Austrians. After having been raised to the status of an important Power by Stéphane Douchan (1331–1355), a "Great Serbia" was laid low by the defeat of her army on the plains of Kossovo (1389); the national existence of the Serbs then suffered an eclipse which lasted for five centuries. A brief account is given of the Turkish invasion of Bulgaria in 1393, of the occupation of Constantinople by the Turks in 1453, and the effects of Turkish domination in former times on Yugo-Slavia.

In Part II, the gradual restoration of Serbia as a Power is briefly touched upon. Advantage was taken by the Serbs of the French Revolution, and the Islamic Civil War, to revolt against Turkish rule; they were organized and led by Karageorge (a breeder of pigs, who was formerly an Austrian N.C.O.), and seized Belgrade. Russia, being at war with Turkey (1806–1812), at first supported the Serbs, but left them to their own resources, when Kutusoff's army was withdrawn from Turkey to oppose Napoleon's advance on Moscow; the Serbs then took refuge in Austria.

The diplomats who assembled at the Congress of Vienna, in 1815, decided that the Yugo-Slav provinces should be incorporated in the Austro-Hungarian Empire, but they came to no definite conclusion regarding Serbia. An account is given of the manner in which Serbia regained her position as an independent Power, under the rulership of Miloch Obrenovich, a rival of the Karageorges, and of the conflicts between Turkey and Russia, during the latter half of the nineteenth century; Serbia was drawn into the vortex, but was rescued from her difficult position by the intervention of the Great Powers. Finally, by the Treaty of San Stefano (1878), Serbia was granted complete independence and an increase of territory.

The events leading up to the Balkan War (1912–1913) are briefly traced; an outline is given of this campaign, and of the Battle of Kumanovo (October 23rd–24th, 1912), and the Battle of Monastir (November 13th–17th, 1912), which resulted in the destruction of the Turkish Army of Macedonia by the Armies of the Balkan Allies. The Serbian Army played a prominent part in both these battles; in the latter, it took more than 10,000 Turks prisoners and captured 50 guns. The defeat of Kossovo was revenged by the victory of Kumanovo. An armistice was concluded on December 3rd, but as Turkey would not accept the peace terms offered by the Balkan Powers, hostilities were resumed. The Turks met with one reverse after another. The Great Powers, disturbed by the Balkan situation, arranged a Conference of Ambassadors in the spring of 1913; the belligerents were induced to sign the "Preliminaries of London," and hostilities were brought to an

end. The Turks were now virtually expelled from Europe; they were allowed, however, to retain their hold on Constantinople and the Straits.

The ambitions of Austria being thwarted and her *amour-propre* wounded, she concentrated an army of 20,000 men on the Save and Drave, and put forward claims for the extension of the Albanian frontiers; to these, Serbia manifestly could not agree. The outbreak of hostilities on a vast scale became imminent during March–April, 1913; it was probably alone due to the fact that Germany's preparations for the Great War were incomplete at that date that the delivery of Austria's ultimatum to Serbia was postponed. An interesting review of the political situation in Europe, as it affected the Balkan Powers at this time, concludes Part II of the article.

Part III deals with the events connected with the Great War. The situation immediately preceding the outbreak of hostilities in August, 1914, and the Austrian plan of campaign against Serbia are briefly discussed. Accounts are also given of the Battle of the Tser (August, 16th–19th, 1914), and of the third Austrian offensive, during which the Serbs gained a victory on the banks of the Koloubara (December 2nd–15th), when they took 40,000 prisoners and captured 130 guns, together with vast quantities of stores. The Serbs look upon the results of the Battle of the Koloubara as being, in their theatre, similar in its effect on the war as the Battle of the Marne is recognized to have been in the Western theatre. However, the Serbian victory, Major Delvaux suggests, was more complete than the Anglo-French one; it brought about a complete liberation for a time of the invaded territory; the Austrians were pushed back to the strategic base from which they had opened the campaign.

W.A.J.O'M.

AN t-OGLACH.

The Journal of Cumman Costanta Naisiunta (The National Defence Association) of the Irish Free State.

VOL. II, NO. 3.

In the *R.E. Journal* of December, 1928, appeared a short review of *An t-Oglach*, together with remarks on the genesis of the journal. The number now under review is of interest, since it contains the constitution of the new National Defence Association, and defines the object of the Association: the means whereby it hopes to attain its object, the nature of membership, committee, etc., and states that this Association, through its executive committee, shall be responsible for the management of *An t-Oglach*.

In consequence, *An t-Oglach* takes its place alongside publications such as the *Journal of the R.U.S.I.*, as a semi-official publication, controlled by a Military Association.

Bearing in mind the individualistic attitude of the Irish Free State, and the fact that the Free State Army is outside the framework of the armed forces of the Crown, any information as to its military development must be of considerable professional interest.

The Free State Army is undergoing a fresh reduction and reorganization. The effect of that reorganization is to bring the permanent forces in line with the permanent forces in the Dominions, in that the serving personnel exist to staff and train the, as yet, in Ireland, non-existent, active volunteer or militia forces.

Maj.-Gen. Hugh MacNeill, speaking at the Curragh, to an assembly of officers of the Reserve, in August, said: "Ireland has now ceased to attempt to maintain a standing army as such . . . The old army, as we knew it, is dead." It will be extremely interesting to see what arises in its place.

The influence of this period of transition is apparent in the other articles.

The editorial welcomes thirteen cadets, appointed to commissions as 2nd-lieuts., and cheers the incoming enthusiast with the statement that their arrival "has further aggravated the position with regard to promotion. We have now the extraordinary position that 2nd.-lieuts. with from seven to twelve years' service are serving in the same units with officers just commissioned."

So there is somebody worse off than the gunners.

Capt. D. J. Lawlor, of the Q.M.G.'s Branch, ends a well-reasoned article on the cavalry arm, and would like to see some cavalry in the army.

Maj. Cotter, General Staff, desires to "Abolish the Infantry." His arguments are conclusive and interesting. The possible enemies of Ireland, if propinquity makes enemies, are France and England. If the coast defence system, which he would substitute for the more usual army, fails, then the infantry will not be much use after the enemy lands. So why have infantry? The possible ally of Ireland in a world war is England. But England has always, according to Maj. Cotter, exploited the Irish infantry—she will probably do so again. Then why have any Irish infantry for her to exploit? There is something to be said for this argument; if it is agreed that committing suicide before the enemy arrives is the least painful solution of a military problem. Maj. Cotter's views are throughout original, witness his statement that: "It is not pleasant for any officer to send men to their death but, once faced with the necessity, human considerations will direct the sending of the stranger in preference to one's own." This method is no longer approved since the system of "Fighting to the last Russian," failed in the late War, because the last Russian wouldn't fight. Maj. Cotter is, one feels, in the running for the Nobel Peace Prize.

Col. O'Connell has a well-written and interesting article about the "Manœuvre of Bantry Bay," which it is to be hoped the Association will publish in pamphlet or book form.

There are the usual notes on foreign armies and reviews of military periodicals, and the whole publication is a credit to the Association, which is responsible for its direction.

The numerous Irishmen in the British Army will follow with interest the free flow of Celtic military thought, untrammelled by the restraint of the Saxon connection.

E.E.D.-S.

COAST ARTILLERY JOURNAL.

(*June, July, August and September*, 1929.)

