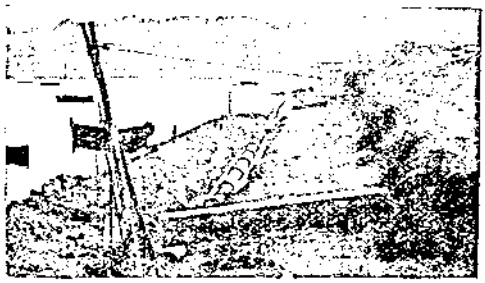
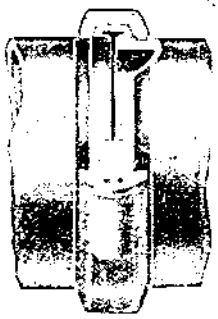


Victaulic joints being assembled in a flooded trench—Weymouth Corporation (Electricity Department).



Section of Victaulic joint—grooved type.

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The Secretary, The Institution of Royal Engineers, Chatham.

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All Reviews of Books on military subjects are included in the provisions of K.R. 522c quoted above.

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ROYAL ENGINEER YACHT CLUB.

THE following correspondence is republished in connection with the announcement on page 217 of the July, 1935, *Supplement* :—

Privy Purse Office,
Buckingham Palace, S.W.,
7th June, 1935.

DEAR SIR,

While considering the question of what Yacht Clubs the King should be Patron, it was brought to His Majesty's notice that the Royal Engineer Yacht Club had been in existence for a great number of years. The King thought that as Colonel-in-Chief of the Corps of Royal Engineers, he would like to give his Patronage to this Club. Will you therefore note that His Majesty will now become Patron of the Royal Engineer Yacht Club.

Yours faithfully,
FREDERICK PONSONBY,
Keeper of the Privy Purse.

The Commodore,
Royal Engineer Yacht Club,
Brompton Barracks, Chatham.

School of Military Engineering,
Chatham, Kent,
12th June, 1935.

DEAR SIR,

I am writing to acknowledge receipt of your letter of 7th June, addressed to the Commodore, Royal Engineer Yacht Club, from which I note the great honour which His Majesty The King, as Colonel-in-Chief of the Corps of Royal Engineers, has chosen to confer on their Yacht Club by becoming its Patron.

I am forwarding your letter to the Commodore, His Royal

Highness The Duke of Connaught and Strathearn, K.G., K.T., K.P., etc., etc.

Yours faithfully,
W. G. S. DOBBIE, *Major-General,*
Commandant, S.M.E.

The Keeper of the Privy Purse,
Privy Purse Office, Buckingham Palace,
London, S.W.

School of Military Engineering,
Chatham, Kent,
15th June, 1935.

DEAR SIR,

I am writing to ask that the enclosed letter from the Keeper of the Privy Purse, conveying the gracious decision of His Majesty The King to become Patron of the Royal Engineer Yacht Club, may be laid before the Duke, who, it will be remembered, does the Royal Engineer Yacht Club the honour of being their Commodore.

I enclose a copy of a letter which I have addressed to the Keeper of the Privy Purse acknowledging the receipt of his letter.

I also enclose a copy of *The Royal Engineers Journal* containing a short history of the R.E. Yacht Club in case it may be of use for reference.

Yours faithfully,
W. G. S. DOBBIE, *Major-General,*
Commandant, S.M.E.

The Private Secretary to His Royal Highness Field-Marshal The Duke of Connaught and Strathearn, K.G., K.T., K.P., etc.

Bagshot Park, Surrey,
June 19th, 1935.

DEAR SIR,

Thank you for your letter and enclosures. I have laid these before the Duke of Connaught, and am desired by His Royal Highness to thank you for informing him of His Majesty's decision to become Patron of the Royal Engineer Yacht Club.

As Commodore of the Club His Royal Highness is delighted to hear of this.

He is reading with interest the article in *The Royal Engineers Journal* concerning the history of the Club.

Yours faithfully,
FITZROY H. FYERS, *Captain,*
Equerry-in-Waiting.

Major-General W. G. S. Dobbie, C.B., C.M.G., D.S.O.,
Commandant, S.M.E.

CROSSING THE NILE.

By LIEUT.-COLONEL C. C. PHIPPS, O.B.E., M.C., R.E.

PART I.—TACTICAL.

1. In the December, 1934, issue of *The R.E. Journal* an interesting article described a bridging operation carried out by the 1st Division across the Kennet and Avon Canal.

2. In Egypt we have just carried out a more ambitious scheme in putting an infantry brigade plus attached troops, consisting of tanks, cavalry, horse artillery and light artillery, across the Nile.

3. The operation was carried out south of Cairo where the Nile varies in width from about 1,000 yards to about 500 yards, and there is a current which varies considerably with the wind, but may be as much as 4 or 5 knots.

4. The tactical situation may be described very briefly as follows :—

An Arabian force had been attacking Cairo for some time from the east, without obtaining any appreciable success. It was therefore decided to make a turning movement by crossing the Nile above Helouan, some 17 miles south of Cairo, thus investing the city on the south, west and east sides.

With this object in view the Canal brigade and attached troops were ordered to form and hold a bridgehead, south of Helouan, for the crossing of the 5th Division of the Arabian army.

5. The Canal brigade concentrated at Helouan on 23rd February, 1935, for brigade training and carried out normal training until March 2nd. The 3rd and 4th March were spent in practising embarkation and disembarkation of troops, animals and vehicles, both by day and night. The infantry had previously detailed 60 men from each battalion, mostly from the bands, and these men had received a certain amount of instruction in rowing previous to coming to camp.

6. From the evening of March 5th onwards " the war was on," and it was necessary to take all precautions for concealment, as well as for protection generally, including the defence of the camp. The enemy were known to have cavalry, armoured cars and embussed infantry on both banks of the Nile. Both forces were well equipped in the air.

7. The brigade commander, in appreciating the situation, came to the conclusion that, as secrecy was vital for success, his best chance

lay in concentrating the boats and troops at the various crossing places during the hours of darkness and commencing the crossing in the early hours of the morning, the first troops getting over in actual darkness.

For various reasons, however, the directing staff controlled the arrangements in such a way that the crossing was to take place as a night operation, the first flight going over immediately it was dark.

PART II.—ENGINEERING.

The above is only a very brief note on the tactical situation and we must now describe in rather more detail the R.E. aspect of the crossing.

1.—RECONNAISSANCE.

The Nile is constantly changing its banks and the only available maps, made in 1928 and 1929, bear no resemblance at all to the existing conditions.

A preliminary reconnaissance was made in December, 1934, to obtain some idea as to possible crossing places. A second reconnaissance was made in January, when the river is normally at its lowest, and again in February when it was expected to be at about the same level as it would be in March.

As a result of these reconnaissances, a fairly accurate survey of the actual banks and islands was obtained, but very little information could be obtained as to submerged sandbanks, as time was not available to take soundings, and, as the river did not drop to any very marked extent in January, very few extra banks were then noticed.

Air photos were useful in showing islands and the river banks, but the Nile is too muddy to show any submerged banks.

Furthermore, as elaborate soundings would have been difficult in war, nothing was done in this way until shortly before the actual crossing, when rough soundings had to be taken at the more probable sites.

The final reconnaissances extended over a distance of nearly 20 miles, going about 5 miles north of Helouan and some 15 miles south. In this way a number of possible crossing places was found and was divided under three headings :—

(*a*) Infantry.
(*b*) Light tanks and H.T. transport.
(*c*) Medium tanks and M.T.

As a result of further reconnaissance shortly before the actual

crossing and the taking of rough soundings, various submerged banks were discovered, which made several of these crossings useless. In the end the number of sites suitable for pontoon rafts or horse-boats was decidedly limited. Again, a drop of about 9 in. in the river two days before the crossing necessitated some last-minute change of plans.

Infantry crossings were restricted to some extent by the varying width of the river which varies from about 1,000 to 500 yards over the area reconnoitred.

Current had also to be considered and this varies in different stretches considerably. It is also very greatly affected by the wind. With a south wind there may be a current of 4 or 5 knots, whereas with a north wind the current may be practically neutralized.

In addition to crossing the Nile itself, arrangements had to be made for crossing numerous canals and channels, which exist between the river and the desert on the west. There are numerous bridges over these waterways, but they are difficult to find in the dark and an unknown number might have been destroyed by the enemy. The smaller channels vary in width from 10 ft. to 20 ft., and the main Giza Canal running alongside the Cairo road is about 60 ft. wide.

To compete with these obstacles each infantry battalion was provided with 130 ft. of Kapok assault bridging, which was taken over by hand in the rowing-boats.

As the enemy would have to rely on a very large measure of mobility, it was not anticipated that he would demolish many bridges. It was reckoned that the necessary repairs to enable transport to move forward could be carried out the following day by means of equipment from the Corps Bridging Park, which would have had to be pushed up in connection with the operation.

2.—Size of Force.

The preliminary calculations were based on a force comprised as under :—

1 Squadron Cavalry.
1 Battery R.H.A.
1 Light Battery R.A.
2 Field Companies R.E.
1 Wireless Section R.C. of S.
1 Cable Section R.C. of S.
3 Battalions Infantry complete with transport.
1 Mixed Company of Tanks (5 Medium, 9 Light).
R.A.S.C. transport for supplies.

Eventually the medium tanks and R.A.S.C. transport were cut out to reduce the expense of hiring boats and purchasing materials for decking them. Also only five light tanks could be made available.

3.—EQUIPMENT AVAILABLE.

The military equipment available in Egypt was only sufficient to form the following :—

2 medium pontoon rafts or 1 heavy raft.
2 folding-boat decked rafts.
400 ft. Kapok assault bridge.

It was obvious, therefore, that a considerable amount of shipping would have to be hired.