The June number begins with an article on "Anti-Aircraft Defence Tactics with a Mechanized Force," in which the writer first describes the different functions of a mechanized force. He then assigns to an efficient covering A.A. unit the following characteristics:—

(*a*) Easy cross-country ability.

(*b*) Speed not less than the average speed of the force it is designed to protect.

(*c*) Ease of changing from travelling position to firing position and *vice versa*.

(*d*) Rapidity in engaging targets.

(*e*) Fire power.

Of the three guns used in the American A.A. units, he considers generally that the 3-in. M.I. mobile gun, on a trailer mounting with large-size balloon tyres, fulfils conditions as enumerated in (*a*), (*b*), (*d*) and (*e*), but takes twenty minutes to come into action; the 37-mm. automatic gun, with its 80 rounds a minute, fulfils (*a*), (*b*) and (*d*), but has a vertical range of only 10,000 to 12,000 ft., and takes nearly as long as the 3-in. gun to come into action ("the operation taking less time than the 3-in. gun"); the 50-calibre M.G., when mounted as a four-gun mount on a light trailer, with its 450 rounds a minute, would fulfil (*a*), (*b*), (*c*) and (*d*), but has a vertical range of only about 6,000 ft. In conclusion, the 3-in. gun is the only weapon which might keep enemy bombers at a high altitude and render it more difficult for them to make accurate shooting, but none of the weapons could prevent an attack by fast fighters, while the mechanized force was on the move. He deduces the opinion that the best defence, while on the move, would be put up by the 50-calibre multiple-mounted M.G.s, but efficient protection while in bivouac can be maintained by the 3-in. and 37-mm. guns, which would, in that case, be always ready for action.

An essay on the "Army Mine Planter Service," shows how submarine mining has always remained an integral part of coast defence, under the Chief of Coast Artillery. Both the work and even the interest in the work seem to have declined since the War, so much that the Chief of C.A. has issued stringent orders this year, stressing the importance of this part of the defence training, and requiring all units to plant full groups of 19 mines at practice, instead of only fractions of these groups, as has lately become the custom.

Articles on the "Training of the National Guard," and "Details of Method and Material for Dismounting Heavy Guns and Carriages," are followed by a discussion of the mechanization of Europe. The principal portion of the latter is devoted to a very interesting disquisition on the prevailing military situation of Russia, where the authorities follow Lenin's policy that, "the soundest strategy in war is to postpone

operations until the moral disintegration of the enemy renders the delivery of the mortal blow both possible and easy." "Communism is frankly imperialistic with the world as the limit."

The author tells how, "in September, 1928, the effectiveness of air and gas defensive measures was tested in a manœuvre at Kiel, a Ukrainian city of some 525,000 inhabitants." "Business activities were practically suspended during the manœuvres, and the entire civilian population co-operated enthusiastically with the military authorities." "The armed forces include 250,000 secret police (O.G.P.U.), 600,000 regulars on active duty, 500,000 men in the regular army reserve and 800,000 in organizations which correspond to our National Guard Reserve Units," *i.e.*, Territorial Army, while the available man-power is given as about 15 millions. Russian military aeroplanes are said to be under production with gas-proof hulls and oxygen containers for purifying the air in the fighting compartments, together with devices for emitting lethal gas and toxic smoke. "Directions have been issued for the formation of independent mechanized units and for large numbers of tank regiments, and regulations for their training have been published."

The writer on "The Organization and Employment of British A.A. Artillery," comes to the conclusion that, "in technical development we are probably far ahead of Great Britain, in tactical principles we are on a parity, but in the conception and execution of a combined defence they are probably ahead of us, due to the experience gained in the annual combined manœuvres." He had drawn attention to the fact that the British A.A. defence units have twice as many A.A. guns, and eight times as many searchlights, as the corresponding United States units.

Another writer relates a dozen instances of "Panics," which beset troops during war, with a view to familiarizing the younger generation of military men, who are as yet without war experience, with the nature and substance of panics, the circumstances that gave rise to them, and the means taken to suppress them. Measures for quelling panics should be taught to every officer. Panic seems much more liable to overcome bodies of men at the beginning of a war, and only seems to occur very rarely when they have become inured to its conditions. Most of the examples occurred in August, 1914. Also, the mass suggestion of utter fear will often corrupt a body of men when the same conditions would fail to overcome the unweakened discipline and high instincts of a single man. One of the most powerful prophylactics is tradition.

There are also two articles in a very condensed diary form of the "Atalanta Campaign," and "The Cavalry in the Atalanta Campaign."

In the July number there is an article on the "Mobility of the New 3-in. Gun, A.A.," with its recently issued trailer mounting (M.I.). A motorized Coast Artillery (A.A.) regiment of the U.S. Army, marched from their permanent station at Fort Totton, New York (near Brooklyn, N.Y.), to the practice camp at Fort Storey, Virginia (near Cape Henry, Va.), for its annual target practice, including fire against gliders, in conjunction with the U.S. Air Corps.

The regiment consisted of :—

Headquarters and band.
Headquarter's battery.
Service battery.
1st Battalion : Headquarter's detachment and combat train.
Battery A. (searchlights).
Battery B. (four 3-in. A.A. guns on trailer mounts, M.I., 1918).
Battery C. (four 3-in. A.A. guns on trailer mounts, M.I., new model).
2nd Battalion : Battery E. (machine guns).
Battery F. (machine guns).

The convoy of the 1st Batt., which is given in detail, consisted of eight 3-in. A.A. guns and 76 other mechanized vehicles. The 520 miles was covered in 10 days, at an average speed of 52 miles in a day of slightly less than 11 hours, showing an average rate of 4.8 miles an hour, including the 10 minutes' stop every hour. Three-ton F.W.D. lorries were used as tractors for the guns, and other trailed loads : they were fitted with solid tyres and 36 H.P. engines ; most of them were old. In some cases they could not pull the guns up short steep grades. The new 3-in. A.A. gun trailer was fitted with 40 in. x 9 in. balloon tyres, inflated to 55 lb. per sq. in. The gun is equipped with a removable liner : m.v. 2,600 f.s., giving a vertical range of 10,000 yd., and a horizontal range of 15,000 yd. : rate of fire up to 25 rounds per min.

With the new mounting the trailer can be drawn at 25 m.p.h., without undue strain, sway or vibration, and over good roads at 40 m.p.h. One 5-ton caterpillar was supplied to each battery to take the A.A. gun mountings into action over bad country or to assist ditched vehicles. The author of the article thinks that the greater part of the trouble met on the road was caused by the poor quality of the type of enlisted personnel (*i.e.*, the private soldier) now being recruited.

On one day of the march, 10 of the F.W.D. lorries were towed into camp at the end of the day. On the last day of the march, one F.W.D. lorry had to pull into camp, besides its own 3-in. gun, a travelling kitchen, and another disabled F.W.D. lorry. During the march a number of the lorries had to be left behind at an arsenal, and other efficient lorries borrowed to replace them. A maintenance section had to be organized to march at the tail of the convoy to patch up and bring on the lame ducks. During the manœuvres of the Experimental Mechanized Force of the U.S. Army, in the summer of 1928, single daily marches of similar units covered 70 or 80 miles on several occasions.

Another writer on " The Development of Heavy Artillery during the World War," states that the years 1914–15 were the years of the howitzer and the mortar. Howitzers had a tendency to increase in weight for destructive and counter-battery fire. Trench warfare in 1916 saw the development of more powerful howitzers, long-range and Q.F. guns firing by the map, sound-ranging and gas shelling. Heavy naval guns were put on railway mountings and long-range destructive fire increased. In 1918, a revulsion was caused because all these heavy-weights were

unsuitable for fluid warfare, but the writer fails to draw any conclusion as to the future from a well-begun essay.