The shipping available on the Nile may be classed roughly as follows :—

(*a*) Steam- or Diesel-engined barges of varying capacity up to about 1,000 tons.
(*b*) Similar steel barges with no motive power.
(*c*) Native sailing-boats, about 40 ft. overall length, called *ghyassas*.
(*d*) Smaller sailing-boats, about 20 ft. to 25 ft. long, called *merkebs*.
(*e*) Still smaller sailing-boats and rowing-boats, both called *feluccas*.
(*f*) Launches, both steam and motor, of varying sizes and types.

Types (*a*) and (*b*) were considered to be unsuitable owing to difficulties of navigation and of finding suitable places for landing.

The remainder could be utilized as follows :—

(*c*) *Ghyassas.*

(i) For use as heavy rafts for medium tanks or M.T.
Using boats which had their two masts not less than 25 ft. apart, a double roadway could be provided between the masts.
(ii) For use as landing-stages between rafts and shore. For this purpose the holds would have to be filled up with cribwork and decked over.
(iii) For use as horse-boats with the holds partially filled with sand and earth and ramped towards one end.

Types (i) and (ii) were not actually used on account of expense (see para. 4 opposite).

(*d*) *Merkebs.*

These were suitable for animals, some being already decked for this purpose.

(*e*) *Small sailing-boats or rowing-boats.*

Both types could be rowed and were specially suited for infantry on account of quietness and ease of manipulation.

(*f*) *Launches.*

Both steam and motor were suitable for towing *ghyassas, merkebs,* as well as pontoon or folding-boat rafts.

Only the more powerful types were suitable for towing the *ghyassas.*

4.—Cost of Hiring Shipping.

The original estimate for the cost of hiring the necessary boats and purchasing material for decking them came to some £1,600, and it was obvious that the cost would have to be cut down to an absolute minimum.

It was at once decided to leave out all medium tanks and M.T. from the crossing and to do without any boats or barges as landing-stages. The latter proviso meant that the sites selected for crossings must be very carefully chosen, and the number of places available was at once considerably reduced.

As a result of the most careful consideration it was decided that the following was the absolute minimum of boats, in addition to the military equipment available, with which the crossing could be carried out.

30 rowing-boats (10 per battalion).
3 horse-boats.
11 launches.

It was essential to have a certain number of these boats available for practice beforehand. Furthermore, we had to pay for the day of delivery and day of return and also had to allow for time for taking the boats to their correct positions beforehand.

The cost of this reduced amount of shipping actually came to approx. £.E.500, plus an additional £.E.80 for various R.E. materials and stores.

5.—Details of Craft Used.

Rowing-boats.

These consisted of eight steel boats and 22 wooden boats of various sizes (see Photos 8 and 9).

The steel boats held about 20 fully-equipped men and the wooden boats varied from about 18 to 36 armed men.

The above figures in each case include four rowers and a cox.

One native boatman was provided with each boat.

Five oars were supposed to be supplied with each boat to include one spare, but in some cases the number had to be completed from military equipment.

Wooden boats had masts, but the rigging got in the way and the masts were dismantled.

Horse-boats.

These consisted of three *ghyassas*, with a crew of four native boatmen each (see Photos 1 to 4).

They were capable of holding 10 horses down each side, with heads in the centre, making a total of 20 horses. Arranged thus, however, it was found that the boat was liable to get up a very alarming roll, and in consequence the horses were placed in three rows of four, facing bow or stern.

It was only possible with this loading to take a maximum of 12 horses on each boat.

To further reduce the chances of rolling, the yardarm which carries the sail on the front mast, and is some 80 ft. or more long, was dismantled (see Photo 2).

These boats have a hold about 6 ft. deep and this was partially filled with sand and mud, up to the gunwale level near the bows, where animals were loaded, and ramped down to about 3 ft. near the stern. The filling, which was carried out by the native crew, actually contained a large quantity of straw at the bottom, and a considerable amount of consolidation was required before it was fit for use.

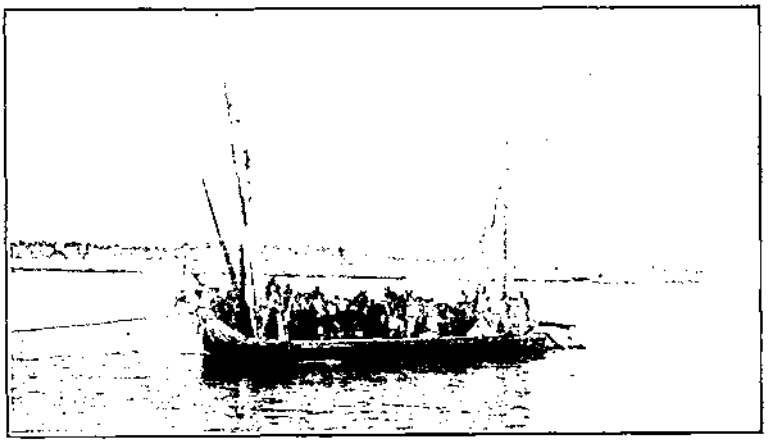
Wooden ramps 12 ft. long and 3 ft. 6 in. wide were constructed to connect the boat to the shore (see Photo 4). They had to be strongly made with 1½-in. boarding as horses are apt to jump on them. This is about the maximum size which can be conveniently lifted, but is rather narrow and it would be better to have two of them side by side.

Further, a pair should be available on each shore, as there is not much space to load them on the boat.

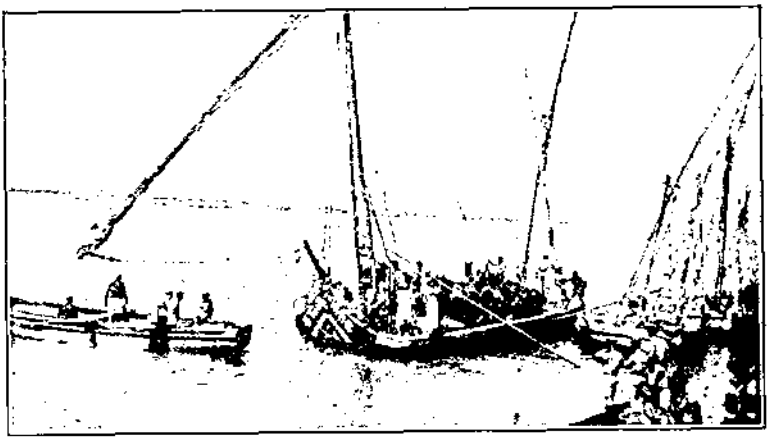
Launches.

These consisted of two steam launches and nine motor launches of various sizes. Some of the latter were rather small. It is most important to have ample power. It is also essential to have plenty of spare launches. We had one motor launch out of action during the whole practice period and two out of action nearly all the night of the crossing. In addition one launch was commandeered by the chief umpire, and one steam launch broke a steam pipe, which, however, was mended in about an hour.

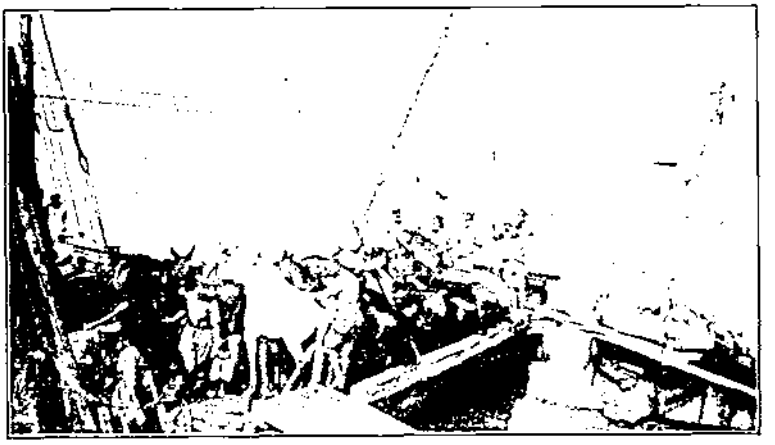
NILE CROSSING.—MARCH, 1935.



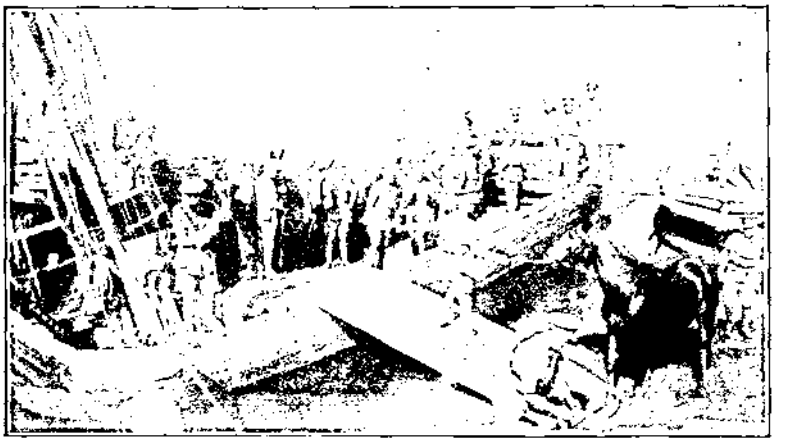
1.—Loaded horse-boat being towed.



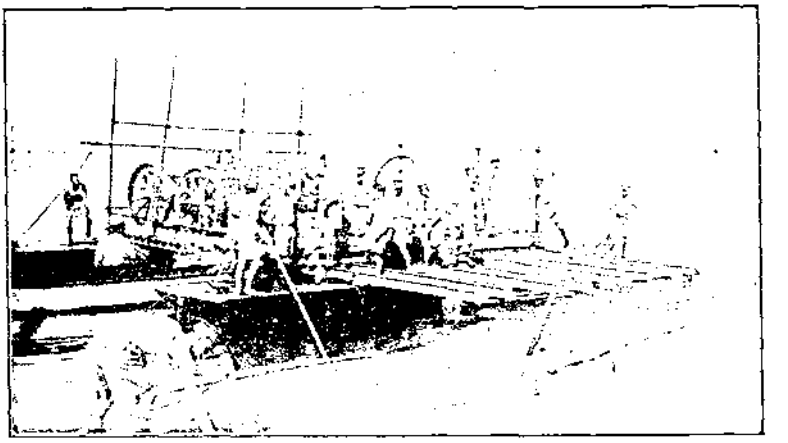
2.—Horse-boat being taken in tow. *Note.*—Bottom end of yard-arm in front, which accentuated roll on account of its swaying motion.