The series of articles on "Colonial Coast Forts," is continued, with a description of the Hawaiian Islands, which form one of the keys of the Pacific. They appear to have been discovered by some shipwrecked Spaniards as early as 1527, but Juan Gaetano, in particular, is credited with having located them in 1555. Spanish buccaneers made use of them in the seventeenth century till they were sighted and definitely re-discovered by Capt. Cook, on January 18th, 1778. At that time, the four principal islands, Hawaii, Mani, Oahu and Tanai, constituted four separate and independent kingdoms. Later on, Kamehameha I., Prince of Hawaii, rose to power and had made himself master of them all by 1810, with the assistance of two white men, named John Young and Isaac Davis, who had been captured from the vessels of an American fur trader, in 1790.

In 1815, the Russians attempted to establish a trading settlement in Hawaii and built some forts. Kamehameha soon realized the value of permanent fortifications and built a strong fort at Honolulu, under the supervision of John Young. It was completed in 1816. It was square in trace, with sides of over a hundred yards in length, while the walls were 12 ft. high and 20 ft. thick. At first it mounted forty pieces of different sizes, varying from 6-pr. to 12-pr., but later eight 32-pr. were added. The site is commemorated to this day by the name, Fort Street. Another defensive post with guns at Punchbowl Hill completed the security of Honolulu. In 1849, the fort is reported to have mounted 70 guns, but this number on a 400–500 yd. perimeter seems excessive. It was during this year that the French dismantled it, owing to an unfortunate misunderstanding, and in 1853, it became a prison. In 1894, Hawaii deposed its Queen and became a republic, only to be annexed by the United States in 1897.

The island of Guam was discovered in 1521, by Magalhaes, during his historic voyage of discovery round the world. In 1565, it was taken possession by Lopez de Legaspi, in the name of King Philip II. of Spain, and the first settlement was effected three years later, the garrison consisting of a captain, a priest, and 32 men. The natives soon rose in revolt, till in 1674, Don Damian de Esplana arrived as Military Governor, with an increase of garrison. It took them 21 years to complete the conquest of the island.

The Spaniards built a number of forts along the shore to protect the island from enemies and buccaneers. Umata Bay was strongly fortified with four forts. By 1817, Port San Luis d'Apra was also heavily defended. In 1898, the U.S.S. *Charleston* had been ordered to take possession of Guam. The Americans entered Port San Luis, and opened fire, but found that all the forts had been abandoned and allowed to fall into disrepair some years previously. The Spanish Governor had not been informed of the outbreak of war and thought that he was being given a salute from a friendly vessel, till the boarding officer from the *Charleston* arrived to take possession. The island was surrendered to the United States and formally annexed in 1899.

The August number contains further information as to the new 3-in. A.A. gun. The writer tells us that a battery firing at maximum rate, imparts 80,000 foot-tons of energy to its projectiles, or more than half as

much again per minute as a 12-in. mortar battery firing two salvoes at a battleship every 45 seconds. The gun fires from a star-shaped platform, with four spider legs to give it stability: these legs are folded up and carried on the trailer with the gun when on the march. The stereoscopic height-finder, on the Barr and Stroud principle, has an optical base of 4 metres: the scale readings of altitude are transmitted electrically to the director. The data, as computed, are continuously indicated on dials on the guns, which can thus be kept continuously and correctly laid. The fuze-setter is also of the continuous type, which keeps on changing the setting for the fuze to correspond with the ever-changing data, until the round is removed.

The searchlight at present in use consists of a 150 amp. arc-light, enclosed in an aluminium drum, and backed by a 60-in. parabolic mirror. It has 360 deg. traverse and 90 deg. elevation. It is fitted with ventilating motor and fan, thermostatic carbon control with a manually-operated occulter.

The sound-locator is carried on a low, 4-wheeled travelling platform, and consists of 4 trumpets of square section, with seats for the listeners.

Another article on the same subject gives a slightly different class of information.

The story of the successful Confederate attack on Fort Sumter, on 12th April, 1861, is told. How it was held by Major Robert Anderson, of the Federal Artillery, with about 60 men. There were other forts dotted about Charleston Harbour, but when the South seceded, Forts Moultrie, Johnson, Castle Pinkney and Morris Island, had to be abandoned, because of the impossibility of holding them with such attenuated numbers. They were practically trapped, though war was not yet declared.

Early in January, 1861, a ship, with troops and stores, tried to steal through in the dark, but was spotted, and an alert Confederate gunner fired the first shot of the American Civil War, to turn her back. In April, Anderson was forbidden to purchase any more food in Charleston, and the investment began. At 4 p.m., on the 11th April, the Confederate general demanded surrender, and upon refusal by the garrison, he gave notice that he would open fire on the following day. Consequently, at 4.30 a.m., the South opened fire, and at 7 a.m., the North replied from the fort.

At 3 p.m., three Federal ships appeared off the harbour with help for the beleaguered garrison: it had been arranged that they should run in under the heavy covering fire of the Federal man-of-war *Powhattan*. Unfortunately, someone had blundered, and the *Powhattan* had already been ordered to, and had started for, another destination. So, with empty magazine and depleted larder, with the interior of the fort a roaring furnace, Fort Sumter surrendered at 7 p.m., on the 15th April; the commander accepted the easy terms offered by his chivalrous enemy and prepared to embark with his men on some Union vessels in the harbour and sail away to the North. For the last time, "the flag of the Union is hoisted and a salute fired in its honour. During the firing of the salute some of the loose powder explodes, killing one Union soldier and wounding several others. Thus, in a ceremonial after the battle, is killed the first soldier of the great war."

So, apparently, there were no casualties during the siege.

A lieutenant in the First Gas Regiment of the U.S. Army has contributed a short article dealing with protective clothing, of which he says that, " the latest type is very light and comfortable and offers very complete protection against blistering liquids." No details, however, are given.

The September number contains an article on " Mine Defence—To-day and To-morrow," bewailing the low status into which submarine mining in the U.S. Army has been relegated. He also describes an economy in submarine firing control by means of a synchronized pair of revolving selectors, which can give control over twenty mines through one cable, thus obviating the necessity of having twenty lines. A revolving contact arm inside each mechanism provides a means of obtaining a clear line to any one mine when required.

Another article also laments the fate of the submarine mining officer of to-day, who cannot get away from that branch of the Coast Artillery to widen his knowledge of gunnery, because there are so few officers qualified in mine defence work.

The new Christie model of tank is described as having the best heavy chassis in the world up to date, for transportation needs of all kinds. " Christie has given us, in his new machine, more technical progress than Great Britain has secured during the past ten years, for the expenditure of some sixty million dollars. However, in technical methods and practical experience with fast fighting-machines, the British Army is far ahead of us."

The author does not seem to give credit for all the costly and hard-won information used by Christie, but gained by us.

D.M.F.H.

THE BUILDER.

In the issue of September 13th, 1929, a description is given of the cork tile flooring, made by the Cork Insulation Co., Ltd., of 14, West Smithfield, London, E.C.1. It is described as hard-wearing, warm, noiseless and non-slippery. It is manufactured of ground cork, compressed and baked in moulds. It has been seen by the writer, and is of a pleasing brown colour in three shades. The tiles are made in two thicknesses, 9/16ths inch and 3/8ths inch, and in varying sizes from 6 in. by 6 in. to 12 in. by 36 in. The price for a minimum of 25 sq. yd. in the London district, supplied, laid and polished complete, is 17s. 6d. a sq. yd. for the thicker, and 15s. a sq. yd. for the thinner variety.

D.M.F.H.

MILITÄRWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*January–February*, 1929.)—*The Campaign against Roumania*, 1916. The report of a lecture, delivered by Lt.-Col. Kissling, before the Military Scientific Society of Vienna. The lecturer quotes amongst his references the works of Averescu, Conrad von Hoetzendorf, Falkenhayn, Hindenburg and Ludendorff, in addition to which, as an official at the Austrian War Archives, he has easy access to the war diaries of all formations. He recommends the Campaign as containing, perhaps more than any

other in the Great War, a very great deal of interest, because in it appear in a comparatively short time: fighting retirement, offensive in open country, mountain warfare, wide-sweeping use of cavalry, the capture of a fortress by *coup de main*, river crossings on the largest scale, the use of river monitors, etc. He also claims that the campaign shows how, on one side by unity of command, all obstacles were successfully surmounted, while the difficulties of carrying on coalition warfare brought the other side to destruction. Lt.-Col. Kissling's method of dealing with his subject is instructive. After setting the scene by a short exposition of international relations, before and since the Treaty of Bucharest, and by discussing the war plans on both sides, he runs over the chief events of the campaign, their origin and their effect on both parties, the considerations weighed by the commanders and what led to their decisions.

The first instalment takes us as far as the clearing of Siebenbürgen by the Germans and Austrians, while on the other wing, the Roumanians and Russians had just brought the Bulgarian advance in the Dobrudja to a standstill.—(*To be continued.*)

Guerilla Warfare and the Means taken to Combat it in the Occupation of Serbia. This article is composite; the first half, by Maj.-Gen. Kerchnaue, dealing with the organization of the Austrian Government forces in the occupied territory, and with the course of the operations which took place there; while the second half is by Capt. Maulik, and rehearses the various characteristic methods of dealing with guerilla warfare. The editor thinks it necessary, in the face of more serious and more likely forms of warfare, to start with a short apology for introducing to his readers anything so comparatively unimportant as guerilla warfare, an apology which would not have been necessary in introducing the subject to British officers, or, indeed, to officers of any power, holding possessions in Africa or in Asia. The value of success in combating guerilla warfare was in any case abundantly proved in Serbia, since it permitted a material exploitation of the occupied territory which, according to the Q.M.G. at Austrian G.H.Q., was of decisive importance for the further prosecution of the war in other theatres. The Austrians took the wise step of supplementing, by means of enlistment among the natives, the 70,000 second-line troops and Gendarmerie, which were all that they could spare to form the Army of Occupation. Such enlistment was restricted to the Mohammedan population, which could be relied upon to regard the Austrian occupation as a release from the hated Serbian rule.

In a few months this measure provided 30,000 irregulars, knowing the country and already trained in guerilla warfare, of which Serbia furnishes, as it were, the classic example.

Apart from the services rendered in rounding up bandits, the formation of this force of natives enabled 18,000 of the garrison to be released for the field. Photographs show some very useful types, Turks and Albanians, including mounted scouts. Exception only must be taken to the *white* Albanian fez. It is hoped for the wearer's sake that it is less conspicuous on a hillside than it is on a photograph.—(*To be continued.*)

Armoured Trains, by Capt. Wagner. The author looks upon an

armoured train as a battery capable of escaping danger by its superior power of manœuvre, and, by reason of its armour and its many machine-guns, capable of taking part in the foremost lines of infantry action.

Different make-ups of A.T. are shown by sketches, the fighting wagons varying from three gun wagons with one gun and one heavy m.g. (two ports) each, and one wagon for O.C. and ammunition, with three to four heavy m.g's., to a train containing as fighting wagons only one gun wagon, one O.C.'s and ammunition wagon and one m.g. wagon. All guns fire from movable cupolas, and all m.g's. through ports, except that an m.g. turret is provided in the O.C's. truck.

The Russians, from 1918 on, distinguished two kinds of armoured trains. Light A.T.s carried guns up to 3 in., were heavily armoured, and worked mostly in line with, and often in front of, the infantry. Heavy A.T.s carried guns from 3 in. to 8 in., were less heavily armoured, and were generally brought into action among the light position artillery. For tactical purposes an armoured train division was often built up, consisting of two light A.T.s, one heavy A.T. and one breakdown train, which was also a work train for larger permanent way repairs.

Steel armour on these trains was often replaced by concrete, up to 6 in. thick, with great success.

The author then gives us, from his own experience, detailed account of A.T. action in the neighbourhood of Libau in June, 1919, when the Germans were fighting the Esthonians. The descriptions become thrilling, especially when train fights train. One fight lasted exactly one minute! In another, which lasted seven minutes, the author's train received seven direct hits. It comes, then, as a relief to read, "The next day we spent in repairs."

In this short report, we see the armoured train most variously occupied, in close fighting, in long-range fighting, as ammunition transport, as wounded transport, as breakdown gang, as scout, as rearguard, in attack, and finally doing police work amongst civilians storming the railway stations. An excellent testimonial closes the account, "In whatever capacity the armoured train appeared, it was always joyfully welcomed by the other arms."

The New Musketry Regulations, by Maj.-Gen. Büttner, Inspector of Infantry. These have appeared recently in three parts: (1) General Theory of Projectiles, and Aids to Shooting; (2) Instructions for the Use of Rifle, Light Machine-Gun and Pistol; (3) Instructions for the Use of Heavy Machine-Gun.

The issue of these regulations marks the transition from the m.g. as auxiliary of the rifle, and as weapon of occasion to the m.g. as the chief bearer of the infantry fire fight.

Signals in Mountain Warfare, by Major Werner. This is no exhaustive treatise on the subject, but a good example of a thoroughly practical article. The writer draws upon his experiences as a signal officer in war during winter in the mountains. Heights above sea-level were from 4,500 to 7,500 feet, so that it was necessary to defeat depths of snow up to 20 feet, in addition to snowstorms and avalanches.

A cable line for the winter is best laid on the surface of the ground, as soon as the latter is frozen. The cable must carefully follow every inequality of the surface. Every quarter-mile or so, a 30-ft. loop is

twined round a six-foot pole. After every heavy fall of snow the linemen lift the poles, and stick them into the fresh snow.

Fresh routes required during the winter are buried in the snow, preferably in the bottom layers where movement by side-slipping is less likely. Ordinary field cable will remain good for months like this.

Armoured cable is used if available, but it is not avalanche-proof.

Major Werner then gives us two successful examples of the use of lamp-signalling, drawn from the 11th and 12th Isonzo battles. The Commander of the 7th Austrian Mountain Brigade was a great believer in lamp-signalling, a statement for which one is not unprepared, since a brigadier who demands visual communication is likely to bear its necessities in mind when choosing headquarters, and is certain to get back in good service what he has expended in interest.

The two examples show lamp-signalling rendering invaluable services in a defensive battle, and in a victorious advance. In the latter case, it was able to carry out both quickly and safely what line communication could at best do slowly and precariously.