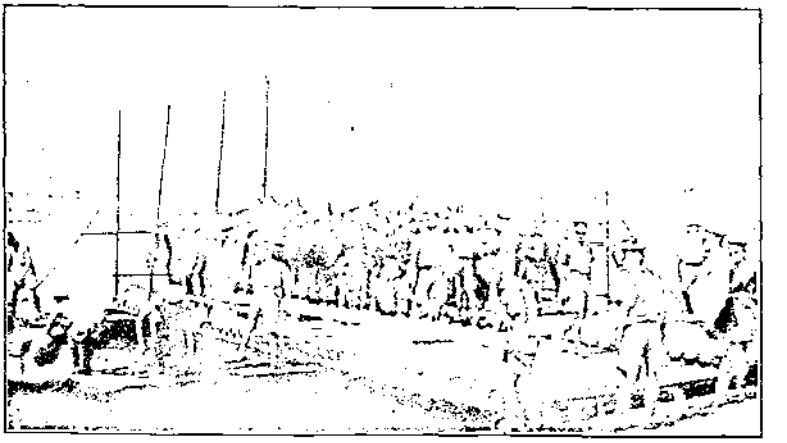
3.—Horse-boat loaded down sides, heads in centre. This loading increased roll when once started.



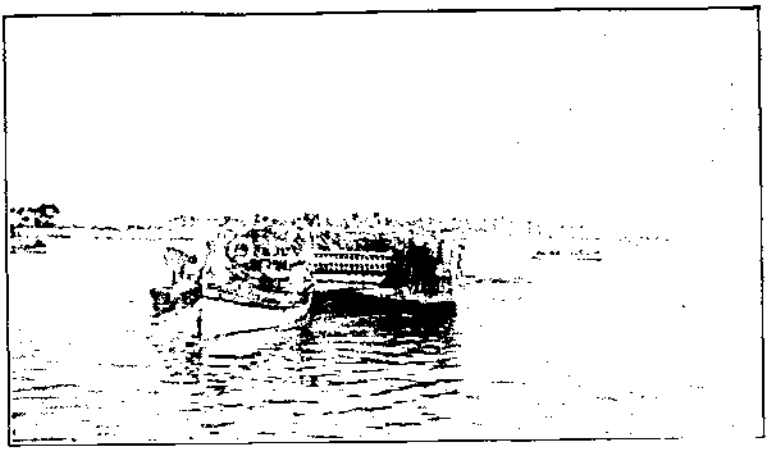
4.—Horse-boat showing gang-plank as used.



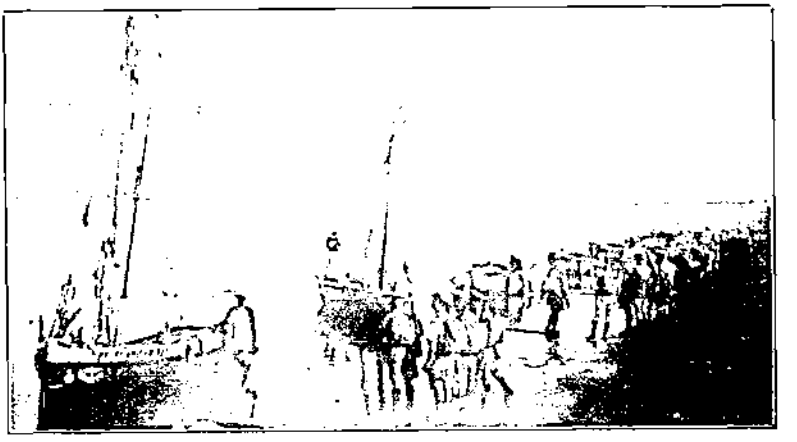
5.—Pontoon raft loaded with three rows of vehicles.
Note.—Tubular scaffolding screen for horses, draw-bay for double roadway with road-bearers unchessed.



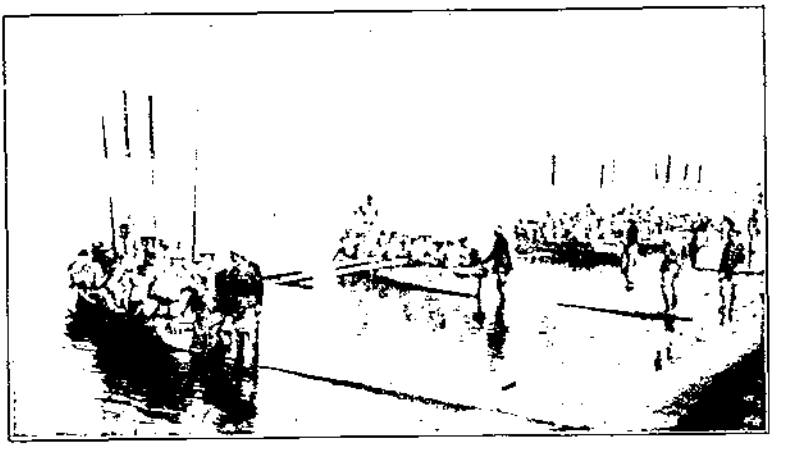
6.—Pontoon raft loaded with horses. *Note.*—Double draw-bay fully chessed.



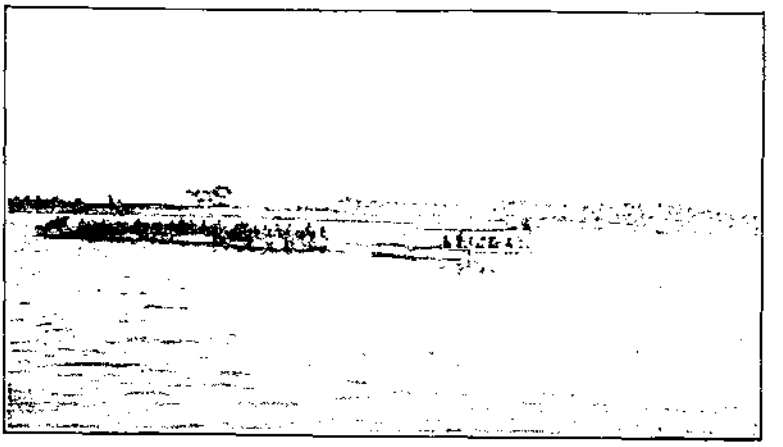
7.—Pontoon raft with mixed load of horses and vehicles, towed by motor launch. *Note.*—This raft has timber screen for horses.



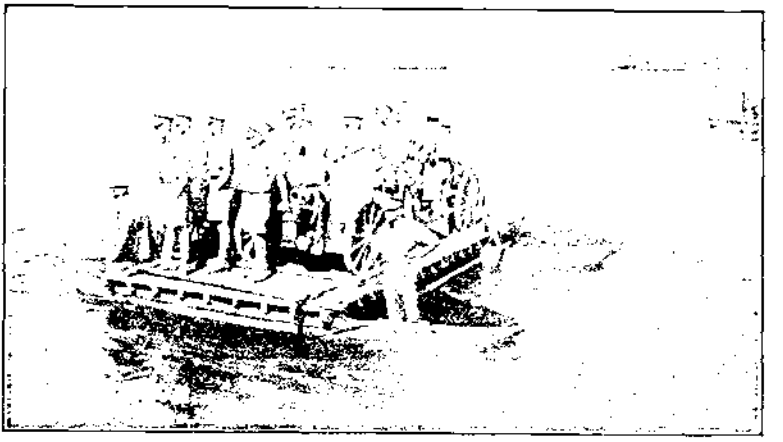
8.—Infantry rowing boats, showing wooden boats before masts were dismantled.



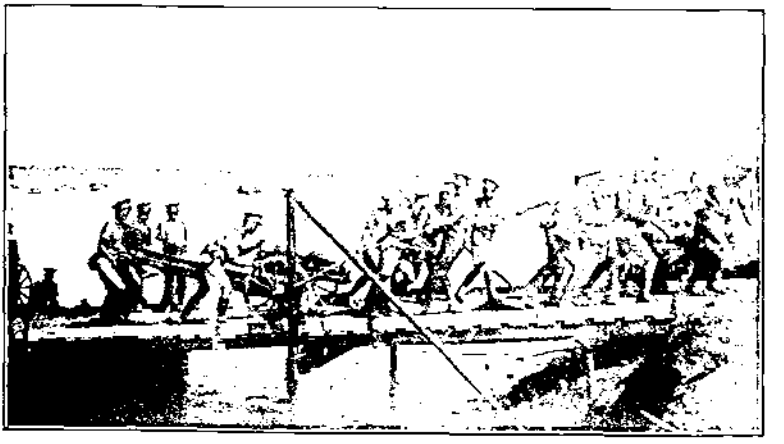
9.—Infantry embarked in steel rowing boats.



10.—Infantry returning after the exercise—10 boats being towed by one motor launch.



11.—Folding boat raft loaded with 4 3·7 hows. on wheels.



12.—Folding boat equipment landing bay. 3·7 hows. coming ashore on wheels.

The original allotment of launches was as follows:—

3 for towing horse-boats.
2 for towing pontoon rafts.
2 for towing folding-boat rafts.
1 for Headquarters, Canal Brigade.
1 for Commander, Royal Engineers.
2 spare.

Medium Pontoon Rafts.

These were fitted out with double decks. The outside ribands were spaced about 23 ft. apart in the clear which gave space for three lines of vehicles. In the case of the pontoon raft for the light tanks the roadbearers were spaced to allow for the additional weight in the centre, although in the end only two tanks were loaded on account of difficulties with shallow water, which did not permit of the deep draught caused by loading three tanks on the medium raft. For connecting to the shore "draw-bays" were provided (see Photos 5 and 6).