The author concludes: "This does not imply that lamp-signalling alone can be the mainstay of communication; but rather that, properly applied and served, it is able to bridge over a break in communication of some duration. It is a very valuable auxiliary to telephonic communication, and can often replace it. Especially in mountainous country it reaches its highest value. In pursuit of the enemy it is a quickly movable means which can always accompany the pursuing troops."

All this may be heartily endorsed, the words "properly applied and served," being understood to exclude any attempt, as sometimes made, to extemporize a visual service, as, indeed, excluded by the German and Austrian Armies, which, realizing that visual signalling to be effective must be in constant use, keep their lamp-signallers apart.

The Development of Artillery Material since 1914. In honour of the tenth anniversary of the end of the War, Major Heigl made a slight diversion in his series of articles, by devoting the last instalment entirely to the most powerful weapon used against the Austrians, the Italian 30·5-cm. howitzer. He now returns to the other heavy siege howitzers. Of these in general, he says that the kind and quality of most guns can only be of importance for the issue of a campaign in their totality; but to this rule, the siege howitzer is an exception. The fate of a campaign can depend upon it, upon its performance and mobility. Without the timely fall of Port Arthur, there would have been no decisive battle of Mukden: without the speedy fall of the Belgian fortresses, the long, devastating War would have taken place, not in France, but in those frontier provinces of Germany, which were so important for war industries.

From this peculiarity of the heaviest howitzers arises the necessity for strict secrecy; and there were few who knew that 28-cm., regarded before 1914 as the largest calibre for land warfare, had been far surpassed by both Germany and Austria.

The 28-cm. howitzer of the Spezia type, was built by Krupp's for Italy, in 1879. The Japanese bought a number of these for coast defence from the Italians, and 18 of them took part in the bombardment of

Port Arthur, where they contributed to the surrender, both indirectly, by piercing the concrete, and directly, by killing General Kondrachenko, "the soul of the defence." Ten years later, in 1915, the Russians, being very short of *matériel*, owing to their losses in retirement, bought these howitzers from Japan, and used them against the Austrians. During the offensives of 1916–17, in Tyrol, very many of these Italian howitzers were captured by the Austrians, both in their original design, and with a lengthened barrel. A photograph shows the latter type.

In the matter of the heaviest howitzers, Germany led the way by building, in 1907–09, in the strictest secrecy, their 42-cm. howitzer, later to become famous. It was a master performance of the celebrated gun-designer, Prof. Rausenberger, has all the appearance of being intended for coast defence, but was, as we now know, meant from the first for siege purposes. For secrecy, it was known as "The short Naval Gun," and by other code names. Some idea of its size is given by stating that the pit alone was 12 yards long, and the muzzle at maximum elevation of 65 degrees, was 26 feet above the ground. A photograph is given. In 1914, there was much puzzling over this monster, and one English artist drew it on a railway mounting, a picture which must have been on the other side of the line "a source of innocent merriment."

The Austro-Hungarian 30·5-cm. howitzer is also shown by a photograph, in position on the Russian front. It comes in the same category as the 42-cm., as a secret siege howitzer, and contributed likewise to the precipitate fall of the Belgian fortresses. It is transported in three units, drawn by one 100 h.p. tractor. The remaining howitzers described with photographs or drawings are :—

The Austrian 24-cm., dating from 1900, and copied by the British at the time of the Boer War as our 9·45-in. howitzer.

The French 280-mm. M14 Schneider of 1909 ; and the French 370-mm. Filloux, which designed apparently in the 'nineties, was still only on paper when the War broke out.—(*To be continued.*)

The International Situation, by Col. Paschek. This is a sturdy attempt to run briefly, country by country, through those events of the year (1928), which have a bearing on international relations or politics, and thus to arrive at a summing-up of each country's position and tendencies. The notes are well thought out, objectively written, and make entertaining reading.

The Official Austrian History of the War, by Maj.-Gen. Kerchnaue. Thanks to the initiative of the War Archives Directorate, and to the publishers of *M.M.*, the greatest obstacles have been overcome, and the "General Staff History," as it is popularly called, has started to appear.

It is planned in five to six volumes of six parts each, appearing one volume every year, starting with 1929. Price of Vol. I, 40 Austrian schillings = £1 5s., or bound in half linen, £1 8s. ; to be obtained from the publishers of *M.Mitteilungen*, Vienna I, Stubenring 1.

On the same scale as previous histories issued by the War Archives —*e.g.*, the Campaign of 1809, which lasted six weeks, four large volumes ; and the Campaign of 1866, which lasted five weeks, five volumes—this history would have comprised 175 to 180 large volumes. Gratitude should mingle with congratulations.

(*March-April* 1929.)—*The Campaign in Italy in* 1849, by Col. Baron Wolf-Schneider. The Campaign is used as a good introduction to a panegyric on the great Field-Marshal Radetzky, the victor at Custozza. The author does not hesitate to mention him in the same breath as Frederick the Great and Napoleon; and Radetzky certainly seems to have possessed all the qualities of leadership, from that of inspiring confidence and admiration bordering upon worship, through iron resolution, to the faculty of selecting the right man for the job, and then giving him the chance to develop to the fulness of his powers.

Guerilla Warfare and the Means taken to Combat it in the Occupation of Serbia (*continued*). Maj.-Gen. Kerchnaue finishes off his share of this article. Incidentally, he gives us an example of how it should not be done, which might serve as a theme for the talented author of *Duffers Drift*.

Four coys. of irregulars with half a squadron and one battery of 9-cm. were occupying village B, to protect it from the rebels. Three more coys. with three m.g. sections, were sent as a reinforcement, and the whole force ordered to advance to village P, to relieve pressure on allies. Because a party of his dragoons had been ambushed and cut up in a defile in his rear, and because he had received exaggerated reports of the rebels' strength, the O.C. Force disobeyed this order. (*Note.*—The actual strength of rebels transpired later to have been two parties of 15 men each.) Instead, he sent out a reconnoitring party, which came under long-range fire (2,000 paces and more) and remained in action all day, firing in three directions, until it ran out of ammunition. A company which was sent out in support of it, did the same. Total casualties *nil*, ammunition all *gone*.

This brisk fusillade made none the less a great impression on both sides. 1,500 rebels (half with rifles and half with hand-grenades) were brought up, surrounded B, and attacked it at night, but were driven off by m.g. fire. Losses on both sides "considerable." Both sides considered themselves defeated. The rebels fled in disorder, while the irregulars evacuated the village and retired in the other direction.

Gen. Kerchnaue calls the foregoing a classical example of how unsuitable untrained troops, under inexperienced leaders, are for dealing with guerilla warfare.

It is that and more; for, considered from both sides, it shows that for war, guerilla or otherwise, one needs people trained and people disciplined, in fact, soldiers.

The remainder of the article is by Capt. Maulik, and embodies his experiences fighting and trying to outwit rebel bands for fourteen months. The difficulties caused by the civil population supporting the rebels; the impossibility of enlisting an intelligence service; the hiding of weapons at the critical moment, and playing the peaceful peasant; all these features, well known to British officers from S. Africa, Burma, the N.W. Frontier, and from Ireland, appear.

The methods tried and their results are:—

1. Encircling and driving. These elaborately-organized "combings" had no success. At the end the net was always empty, owing to various reasons, such as, insufficient search of the country

lying between paths and routes; the troops drawing together for rations and rest, etc.

2. Driving by patrols against a line of pickets. This system was also a failure. The drives took much time to arrange; and the quarry was often away before they started. Also the patrols did not keep direction well, and both the line of pickets and the closing line of patrols were passable.
3. Occupation by small detachments, 10 to 12 men, of the rebels' re-victualling points. This system did not succeed up to expectations. The villages were very hard to control, being both wide-spreading and containing much cover, such as maize-fields. The villagers also had their own warning posts, often using children for the purpose. Also, all possible villages could not be thus occupied by troops, and the rebels quickly changed to those which were not occupied. A bad feature was that discipline amongst the troops soon suffered through lack of control.
4. Ambushes. This was the best system tried so far. The chief difficulty was the unnoticed occupation of the ambush. Also the long waits, perhaps weeks waiting for a catch, were bad for discipline.
5. Counter-guerilla bands. A band of 15 to 50 men was formed under a very specially selected leader, for the sole purpose of chasing down a particular rebel band. They had nothing else to do or think about. This was the best system of all, and in one district alone, during the summer of 1918, four large rebel bands, each under a well-known leader, were chased down and wiped out.

Two Light Machine-Guns, by Capt. Däniker, Swiss Army. The light machine-guns here described are the French *Fusil mitrailleur* 24, and the Italian *Mitragliatrice leggera Fiat*, 1926 pattern; and they have been chosen as representing different directions of development of the light m.g. of the future.

On the appearance of the light m.g., firing rifle ammunition, certain difficulties arose from the lightness of the weapon, which had to fire a powerful cartridge at a great rate. Also, it appeared that the rifle cartridge for this weapon, which was only intended for short-range use, gave a certain excess of performance.

From these two considerations arose two possibilities of development. The first was, should not the light m.g. with its carriage, be built somewhat heavier, so as to utilize the good ballistic properties of the bullet at longer range? The affirmative answer to this question led to the construction of light carriages for light m.g's., as in the Hotchkiss, Madsen, KE7, and the Czecho-Slovakian ZB26. This is the road to the medium-heavy machine-gun, as is shown even more clearly than in the models mentioned by certain Italian types, the Breda (*vide R.E. Journal*, March, 1929), the Fiat light m.g., 1924, and the 1926 pattern of the latter, one of the subjects of the article. These three last-mentioned are really medium-heavy m.g's., and, as they will no longer be able to fulfil all the requirements of a light m.g., sooner or later there will be a demand for a type intermediate between them and the rifle.

The other possibility was to build the weapon for a lighter bullet. This light bullet with high muzzle velocity gives a very flat trajectory for short ranges. It is no disadvantage that, as the German S-bullet shows, the flight becomes unreliable at long ranges, because the light m.g. will not be used at long-range.

But, since in the infantry coy. there must be only one kind of ammunition, rifles and automatic rifles must follow suit. This is all to the good, since they also are short-range weapons. Further, the automatic rifle will gain in lightness and handiness.

A necessary consequence will be a separation of ammunition between the automatic rifle and light m.g., on the one side, and the heavy m.g., on the other, since the heavy m.g. must keep its heavy bullet. Disadvantageous as this separation is, it was bound to come somewhere, and is better here than between automatic rifle and light m.g. It also makes possible the granting of certain other demands which are always cropping up, *e.g.*, a still heavier bullet for the heavy m.g.; and a larger calibre, possibly to the extent of making it an anti-aircraft weapon.

The French with the *Fusil mitrailleur* 24 have adopted the second method. They have reduced the weight of the bullet to 9 grammes, and the calibre to 7·5 mm.

There appears little doubt in Capt. Däniker's mind that the French answer is the correct one (*cf.* his views in *R.E. Journal*, March, 1929).

Anti-Aircraft Defence. Under this heading follow certain articles which really belong to the encyclopædia on aerial warfare, published last year by *M. Mitteilungen*, under the title of *Luftflotten* (reviewed in *R.E. Journal*, March, 1929), but which were crowded out. They are:—

"A.A. Guns and Machine-Guns," by Lt.-Col. Milhard, Czecho-Slovakian G.S.

"Range-Finders," by Capt. Maurer. (Shows clearly why the monocular invert is better than the stereoscopic.)

"Position-Finders working by Sound," by Capt. Schubert. (Shows how the Goerz direction-hearer, which is monotic, is superior to all the diotic instruments, the *Télésimètre* Perrin, the German *Doppelrichtungshörer*, and the American exponential hearer.)

"Shooting at Aircraft," by Maj.-Gen. Scheiner. (Worked out graphically and mathematically, (*a*) for machine-guns, (*b*) for artillery.)

"Kite Balloons for Night Defence," by Lt.-Col. Hirsch.

A New A.A. Gun by Bofors. The well-known Swedish gun firm of Bofors has brought out since the War a number of A.A. guns up to 10·5-cm. calibre, some on lorries and some on what the firm calls the field air-defence carriage. The principle is not new, having been introduced towards the end of the War by Skoda for the Austrian Army, and by Krupp for the German Army, without, however, reaching the front.

The mounting of the new 7·65-cm. field Anti-Aircraft defence gun Bofors consists of a central pivot on four arms, which lie flat on the ground, in the shape of a cross. The object of the arrangement is to afford 360 degrees field of traverse, and greater elevation, in this case 85 degrees.

Three of the arms have ends which can be adjusted to uneven ground. For transport, the arms are detachable, and are slung under the axle of the same pair of wheels as carries the gun and pivot.

F.A.I.

HEERESTECHNIK.

(*January*, 1929.)—*Instructions for the Administration of Regimental Stores and Equipment.* Can only be read in conjunction with the Regulations on the subject, H.Dv 488, which it elucidates.

The Recent Italian Publication on External Ballistics. (*Balistina esterna*, by Lt.-Gen. Cavalli, Professor at the School of Application for Artillery and Engineers.) This textbook of external ballistics claims our notice through the wealth of its material, and the clearness of its exposition. Gen. Cavalli, as a pupil of the celebrated Italian ballistician, F. Siacci, who died in 1907, devoted himself to the task of carrying on and perfecting Siacci's methods. The book is dedicated to Siacci's memory. The letterpress is much lightened by numerous completely-worked, practical examples.

The contents of the chapters are then given *seriatim*. In Chapter VI are defined Siacci's four primary functions and four secondary functions, with the geometrical signification of the latter for any point on the trajectory.

The German Railway Guns in the Great War on the Land and Coast Fronts. The initial successes of the heavy artillery, which surpassed all expectations, led to the extension of this arm, and in especial to the introduction of the long barrel, so as to obtain low-angle fire of the heaviest sort. The task of making land guns out of naval guns, which could be spared, fell upon the navy, which was called upon at the same time to find the necessary ordnance for fortifying the coast of Flanders, and for strengthening the coast defences of Germany.

The first guns which could be made available were 16-in. reserve guns. To these were added from the scrapping of the battleships of the old *Kaiser* class a large number of 9·6-in., then, after the loss of the *Prinz Adalbert* and *Blücher* and the *Scharnhorst* class, a number of reserve 8·4-in. guns of these ships. After the scrapping of the battleships of the *Brunswick* class, following the Skagerrak battle, 11·2-in. guns became available. Also should be mentioned a 14·2-in., which had been used before the War for trials at Krupp's, six 11·2-in. of the *Brandenburg* class, and four 9·6-in. from the old *Oldenburg*.