As these rafts also had to take animals on some trips, a screen of tubular scaffolding was provided in one case and of timber in the other. It was originally intended to put canvas on these screens, but it was found that the flapping of the canvas frightened the animals and it was not used. The animals were quite quiet without the canvas (see Photos 5 to 7).

The load carried varied with the type of vehicle, etc., but with horse-drawn vehicles three abreast, an average of nine axles can be taken or alternatively 18 horses, provided chesses for draw-bays can be left on shore on each bank and not loaded on the raft.

Folding-boat Rafts.

These were of normal construction for a decked raft, and were connected to the shore in the normal manner with a trestle and one boat pier (see Photos 11 and 12).

The load carried varies with the type of vehicle, but three axles may be taken as an average.

6.—Selection of Crossing Places.

In order to secure secrecy, the selection of the actual sites to be used was left as late as possible and was not settled until March 3rd, four days before the date fixed for the crossing. It had then been possible to take some soundings and get a more accurate idea of the depth of the water, and it had been discovered that the actual number of suitable crossing places was strictly limited, as landing-stages had had to be cut out on account of the expense.

In war it might have been very difficult to take soundings near the

far bank and some form of landing-stage would have been practically essential to ensure success.

The sites actually selected consisted of four main crossings, as follows (see Plan " A ") :—

X Crossing, near El Tabbin village—

Length of beach about 800 yards.		
Equipment	10	rowing-boats.
	2	horse-boats.
	2	folding-boat rafts
	5	launches.
Troops using crossing ..	1	Light Battery R.A.
	1	Battalion Infantry complete with transport.

Y Crossing, S.E. of Mazghuna—

Length of beach about 1,000 yards.		
Equipment	10	rowing-boats.
	1	horse-boat.
	1	pontoon raft.
	3	launches.
	1	pontoon raft } later.
	2	launches } later.
Troops using crossing ..	1	Squadron Cavalry.
	1	Battery R.H.A.
		Detachment of Signals.
	1	Infantry Battalion.

Transport of Two Infantry Battalions.

Z Crossing, S.W. of El Ikhsas el Qibliya—

Length of beach about 100 yards.		
Equipment	10	rowing-boats.
Troops using crossing ..	1	Battalion Infantry.

T Crossing, south of Nazlet Ileiyan—

Equipment	1	pontoon raft.
	2	launches.
Troops using crossing ..	5	light tanks.

On completion of its task the equipment from this crossing moved down river to " Y " crossing, but arrived very late, some seven hours after calculated time (see para. 9).

The total distance from " X " to " T " crossing was approximately eight miles.

7.—CAMOUFLAGE OF BOATS.

All boats were taken to the neighbourhood of their respective crossing places on the day before the operation.

In the case of " T " and " Z " crossings the pontoon raft, launches and rowing-boats could all be put in narrow creeks, where they could be completely covered over with matting, grass, etc., which hid them from air observation and the ground hid them from observation from the far bank.

At " Y " crossing the pontoon raft and rowing-boats were hidden in some small creeks near the infantry beach. They were covered with matting and netting, but the site was in view of the opposite bank and the pontoon raft was spotted by the enemy, and on the night of the crossing the enemy were waiting for us at the infantry crossing.

The pontoon raft crossing was actually about 1,000 yards downstream from the site where the raft was kept and there was no opposition at this crossing.

At " X " crossing the folding-boat equipment was stacked on shore and covered with matting and was quite invisible from even a few yards away.

The rowing-boats could not be hidden at all and were tied up to the bank some 800 yards upstream from the actual crossing place. They do not appear to have been noticed.

Horse-boats were tied up to the bank at their respective sites. Being exactly the same as the majority of the ordinary native craft on the river no attempt was made to hide them.

The launches for " X " crossing were parked some three miles downstream, at Kafr-el-Ilw, where there is always a considerable amount of shipping. As there are good road approaches on both banks the enemy thought this was a probable crossing place.

On the night of the operation these launches started up about half-hour before the attack commenced at " X," and the sound of the launches drew some enemy away from the proper crossing.

Launches for " Y " crossing were sent well upstream some five miles and were not apparently seen.

8.—Beach and Raft Parties.

Infantry Beaches.

An infantry officer was in charge of the beach and he had two or more guides to bring parties from the assembly position to the beach.

The R.E. party consisted of :—

1 officer.
1 N.C.O.
2 or 3 sappers.

This party was responsible for seeing that the boats were in their proper position at the correct time for the first flight.

The N.C.O. and one Sapper went over with the first flight.

They erected navigation lamps on both banks as soon as the first flight had made good.

Horse-boat Parties.

It is essential to have a man to each animal and for this purpose six men from the R.A. were allotted to each horse-boat. They travelled to and fro with the boat.

The R.E. party for each boat consisted of :—

1 officer.
1 N.C.O.
9 Sappers.

They controlled the launch, steered the boat, handled the landing brow and manipulated breast lines on the boat and on shore.

Vehicle Raft Parties.

An infantry party of 30 men was provided at each vehicle crossing place for handling vehicles on and off the rafts.

Generally 10 men were sufficient on the embarkation side and 20 men on the landing side to push vehicles well clear of the beach.

Each R.E. raft and launch party consisted of 1 officer, 1 N.C.O. and 13 Sappers with two extra Sappers on each bank to take breast lines, except in the case of the tank raft when the number of Sappers was doubled.

The total strength of the R.E. detachments employed on the exercise was as follows :—

Headquarters	Commander, Royal Engineers. Adjutant.
2nd Field Company R.E. ..	4 officers. 7 N.C.O's. 50 Sappers.
42nd Field Company R.E. ..	4 officers. 8 N.C.O's. 60 Sappers.

9.—TIMINGS FOR ROUND TRIPS.

The timings allowed when preparing the scheme were as follows for the round trip in each case :—

Infantry	1 hour.
Vehicle rafts ..	1 hour.
Horse-boats ..	1½ hours.
Tank raft	¾-hour.

The actual timings on a very dark night and with a slight wind somewhat counteracting the current were roughly as follows :—

Infantry	.. ..	¾ to 1 hour.
Pontoon raft	..	¾ to 1 hour.
F.B. rafts	.. ..	½ to ¾ hour.
Horse-boat	.. ..	1 hour at " X " crossing.
		½ to ¾ hour at " Y " crossing.
Tanks	.. ..	1½ to 2 hours.

On the return journey by day the times taken were less than half those at night.

At every crossing, either owing to enemy action or for other reasons, the commencement of vehicle- and animal-ferrying was considerably delayed, but once started, except in the case of tanks, the lost time was to a large extent made up.

The delay in the case of the tanks was caused by the difficulty of getting in and out of the embarkation beach, which was up a narrow creek. This site had been selected entirely with a view to concealment. The launch was also under-powered and towed the raft very slowly.

10.—Local Factors.

The Nile, being a " controlled " river, is liable to constant changes in level.

When selecting sites an ample margin should be allowed for a possible fall when calculating depths of water available. The river actually dropped about nine inches two days before the operation, and this made the horse-boat site at " Y " crossing unusable and a new one had to be found.

The amount of native shipping lying at various places varied considerably and an unexpected concentration opposite " X " crossing on the night of the operation also necessitated a change of site for horse-boats here.

In both these cases the change entailed landing the horses some 800 yards or more from the vehicles.

We were fortunate in having a northerly wind on the night. This is usual, but if it had happened to be from the south some of our launches would have been unable to tow their loads.

As soon as the infantry had made good on the far side, navigation lights were used on both banks.

PART III.—GENERAL ORGANIZATION.

1. The administrative arrangements required an immense amount of care and thought.

2. The distances of the crossing places from the camp at Helouan

varied from 4 miles to 15 miles. The march table involved, therefore, the most intricate calculations.

3. A table of boat flights was first drawn up and the march table was then made to fit in with these boat loads.

4. The infantry rowing parties, beach-loading parties and animal parties were sent down to the neighbourhood of their respective crossing places before dawn on the morning of the 7th March. Their instructions were to keep concealed as much as possible from the opposite bank, but at the same time to form road blocks and generally protect the approaches to the crossing places against raids by armoured cars.

5. The R.E. parties were allowed to proceed at intervals during the day of the 7th March to the neighbourhood of their respective areas, but with strict instructions not to approach the riverbank before dark.

6. The main body left camp just after dark. The infantry proceeded to the farther crossings by lorries, which were limited in number and were only sufficient to take one flight at a time to each of " Y " and " Z " crossings.

7. The tanks were timed to commence crossing about 19.00 hours which was half an hour after dusk.

8. The first infantry flight could not reach their beaches and be embarked before 20.00 hours.

The animals and transport were timed to commence crossing about 20.30 hours.

According to the programme the whole force should have been across by about 08.00 hours on the morning of March 8th.

9. Actually operations proceeded as follows :—

" X " Beach.

Embarkation proceeded smoothly and the enemy were unprepared on the far bank, although a small detachment were most enterprising and came across and attacked us on our bank while the folding-boat equipment was being prepared.

All troops and transport were across by 06.00 hours.

" Y " Beach.

The infantry first flight met very strong opposition and were practically wiped out. The second flight, however, changed the disembarkation site, landed without any opposition and attacked the enemy in the rear and captured the lot.

This took a considerable amount of time and the animals and transport could not commence crossing until 23.30 hours.

The second raft, which should have come back from " T " crossing about 21.00 hours on the 7th March, did not actually get here till 04.30 hours on the 8th March, thus causing more delay at this

crossing. By 05.30 hours everything except infantry transport was across.

" Z " Beach.

This crossing went without any hitch.

" T " Beach.

Considerable difficulty was experienced in getting the pontoon raft in and out of the narrow creek and the motor-launch was rather under-powered.

The tanks were not all over till about 01.30 hours.

10. Our fighting troops had got possession of all their objectives by 05.30 hours on the morning of the 8th March and a halt was then called.

Troops were given breakfast and the whole force started on the return journey about 08.30 hours.

Very rapid work was done by daylight and all troops and transport were back on the east bank before noon.

The tanks alone were not ferried back as they returned to Cairo by road on the west bank.

11. Having completed the ferrying of troops and transport in both directions, the Sappers had to collect the whole of the equipment, including all spares, camouflage material, etc., and tow it back to Helouan, a distance of some nine miles from " Y " beach.

This was completed by about 19.00 hours after a most strenuous 24 hours with hardly a break.

PART IV.—SUMMARY OF IMPORTANT FACTORS ARISING OUT OF THE EXERCISE.

(i) Very thorough reconnaissances are essential, especially for depth of water right across the river at all possible crossing places.

(ii) Alternative sites should be selected, if possible.

(iii) At least 30 per cent. of spare launches are required to compete with breakdowns.

(iv) Animals must have plenty of practice in being loaded on boats, firstly by day and then by night.

(v) If *ghyassas* are used for animals the latter must be loaded heads to bow or stern and not inwards along the length, in order to prevent excessive rolling.

(vi) Sail yardarms must be removed for the same reason.

(vii) Gang-planks for loading animals should be made in two halves, each 12 ft. long by 3 ft. wide, and must be strong.

(viii) Masts and rigging should be removed from rowing-boats.

(ix) Steel rowing-boats are more noisy than wooden boats.

(x) Shore bays for pontoon rafts require further consideration.

Draw-bays are simple but entail a lot of work each time chessing down.

A lifting bay on a trestle takes time to construct and is apt to be carried away at night. It is also not very suitable when rafts are double-decked.

Some form of decked barge as a landing-stage with a short connecting bay is probably the best.

(xi) Horses and vehicles should be landed close together and horses for respective vehicles should arrive first.

(xii) With a double-decked pontoon raft horses and their vehicles can go across together, but in this case one cannot make use of the centre portion for extra vehicles.

(xiii) Vehicle loading and unloading parties must be under charge of an officer or senior N.C.O., otherwise they are apt to disappear between loadings.

(xiv) There must be one man per animal and for this purpose it is best to detail a special party of men sufficient for 50 per cent. of animals on each horse-boat, to travel to and fro on the boats.

(xv) Special arrangements must be made for rations for vehicle and horse parties.

(xvi) Ample guides must be available to conduct men, animals and vehicles from assembly positions to their respective beaches and from landing beaches to rendezvous.

(xvii) Officers must be detailed by headquarters by name to be in charge of beach parties at each transport embarkation and disembarkation beach. The R.E. are responsible for supervising actual loading on the rafts.

(xviii) At infantry beaches each battalion should be responsible for its own arrangements.

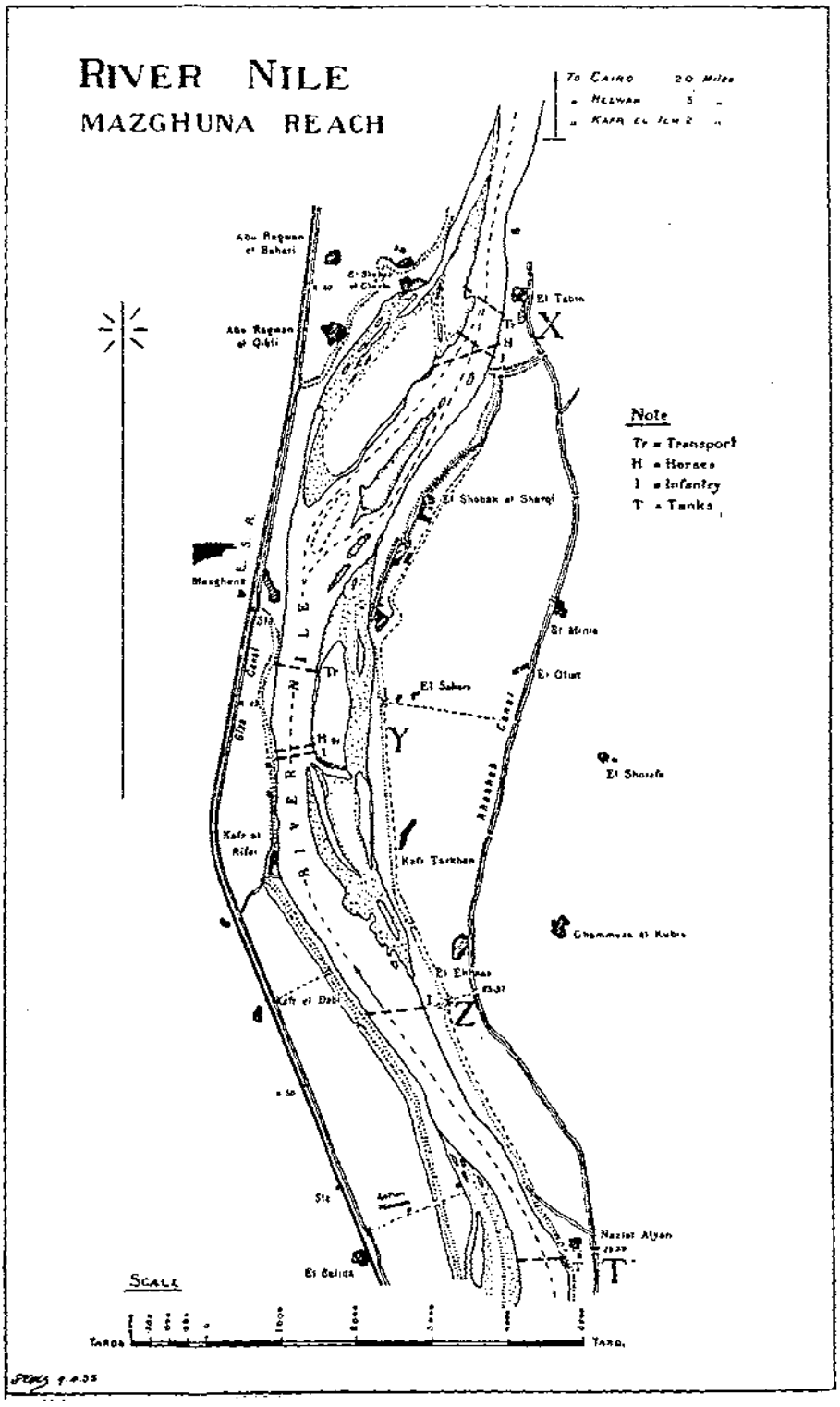
(xix) No boats or rafts should be located near the actual beaches which will be used. They should be placed beforehand some 1,000 yards up or downstream and only moved to their proper beaches at the last possible moment.

(xx) Sites suitable for concealment of boats or rafts are not usually good for navigation and should not normally be used for embarkation beaches.

(xxi) There will usually be delays in commencing operations, especially in the case of transport crossings.

If boats or rafts have to be moved from one position to another during the operation in order to undertake different tasks, these delays will be accentuated.

PLAN A.


RIVER NILE
MAZGHUNA REACH
To Cairo 20 Miles
" Helwan 5 "
" Kafr el Ilw 2 "
Abu Regwan el Bahari
Abu Regwan el Qibli
El Tabin
X
Note
Tr = Transport
H = Horses
I = Infantry
T = Tanks
El Shobak el Sharqi
Mesghena
El Minia
El Otuf
El Sahun
Y
El Shorafa
Kafr el Rifai
Kafr Tarkhan
Ghammura el Kubra
El Ehnasa
Kafr el Dab
Z
Nazlat Alyan
El Gelica
T
SCALE
Yards
Yards

A SPECIALIST LOOKS AT WAR.

By BRIGADIER M. N. MACLEOD, D.S.O., M.C.

SPECIALIZATION is a word with which the army is becoming familiar, but generally in association with matters technical. The only specialists whom the army recognizes as such are technicians like the sapper and the signaller. The fighting man, by contrast, is expected to be a Jack-of-all-trades.

In industry or business, specialization may make for efficiency and be worthy of recognition and even encouragement ; but in fighting, apparently, the reverse is the case. In the forefront of battle the specialist, the man who concentrates on one thing only to the neglect of all others, is thought to be a nuisance and even a danger ; for who can predict the situations which may arise in war, or forecast the number and nature of the specialists who would be required to deal with any one of them ?

There is truth in this, but not the whole truth. At all events the tendency towards specialization in armaments has already gone a long way, far enough to make it worth considering whether it might not be better to accept than to oppose it, and to see if it cannot be turned to advantage. The technique of fighting has become so complicated that the fighting soldier cannot any longer hope to be a Jack-of-all-trades. Its complication is the natural product of scientific progress and invention, which, ever since the invention of gunpowder, has made land warfare more and more a lopsided affair, with attack so much more difficult than defence, that all wars threaten to degenerate into stalemates. And since military theory insists that wars cannot be won by defence alone, the soldier is being steadily driven, most reluctantly, farther and farther along the specialist path notwithstanding the many and difficult problems in the " co-operation of all arms " which specialization begets. Nor is his reluctance difficult to understand. Specialization in fighting men may be found to divide them into either " attack " specialists or " defence " specialists, yet the soldier engaged in an attack may at any moment find himself suddenly thrown on the defensive and if he cannot then defend himself what good is he ?

With attack and defence alternating in sequences impossible to forecast, how can the soldier be a specialist in only one of these operations ?

If war were merely a multiplication of single combats it would be absurd to suggest such a thing ; but war has long ceased to be anything like that. Modern war is mass destruction ; and mass

destruction, like mass production, opens the door to the specialist; for it is the mass operation which especially profits from the sub-division of labour and specialization.