All these guns were placed on mountings which had been erected, by means of powerful cranes, upon concrete beds; such mountings consisting principally of a built-up framework supporting the trunnions. The placing of a heavy gun thus on a concrete bed took eight weeks, exclusive of the provision of bomb-proof shelters, ammunition chambers, travellers, etc. Besides this loss of time, there was also the loss of material when a gun's position was changed. A new method had, therefore, to be found, and for land-front guns, the concrete bed was replaced by an iron bed, capable of being dismantled and re-assembled. This reduced the time from starting work to the firing of the first round to 35 days, for the heaviest guns.

The change from concrete to iron beds introduced, however, a fresh trouble. The lack of cranes was soon felt. The number of heavy guns to be mounted was increasing, and the cranes were necessary at each gun position for a longer time.

Twelve cranes were, therefore, built for guns up to 11·2-in. They could lift up to 60 tons, and did not take more than three hours to erect or dismantle. For the 15·2-in., there were three cranes, lifting up to 150 tons, which were lent by a firm from stock for the duration of the War.

Although iron beds, capable of removal, and quickly erected cranes both improved matters, affairs on the Western Front made a greater mobility of the heaviest ordnance necessary. A sufficient number of cranes could not be built to achieve this. Hence arose the idea of building mountings enabling guns to fire from the railway trucks used for their transport. Amongst the rolling-stock were found four 80-ton trucks, which had been built for carrying guns. Four mountings were ordered for these trucks, and in the autumn of 1916, the first trial was successfully carried out. The gun ran back on the rails 350 metres on discharge, although the wheel brakes were on. During the passage back, the gun recoiled and ran forward.

As only four of these 80-ton wagons were available, other means had to be created. Mountings were designed with longer frames, to be carried on bogies. On arrival, the mounting was off-loaded, the bogies being for transport only. Trials were satisfactory.

Two types were thus arrived at, the E or railway mounting, for guns firing only from the railway, and the B mounting, for guns firing only from a concrete or iron bed off the rails.

The next step was to combine these two ; and finally, all heavy naval guns, converted to land purposes, had an E and B mounting, so that they could fire either from the railway or from the bed.

These E and B mountings were built up to the 15·2-in. A photograph shows this beautiful bit of engineering.

(*February*, 1929.)—*Instructions for the Administration of Regimental Stores and Equipment* (*concluded*). Discusses the alterations which are about to appear in a new edition of Army Regulations (H.Dv) 488, Part 4, Signal Equipment. The endeavour which has been dominant in the revising of these Regulations is given as " to fulfil the known wishes of the troops and to lighten as far as possible their work of administration."

The Manufacture of Army Saddles. From the cutting of the hide into fifty-five shaped pieces, Major Giesecke, with the aid of over thirty photographs, takes us through all the processes to the finished article. He leads with emphasis to his point, that a saddle being destined for wear by a living being, and having its most important part, the saddle-tree, made of wood, and thus subject both in preparation and in the course of time to change, can never be turned out as, for example, a fuse is turned out. Even when the saddle is drawn from ordnance in fourteen sizes, the regimental master-saddler must have the last word.

The Recent Italian Publication on External Ballistics. Professor Cranz, himself one of the world's greatest authorities on ballistics, finishes his review of Gen. Cavalli's book. He finds that the later German measurements of air resistance (1912), also the German methods of successive

approximations, especially the procedure of isoclines, are not mentioned at all, and can only attribute these omissions to the author's belief that no essential progress has been made since 1907.

He considers it would be instructive to test by means of several numerical examples, whether trajectories reaching great heights can be both quicker and more accurately calculated by Siacci's methods, or by the methods of Veithen-Kutta, Wiener, etc., or by the recently published (1924 and 1927) methods of von Eberhard.

The German Railway Guns in the Great War on the Land and Coast Fronts (*continued*). Part II of this article consists principally of photographs and diagrams illustrating Part I. They are :—

The first mounting and bed prepared by the navy for a heavy gun in land warfare, the 15·2-in., at Loison, near Verdun.
Mounting for Krupp's experimental gun, 14·2-in. ; made also to take 15·2-in. ; used at Quéant, Sancourt and Santes.
Heavy mounting, showing early elevating and traversing arrangements.
Heavy mounting, with electrical elevating and traversing ; also 160-ton gantry.
Mounting of 8·4-in. gun on a removable iron bed.
40- and 60-ton hydraulic cranes placing a 15·2-in. gun on its cradle.
The first German purely railway gun, 9·6-in., on an 80-ton truck.
An 11·2-in. gun on E and B mounting (*vide* Part I), about to be deposited on a removable iron (or concrete) bed.
The same deposited.
The same ready to fire.
An 8·4-in. gun on E and B mounting on rails.
A 15·2-in. gun on E and B mounting, carried on 16 axles, 4 bogies.
A French mounting for 9·6-in. guns, or 11·7-in. howitzers, much used in the War, carried separately from the gun on broad, or narrow-gauge railways, or on the road, and capable of rapid assembly.
A railway mounting, built by Schneider, for 11-in. to 12·8-in. guns without barrel recoil.—(*To be concluded.*)

My Commands in the Great War, by Max von Gallwitz. General von Gallwitz's case is interesting as being much of a parallel with that of the late Lord Horne. As Inspector of Field Artillery, he could never have foreseen that he would rise above all the corps commanders, and all the army commanders, to become what was generally reserved for princes, the Commander of a Group of Armies.

What seems to have contributed very much to his success was that he was only occupied for short periods in position warfare, and that in the capture of Namur, the breaking through the Russian Front on the Narew, the passage of the Danube and in Serbia, fortune was continually presenting him with opportunities of distinction in mobile warfare.

(*March*, 1929.)—*Recent Ideas of the Importance of Meteorology for the Fighting Services*, by Dr. Kölzer. This is a fairly full report of a lecture by Commander Garbett, delivered at the R.U.S. Institution, in February, 1928. It even goes so far as to give a *résumé* of the discussion which

followed the lecture. The author considers the whole instructive in more than one respect, as evidence of a greatly increased interest in meteorology in the navy, army and air force, in England since the War, and of the later development of the meteorological service. Both of these facts point to a complete change of opinion as regards the importance of meteorology, as compared with opinion before, and even to some extent since the War. It is obvious that they must lead to tangible advantages.

The Trade Automobile Exhibition, Paris, 1928. Large as the "Grand Palais" is, it is not large enough for cars and lorries to be shown at the same time. The exhibition of November, 1928, was accordingly limited to trade automobiles and omnibuses.

The number and nationality of the firms exhibiting was, 21 French, 3 American and 1 Belgian.

The exhibits disclosed strong conservatism in French lorry construction; types and methods being retained which have long since been abandoned in Germany, chain drive, solid tyres, very high frames, and antiquated engines. In the development of the six-wheeler, France is far behind England and Germany. Berliet, with first rear axle chain-driven, and Chenard-Walker, showed six-wheelers of 12 tons and 8 tons useful load, respectively, but neither of these is of any military value. The former is only suitable for good roads; while the latter, which is called the *Appareil 6 Roues, Tous Terrains, Type Forestier*, is intended for carrying heavy logs from the forests, but, owing to the method of drive, by chains on the wheels, has very little axle freedom. On the other hand, Berliet showed a six-wheeler, built for purely military purposes. This has all axles worm-driven. The third axle lies midway between the other two, thus needing to be built stronger and needing twin tyres. It also necessitates the rear axle being made steerable. On account of all three axles being driven, its cross-country ability is greater, but it has no greater adaptability than any well-built six-wheeler, like the W.D. pattern, with two rear axles driven. The Belgian firm, Miesse, also showed a six-wheeler on English lines, a seven-tonner of 105 h.p.