If land warfare is looked at with the specialist's eye, the things that stick out a mile are the difference in method between attack and defence, and the fact that practically none of the weapons yet invented is equally suitable for both purposes. Take, for example, the machine-gun. Its sinister reputation was made entirely in defence. In attack it is, comparatively, of little use, though it is, of course, valuable in supporting roles which are really defensive in character—a fact which quite adequately explains the alleged imbecility of Lord Kitchener and other British military authorities of pre-war days in declining to equip the British infantry, trained and intended specially for attack, with large numbers of these weapons. The machine-gun, in short, is a defensive weapon, as also is the rifle, for the same reasons; and if these were the infantry's only weapons, then infantry ought to be regarded as defence specialists and some other arm should take on the job of attack. This, it seems, is the view of some modern mechanization enthusiasts who assert that henceforth the P.B.I. will become fortress troops specializing solely in static defence. According to these warriors, the business of attack can be entrusted exclusively to armoured vehicles; but the specialist will be disquieted to discover that the vehicles are to be armed with the very same weapons which, served out to infantry, have proved themselves useless for the purpose in view!

He will see something decidedly British in the logic which equips "armoured units" that are "essentially weapons of offence" with armaments which have proved their value only in the opposite role.

This logic will not, of course, lack its defenders, especially among those who pretend to believe that "fire power" consists only in loosing off a stream of bullets in the supposed direction of the enemy. A moment's consideration, however, will show that the reflection on the machine-gun is well justified, for no one would now venture to maintain that a determined enemy could be driven out of an organized position by machine-gun fire alone; at any rate, when delivered from the ground. The reason is obvious enough, but as it is often ignored it is perhaps advisable to state it. It is that machine-guns, like rifles, are effective when there are men, visible men, to shoot at; and that in attack the enemy's men are not visible, but concealed in trenches, upon which shells or bullets travelling along a flat trajectory produce very little effect.

This is the sole reason why infantry soldiers, besides carrying a rifle which will kill a man at two miles, have also to carry a bayonet which will kill only at arm's-length; and why *F.S.R.*, instead of telling them to shoot down the enemy from behind a convenient

hedge after the manner of the up-to-date civilian gunman, finds it necessary to instruct professional soldiers to " close with the enemy and destroy him " at the imminent risk of their lives ! It is true that ever since the South African War *F.S.R.* has qualified these instructions by directing that this closing with the enemy should not be attempted until " fire-superiority " had been gained ; and—until the Great War revealed the error—it was hoped that this fire-superiority could be gained by building up a firing line of expert marksmen at more or less point-blank range from the hostile trench, so that any enemy who was so bold as to show his head above the parapet would get it shot off before he could make himself unpleasant. This amiable notion was the basis of pre-war infantry training ; and provided that the ranks could be filled up with crack shots it must be admitted that it seemed quite reasonable. Unfortunately, though excellent in theory, it failed in practice. Firing lines could be built up at anything from 50 to 500 yards from a hostile trench, but they could never manage to gain fire-superiority, which was found to depend, not only on rounds fired, but on hits obtained on the enemy.

F.S.R. with further and more recent experience to draw upon, now admits that " . . . it is only in exceptionally favourable circumstances . . . that infantry in the attack can produce such fire-superiority unaided. . . ." (*F.S.R.*, 10 (3)), but unfortunately they do not think it necessary to give any reasons. Probably the authors considered the reasons to be so self-evident that they thought it superfluous. Had they done so they might have forced some modern tacticians to explain how the vision can be assisted by enclosing the eyes in an armoured box, or how the aim will be improved by getting into a fast-moving vehicle. In short, how thick armour or high speed can possibly compensate for lack of a visible target !

There are some indications that the distinguished authors of *F.S.R.* did not feel too sure about this business of armour and the tactics associated therewith ; for example, after informing their readers that " Armoured units possess the characteristics of fire-power, mobility, and protection by armour " (*F.S.R.*, 13 (1)), they go on to assert that " These three attributes are *interdependent*," leaving the uninitiated to wonder how " protection by armour " can depend on or assist " mobility," or how either of these two things can affect fire-power ! Nor is this the only peculiarity about " armoured units " ; for, if some of their protagonists are to be believed, it seems that not only do they possess " great mobility," despite their heavy load of armour, but also—even more remarkable—defying relativity, their high speed enables them to shoot down any enemies who oppose them on foot, while preventing these enemies from hitting them.

No wonder *F.S.R.* declare that " they exercise great moral effect," and history seems to bear out the statement. General Fuller has recorded that at Cambrai, on November 20th, 1917, " as the tanks moved forward with the infantry following close behind, the enemy completely lost his balance and those who did not fly panic-stricken from the field, surrendered with little or no resistance " (*Tanks in the Great War*, by Colonel J. F. C. Fuller, p. 145).

This is very interesting, but it would be still more interesting to know exactly why this " great moral effect " seemed to vanish into thin air when the British tried to renew their advance on the following days; for the very same enemy, after fleeing in panic from the strongest position ever constructed, and losing almost all his artillery —his only anti-tank armament—in the process, yet managed to close the gap made in his line and to deliver a highly successful counter-attack. It would be interesting also to know why this " great moral effect " had been so little in evidence during the preceding months on the Somme, at Arras, and at Ypres.

At Cambrai, of course, the tanks were present in considerably larger numbers than on any previous occasion; it has been claimed that Cambrai was the first occasion upon which the tanks were used as their inventors had intended, in masses instead of in " driblets," as on previous occasions, and that their success in this battle was largely due to this fact; but even admitting the justice of this contention, it hardly explains why driblets should have been useless before Cambrai and yet extremely effective afterwards. Here are the numbers of tanks taking part in the various actions before and after Cambrai, as given by General Fuller :—

Before :		
Sept. 15th, 1916	The Somme	49
April, 1917	Arras	60
June, 1917	Messines	76
July, 1917	Ypres	216
Nov. 20th, 1917	Cambrai	378
After :		
July 4th, 1918	Hamel	60
July 18th, 1918	Soissons	225
Aug. 8th, 1918	Amiens	415
Aug. 9th, 1918	,,	145
Aug. 10th, 1918	,,	67
Sept., 1918	Epehy	20
Sept., 1918	St. Quentin	175
Oct., 1918	,,	82
Oct., 1918	Selle	48
Oct., 1918	Le Cateau	37
Nov., 1918	Valenciennes	37

Statistics proverbially can be made to prove anything, but there seems to be enough in these to show that the question of moral effect is not entirely disposed of by this argument. There may be more in it than meets the eye. General Fuller has more to say on the subject; he records that: "Since the German High Command could explain away failure in the event of tank attack, the German regimental officer very naturally came to consider that the presence of tanks was a sufficient reason for the loss of any position entrusted to his care. His men came to consider that in the presence of tanks they could not be expected to hold out. Most German officers when captured were anxious to explain that they had done all that could be expected of them. From this time onwards (August, 1918) their explanations became very simple—'The tanks had arrived, there was nothing to be done'" (*Tanks in the Great War*, pp. 239 and 240). Later he recounts an episode in which three supply tanks arriving at the front to find an infantry attack held up, at once advanced upon the foe, and procured the surrender of a large party of Germans who up to that moment had defied all attacks.

This is moral effect with a vengeance. It seems that the German Great General Staff, in its anxiety to retain the confidence of their men, managed to destroy the confidence of the latter in themselves!

General Fuller mentions that even when the Germans were served out with anti-tank rifles, they would not use them. "It is doubtful," he writes, "if one per cent. of the anti-tank rifles captured in our tank attacks had ever been fired at all" (*Tanks in the Great War*, p. 263).

From the British point of view these results of tank warfare could hardly have been bettered; and when time has allowed the Germans to take a dispassionate view of their actions during these stirring days, another testimonial to the low cunning of the perfidious Albion will doubtless be forthcoming. At the same time, in assessing moral effect in the future, it might be wise to discount that portion of it which is due to psychological factors like the reputations of Staffs and Generals. Future enemies may be led by some thick-skinned ruffian whose reputation rests securely on the bodies of enemies laid in the dust and who does not care two hoots in Hades what his followers think of him so long as they stand up to the enemy. Moral effect is notoriously difficult to forecast and although it can be produced, as in the Great War, by bluff and propaganda, in the end the effects obtained by these means are not likely to be so permanent as those produced by solid achievement. It is wise to remember also that all the feats which General Fuller and others record with justifiable pride were performed against enemies who possessed hardly any anti-tank armament and who would not use the little they had.

Such a situation is not likely to recur; for it is to be observed that a variety of specialized anti-tank weapons are making their appearance, some of them, like the super H.V. rifle (described in the *R.U.S.I. Journal* of February, 1934), quite handy and portable, but which no practicable thickness of armour will resist. In this dilemma the armoured warrior usually abandons arguments based on protection and falls back on others based on mobility or on numbers; the old idea, in fact, of the rapid mass attack which was the foundation of the pre-war French and German infantry doctrine. Colonel Martel, for example, suggests that " . . . the light tanks should have no difficulty in subduing all opposition provided they are used in large numbers. It is these large numbers, again, that will provide safety against anti-tank weapons, for the attack of a swarm of these small fighting vehicles, moving at high speed, will have a most demoralizing effect on the defence" (*R.E. Journal*, Vol. 42, p. 444). Infantry experience hardly suggests that any numbers or any speed will be capable of driving home a charge against a determined and well-organized defence, else masses of cavalry might have succeeded where masses of three-mile-an-hour foot-sloggers failed; but even if it be conceded that a sufficient increase in speed of advance would enable a proportion of the attacking units to reach the hostile position undamaged, this can hardly be called " safety." It would be more correct to describe it as the deliberate sacrifice of some of the attackers in order to enable the remainder to begin the fight. It is hardly necessary to add that these tactics, which were not a British invention, are most unsuitable for an army dependent on voluntary service, and still more so for one composed principally of expensive armoured vehicles.

On all these grounds the specialist will be reluctant to subscribe to the view that the business of attack can safely be entrusted to " armoured units " alone. There remain two other fighting arms to which he can still look for help—artillery and engineers. Hitherto, except in siege warfare, the role of the engineer has been mainly defensive, while as for the artillery, the gunner has been singularly modest in the matter of suggesting himself for a more prominent part in the most important operation of war. Although the casualties inflicted by artillery in the latest and greatest of all wars probably exceeded those caused by all other agencies put together—at any rate in its later stages when all the combatants had learnt something about modern fighting technique—there has been a remarkable reluctance on the part of *Field Service Regulations* to allow the artillery any share in the task of " destroying the enemy." In the past the artillery was required only " to give all possible support to the infantry " and " to assist the infantry in retaining its mobility and offensive power," and even now, after the experiences of 1918,

F.S.R. will concede no more than that "Artillery is used, in co-operation with other arms, in order to gain fire-superiority." Bearing these experiences in mind, the specialist will wonder wherein precisely lies the difference between "gaining fire-superiority" and "destroying the enemy," and whether the step forward from one to the other might not be managed.

F.S.R., which does not go into any details as to how fire-superiority should be obtained "in co-operation with other arms," is not very helpful in this matter; fortunately war experience is more enlightening, for an operation took place right at the end of the war which provides a very striking example of what can be done in this direction.

This operation—the battle of Valenciennes—has been rather overshadowed by the armistice, which followed a few days later, and not very much has been heard of it. As it took place at the end of a long advance it can legitimately be regarded as an operation of mobile rather than of static warfare. It has been described by a thoroughly competent authority. Here are a few extracts from his account:—

"The battle," writes General McNaughton,* "in addition to being one of the best examples of masses of artillery in the intimate support of infantry, is of particular interest because . . . it well exemplifies the long-standing policy of our Corps Commander . . . to pay the price of victory, so far as possible, in shells and not in lives of men." The operations began on October 24th, and by October 26th the British XXII Corps had "secured the German defences south of Famars and were overlooking the valley of the Rhonelle river, but the enemy retained possession of Mount Houy, the prominent hill feature some two miles to the south of Valenciennes on the tongue of high ground which slopes downwards to the north between the valleys of the Rhonelle and the Escaut. . . . This ridge . . . constituted a veritable bastion in the enemy's line . . . and was in fact one of the pivots on which depended the stability of the German defensive position for many miles both north and south."

On October 28th Mount Houy was attacked again, this time by the 51st Division, but without success. ". . . For more than a precious week, in the face of repeated attacks . . . the enemy had been able to hold up an advance of vital significance. . . . The determined resistance of the enemy, his repeated counter-attacks, his steadily increasing artillery fire, and the reported arrival of additional batteries, were conclusive proof that he still attached importance to the position and that its possession would be stoutly contested."

These were the conditions under which the Canadians took over

* *Canadian Defence Quarterly*, April, 1933: A lecture delivered to the U.S. Institution of Canada by Maj.-Gen. A. G. L. McNaughton, C.B., C.M.G., D.S.O. (late Chief of the Canadian Section, Imperial General Staff).

the responsibility for the assault. Their attack was most carefully organized; " . . . the infantry plan was . . . determined so as to take full advantage of the artillery, and the numbers in the advance were cut down to a minimum." The artillery plan included concentrations, harassing fire, rolling barrages, and counter-battery neutralizations. Practically the whole of it was predicted and based on maps and survey. This is what happened:—" At zero hour 0515, 1st November, the execution of the pre-determined plan commenced; a deluge of shrapnel, machine-gun bullets, high explosive shell, of an intensity the like of which has never been approached, swept down on the enemy from front and flank and rear. The barrage moved forward steadily and slowly, precisely according to schedule; the infantry platoon commanders manœuvred their men securely screened by a dense wall of shrapnel, smoke, dust and debris thrown up by the high explosive and were on the enemy before those that were left alive could recover from the inferno through which they had passed. Prisoners, stupefied and demoralized, surrendered freely; in one case a company officer gave up his whole command, saying that 'it was impossible to see or even form an opinion as to which direction the attackers were coming from'."

The infantry attack went forward with hardly a check. The enemy's artillery whose " retaliation was prompt and heavy " was soon overcome by the superior strength and better tactics of the Canadians. At 1230, with the infantry everywhere on their final objective, " . . . there were indications of a counter-attack," but eleven batteries of 6-in. howitzers " . . . rolled an intense barrage, using 106 fuze, across the enemy in their assembly positions and wrought terrific havoc."

" At daybreak on November 2nd the enemy was in full retreat and we in close pursuit . . . reconnaissance of the captured territory revealed some interesting facts . . . enemy dead were everywhere, in rifle and machine-gun pits, in trenches, and sunken roads, in the open, in the rows of houses demolished by the siege howitzers; the concentrations, particularly those in enfilade on railway cuttings and other defiles, had left a shambles; the harassing fire on the sunken roads . . . used by the enemy for the movement of reinforcements and ammunition had in many cases blocked the cuttings with destroyed vehicles and dead animals and men. Over 800 enemy dead were gathered and buried in the Mount Houy area alone; 75 wounded and 1,379* unwounded prisoners were taken." The account concludes: " Our casualties all told, including those in battery positions severely bombarded at zero and before, amounted to 60 killed and 360 wounded . . . the task laid on the artillery by

* This number exceeded the numbers of the attacking infantry.

the Corps Commander had been discharged. The Canadian Corps had paid for victory, decisive, far-reaching, and complete, as he had ordered—in shells and not in life."

The example is certainly impressive ; it shows that artillery can do much more than merely gain fire-superiority. Given certain conditions it can " destroy the enemy " with an economy in life rarely approached by infantry or any of the other arms hitherto regarded as sole specialists in this task. Before the specialist adds artillery to the number of these, however, he will want to know whether its methods and its equipment, designed for the quite different role of support, are suitable for the new purpose. He will observe that the restriction of the artillery to the role of support only, has caused not a few soldiers to expect the gunner to include a high proportion of harmless smoke shell in the very modest ration of ammunition that the high-priests of mobility will allow him to carry. Nor is this the only respect in which action intended for support differs from that intended to destroy outright. Fire intended for support of infantry must be maintained throughout the duration of the infantry advance, and a large number of shells are required if they are to produce any useful effect over so long a period ; moreover, as the shells will achieve their purpose if they make the enemy keep under cover, there is no need for them to hit anything in particular ; it will be sufficient if they burst with a good loud bang somewhere near where the enemy is hiding. To destroy the enemy, on the other hand, the fire *must* be accurate ; unless the shells hit their target they will not do their job at all. While if the aim is correct, a very few shells will be sufficient and it is best to concentrate these few into the shortest possible period, so that the fire comes upon the enemy in a sudden fierce burst from which escape is impossible.

If, as must be admitted, there is likely to be difficulty in providing large numbers of guns, or in carrying about large quantities of ammunition, there can be no two opinions as to which is the better *modus operandi ;* but unfortunately the latter depends not only upon guns which will, and gunners who can, shoot straight, but also upon the ability to discover and accurately to locate targets for them. *F.S. Regs.* agrees (Sec. 11, 14) that " when the enemy dispositions are known in considerable detail it may be effective and also economical . . . to employ concentrations of fire on selected areas, particular attention being paid to the probable positions of hostile machine-guns " ; but, on the other hand, they state that : " a barrage is the simplest and most effective method of giving support when it is not possible to locate enemy positions with accuracy." They do not say when the enemy dispositions are likely to be known in considerable detail or how his positions should be located " with

accuracy " if they are not. The specialist, however, will at once notice that here is more specialist work, for the location of anything " with accuracy " is the ordinary work of the surveyor—though the gunner sometimes likes to call it " registration " and to do it with an 18-pdr. gun !

All the same, notwithstanding anything the gunner may say, there are better survey instruments than the 18-pdr. field-gun, though impatient generals may not always allow time and opportunity for using them. Unfortunately all survey processes, including registration, require a visible " target," and since the enemy cannot be expected to parade for inspection, it does not seem—at any rate at first sight—that many opportunities of locating him " with accuracy " will be forthcoming.

The task is, however, worth attempting, for if the enemy cannot be located there is no choice but to fall back on the old plan of sending forward men to seek him out and fight him at close quarters ; and whether these adventurers are clad in armour, or in plus-fours and deer-stalkers, adequate steps must be taken to prevent the enemy firing at them while they are advancing. It must not be forgotten that the defenders may be specialists too, and so well equipped and so expert at their job that, if even one can get to work, he may bring the whole plan of attack to nought. The alternative to locating the enemy's positions " with accuracy " is large numbers of guns and great quantities of ammunition, and all the objections and drawbacks associated therewith.

Examining the task, it will be agreed that if the enemy himself cannot be seen, the next best thing is the exact location of any natural cover in which he may be lying concealed, and this the specialist will recognize at once as the ordinary job of the map-maker. It is true that the map-maker does not normally reckon to do his job in war, but thanks to the invention of air photography this is not now impossible, though a technique rather different from that most suitable in the less exacting conditions of peace may be required. It is sufficient to say that here is yet more specialist work and that if it can be done in good time the soldier can approach the difficult business of locating the enemy much more hopefully than before. When the cartographer has contributed his bit the character of the problem changes. Instead of the difficult one of locating newly-discovered objects, it has become the much simpler problem of identifying objects already located in which the enemy is taking cover. Whether it can be solved in its new form remains to be seen, but the specialist will notice that it is much more likely to be solved by men equipped with binoculars than by men armed with bayonets ! Perhaps if the infantry cannot find a satisfactory solution it may be necessary to call upon the specialist again. The Sapper in the past

has found answers for problems not less difficult, and if he can solve this one he may not only save many a brave man's life, but also bring consolation to the politicians and the pacifists by the thought that if, unhappily, they do not succeed in abolishing war altogether, they may be able to look forward to a better and brighter brand than that which now offends them. A type of war in which the civilized and cultivated soldier, instead of having to rush out upon his foes boxed up in an extremely expensive and exceedingly uncomfortable armoured vehicle, or hung round like the White Knight with impedimenta, shoots him down in comparative security from behind the nearest hill.