The article then mentions, with photographs, other features of the Exhibition, viz., the Citroën-Kégresse tractor, full-track, originally intended for agriculture, but now subsidized by the French War Office; a Citroën car, half-track, with body built as a wireless office; a Citroën car, half-track, with runners to take the front wheels in snow; an Ara tractor which, having done good work with the artillery in Morocco, is now subsidized. It is characterized by the method of affording a yielding support of the lower band.

As regards the details of lorry construction in France, engine power is much less than in Germany, and four cylinders still predominate. Excepting Saurer, Berliet, Panhard, Renault, Cottin-Desgouttes, and Scernia, all firms showed antiquated shapes and methods of procedure. The clutch coupling was still to be found in the majority of vehicles. This has completely disappeared in German lorries. Many gears are still separated from the engine, and nearly all have four speeds.

A perspective drawing shows the new axle-drive by Delahaye, which may replace the worm-drive. The drive is by spur wheel, which engages

with a large spur wheel below it, so that two cone wheels on the same shaft can each drive a large cone wheel. The Delahaye spur wheel drive is thus specially suitable for any vehicle like a six-wheeler with two driven rear axles.

The use of home products for power purposes still rests mainly upon gas engines, calling for the use of charcoal or carbonite, a charcoal briquette in flat egg-shape. Gas-engine-propelled vehicles have been developed to a remarkable extent owing to military support. Competitions lasting weeks, which have been carried on now for five years, and in which thousands of kilometres are travelled under strict supervision, have caused so great an improvement that the conditions this year have again been made more severe. For example, lorries with pneumatic tyres per ton carried may not use per kilometre more than four and two-thirds ounces of wood, or one-half that weight of briquettes.

The most successful gas generators are those of the firm Rex (Gennevilliers, Seine).

Diesel engines appeared at this Exhibition for the first time. The two-cycle Junkers-Dessau Diesel engines are made under licence by Peugeot, who have had large orders for them, consequent on their success in military trials over 3,000 km.

Photographs then show a very fine four-cycle Diesel engine by Saurer, and a purely French Diesel engine by Norton, of Paris.

A sectional diagram is given of the Perrier centrifugal oil cleanser, which is extremely reliable and which reduces the consumption of lubricating oil by one-half.

A photograph also shows a small air-cooled, single cylinder engine by Renault, 1,200 revs., 1 h.p., direct coupled with a ½ kw. dynamo for lighting purposes; it stands 30 in. x 16 in. x 23 in., and weighs complete 85 lb.

Finally, neither six cylinders, and still less the six-wheeler, have appeared in French lorry construction to any noticeable extent. Also pneumatic tyres have hardly yet found an entrance.

Railway Guns. This is the third and final article on the subject, the title only being changed as German guns have receded into the background. Another type of railway gun used by the French is shown, viz., that of the 7·6-in. gun (without barrel recoil), with a range of 15 km., and all-round fire. Before firing, the centre portion of the gun truck is supported on eight screw legs, four resting on beams laid upon the rails, and four on beams laid outside the rails. The German answer to why they preferred to detrain the gun on to a solid prepared mounting, instead of thus obtaining a 360 degree traverse with a gun that did not leave the track, is that the extreme possible range with such guns was the 16 km. of the French 9·6-in., and that this range was quite insufficient for German purposes.

Photographs are given of the heaviest French naval gun mounting, only slight elevation being possible if used on the rails, and of the far more elaborate German 15·2-in., E and B mounting with all-round fire.

Besides the heavy calibres, 8·4-in. to 15·2 in., already dealt with, Germany had a number of smaller calibre railway guns, three of which are shown in photographs: a 6·8-in. gun on wheeled carriage, upon a special low truck, sunk between the bogies so as just to clear the rails;

a 6-in. on similar truck, photographed in the act of firing when at right angles to the railway line ; and a 3·5-in. A.A. gun on an ordinary railway track, weighted for stability.

An English construction of a special low truck, as in the case of the German 6·8-in. and 6-in., is also shown by a photograph. It had the additional advantage that the whole gun platform was capable of being lowered on to the rails.

A diagram shows a post-war creation of the Americans, an E and B mounting for 14-in. guns, which embodies all their experience of the subject. This, together with their much-described 16-in. barbette guns, is the answer of American coast defence to the increasing performance of the battleship's armament.

The Piezo-Electric Effect and its Use in Wireless, by Lieut. Halder. The author gets round the course, but not without taking a toss at the first fence. He falls over the definition of piezo-electricity. "The piezo-electric properties of crystals are the peculiarity they possess under certain circumstances of displaying electrical phenomena." This statement leaves much to be desired. It is equally true of the photo-electric properties of crystals, and of their pyro-electric properties. The crux is "under certain circumstances" which should read "when subjected to distortion."

Distortion can be caused by mechanical means, producing compression or extension. Such distortion, if correctly carried out upon crystals, results in electrical charges on certain of the crystals' surfaces. This is called a "direct" piezo (compression)-electric effect. It was first noticed in Holland, in 1703, and first studied by the Curies, in 1881, the crystal used being tourmaline, which consists of triangular prisms. Distortion can also be caused by electrical means. This is called "reciprocal" piezo-electric effect.

The crystal most used in wireless is quartz. As, owing to symmetry, quartz crystals do not respond in the same way as tourmaline, it is necessary to cut quadrangular prisms out of a quartz crystal.

When such a portion of a quartz crystal is introduced into an electrical alternating field, it experiences alternate compression and extension. It can thus be set gradually into longitudinal oscillation. The amplitude of the oscillations is very small, but it can be so much increased by resonance, as to cause the quartz to splinter with violence.

It is upon resonance phenomena that the practical use of quartz in wireless depends.—(*To be continued.*)

F.A.I.

ERRATUM.

In the List of Contents published with the *R.E. Journal* for September, 1929, page viii, the entry "Military Engineering. Vol. III—Railways, 1929," should read, "Military Engineering. Vol. VIII—Railways, 1929."

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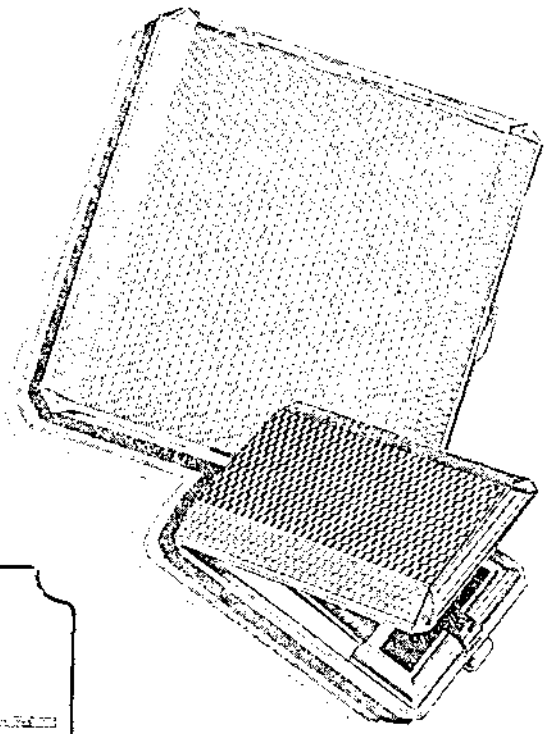

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