The latter method may require a little more organization or a little more time, trouble, and forethought, but that should be no great objection to a technique intended for the use of educated, intelligent, professional soldiers. At all events, it may be said that surveying a target should be decidedly more interesting, if less exciting, than being one, and it should also be decidedly healthier !

A.A. DEVELOPMENT IN THE ROYAL ENGINEERS.

By CAPTAIN J. H. BOYD, R.E.

ANTI-AIRCRAFT searchlight work is one of the most recent forms of R.E. co-operation; already a very important one, the political situation and public opinion in regard to air defence at the present time tend to give it a dominating character. In 1933, when the regular army was at its lowest, provision was made for the conversion of various Territorial Army units to anti-aircraft, and in 1934 a small increase in the size of the Regular Army was entirely accounted for by additional A.A. personnel. This branch of R.E. work is then of increasing importance to all officers of the Corps, and it is of interest to trace the development of A.A. units both during the war and since the Armistice. In some other countries anti-aircraft searchlights have been organized as part of the anti-aircraft gun units, or as part of the defensive air forces, but the advantages and disadvantages of these systems are controversial questions into which it is not proposed to enter here; the purpose of this article is purely to give a brief account of the development of A.A. as applied to the Royal Engineers of our own army. Neither is it proposed to describe in any detail the evolution of equipment, a process which would appear to have lagged behind the vast improvement in performance of modern aircraft. This appearance is perhaps more imaginary than real, and due to the financial stringency rather than to lack of research or experiment.

Aircraft had been employed in 1911 by the Italians in the campaign in Cyrenaica; but at the outbreak of the Great War in 1914 the potential power of the new weapon was not fully realized among the belligerent nations, and little thought had as yet been given to methods of defence against it. It is true that a few one-pounder pom-poms for A.A. purposes had been installed in our East Coast defences, and experimental 3″ and 4″ A.A. guns had been designed, but most of the guns required immediately after the declaration of war had to be improvized by the conversion of existing pieces, more or less unsuitable for the purpose.

Still less thought had been devoted to the problems of night defence. Aeroplanes were as yet incapable of regular night flying, and though the danger from airships was to some extent realized, the general opinion seems to have been that searchlights were unlikely to be of any effect against aircraft. Early in the war each field

company was issued with two 10″ acetylene projectors for purposes that were not clearly specified, and some of these were tried against Zeppelins in the early stages of the war, but their range was too low to be of any practical value. It seems, however, that there must have been some attention paid to the design of special A.A. searchlights prior to August, 1914, as a few 60-cm. projectors and even one special A.A. 90-cm. projector were available for issue at home in the first month or two of war.

Except for one section in Italy, there is no record of A.A. searchlights being used on fronts other than in France and Flanders. Development proceeded on rather different lines with the Expeditionary Force in France and in the home defences, the difference being to some extent perpetuated to this day between the requirements of mobile and fixed or semi-fixed defences.

A.A. Organization in France, 1914–1918.

1915.—In March, 1915, the threat of Zeppelin attacks and the inadequacy of 10″ acetylene projectors caused the Commander-in-Chief to demand three or four searchlights suitable for use with anti-aircraft guns against airship attack by night. Accordingly No. 1 A.A. Section, R.E.—one officer and nineteen other ranks with three searchlights—was formed at Chatham, and sent over to France in April. This section was allotted to the defence of G.H.Q. at St. Omer. In response to a further demand No. 2 Section was formed at Plymouth, sent over in July and allotted to the base defences at Boulogne.

The equipment of these sections consisted of 60-cm. projectors and small stationary generating sets. They must have justified their existence, for at this time only airship raids were expected, and the Zeppelin commanders were very chary of getting within range of the searchlight beams; further searchlights were demanded from home. On one occasion late in 1915 it was reported that a hostile night-flying aeroplane had been picked up and held for half a minute by the beams.

1916.—During the winter of 1915–16 more sections were sent out to France equipped with 60-cm. projectors, and allotted mainly to base depots and the more important headquarters. They were still fairly efficacious against Zeppelins, but aeroplanes were now beginning to fly regularly by night, and creating a much more difficult problem for the anti-aircraft defences. During the battle of the Somme the enemy repeatedly flew low over the roads behind the front at night, causing serious dislocation of the administrative services which had to be carried out during the hours of darkness. In consequence two sections of A.A. lights, soon joined by a third, were sent up close to the front; the enemy was forced to fly higher

and the damage and dislocation greatly reduced. Actual detection and illumination of targets in these front areas was, however, still extremely rare due to a variety of causes ; the chief of these were the unsuitability of the equipment, the inexperience of the detachments, and the excessive noise of guns and transport near the front, which drowned the sounds of the aircraft. At the time, of course, the detachment's own ears were the only means of detecting the approach of hostile aircraft.

1917.—On the night of 8/9th February, 1917, it was credibly reported that one enemy aeroplane was shot down in the searchlight beams. This report was not confirmed, but it appeared to have been the first occasion on which a positive success was claimed for anti-aircraft guns at night working with searchlights.

The number of sections in France had by this time necessitated an Inspector of Searchlights attached to G.H.Q., and one was duly appointed in January. His influence in co-ordinating training and tactics, and his reports on the deficiencies of the equipment, resulted in a great increase of technical efficiency during the year. His first step was to condemn the 60-cm. projectors as being of insufficient power and range to take on aeroplanes with success, and to insist on their replacement at the earliest opportunity by 90-cm. A.A. projectors. Most of the replacements were carried out during the spring and summer. Simultaneously the introduction of the long-arm control placed the man actually directing the beam some fourteen feet away from the projector, enabling him to get a clearer view of the target, with a consequent improvement in picking up and holding.

The increased experience and better training of the detachments also added to the efficiency of the A.A. units, and we find that in the summer of 1917 large numbers of targets were picked up and held. There is still little record of their being shot down, but this seems to have been due more to the inadequacy of the guns than to that of the searchlights. The enemy in general was at least forced to fly over the defended areas at heights of 10,000 feet or more, and the effectiveness of his reconnaissance or bombing raids accordingly reduced.

Early in 1917 the new sections as they arrived in France were mainly allotted to ammunition depots and dumps, priority being given to whichever vulnerable area was receiving the most attention from the enemy at the moment. They were controlled and sited by the commanders and staffs of the particular areas in which they happened to be stationed, and the three lights of a section were usually sited in a triangle round the point they were required to defend. The enemy soon learnt this, and though he might fly high when on the look-out for a good bombing target, he not unnaturally was drawn to the centre of the triangle like a moth to a candle. In order that inexperienced staffs should not fall into this error of giving

the enemy a guiding triangle, the lights were reorganized into two-light sections. The logic of the reasoning is not very apparent and not till the following year came full appreciation of the principle that night defence, to be effective, involved continuous illumination of the target for a considerable period. An isolated section of lights does little real good against a determined enemy, and only serves to point out the target to him.

During the latter part of this year some sections were again sent forward and night defences were organized in the areas round Ypres and Béthune.

1918.—During the early part of the last year of the war, the German bombers were attacking railway junctions with some persistency, and in consequence A.A. searchlight sections were allotted to the more important. More sections were also sent up to the forward areas. Equipment was now almost entirely 90-cm. projectors, but still with stationary generating sets, and during the German attacks in March and April fourteen sets of equipment had to be left behind and were captured. This loss accentuated the need of mobile equipment, a need which had already received some consideration owing to the obvious desirability of being able to shift searchlights at short notice from one area to another more seriously threatened. G.H.Q. pressed for the necessary replacement, and so 1918 sees the gradual introduction in France of the petrol-electric lorry, a vehicle which had already been in use for some time at home, and which could not only transport the projector and its equipment, but also supplied the power for the searchlight.

The most important development of 1918 was, however, the creation of a Night-Fighter Squadron. No. 151 Squadron R.A.F. was ready for action in June, and its sole function was to operate against enemy aircraft flying by night behind our own lines. For the first month or two the squadron was not very effective, as the groups of lights were too far apart to give the pilots a fair chance of seeing and catching their quarry. When it was realized that continuous illumination of the target for five to ten minutes was essential, a wide belt of searchlights was formed in 151 Squadron's operating area; this measure, combined with more experience of searchlight detachments and fighter pilots working together, was so successful that in the late summer and autumn the squadron shot down 25 hostile aircraft. Several more night-fighter squadrons were authorized but only one came into existence before the Armistice.

In consequence of this new form of defensive co-operation, the policy of distributing the ground defences in small packets was abandoned, and instead all A.A. searchlights were to be sited in a continuous belt close behind the front line—this should afford protection to all the back areas and only at a few of the most important vulnerable points such as base depots might it be necessary to

instal local night air defences. It was considered that four rows of lights would form a belt sufficiently wide to enable effective action by defending fighter aircraft or by A.A. guns to be taken against hostile aircraft attempting to cross over. (This compares closely with the policy at the present day, when the speed of aircraft has doubled and seven or eight rows of lights are considered necessary to form an effective defensive belt.) The system was still in the process of formation when the war ended; there were three rows of lights behind most of the front line, in some places the full four rows were complete, but in others still only two. The forward row varied from 2,000 yards to 6,000 yards behind the front line localities.

As regards equipment, demands were sent to England during the summer for 120-cm. in lieu of 90-cm. projectors in order to give better co-operation with the night-fighter squadrons, and to deal more effectively with the higher flying targets. Very few 120-cm. projectors actually reached France, and the wisdom of the change seems doubtful as it was in contradiction of another requirement —that of mobility. During 1918, also, a number of early-pattern sound-locators were sent out. Comparatively little value was derived from them, however, on account of the noise of the front areas where nearly all the lights were now congregated, and of the complete lack of knowledge and training of the detachments in the use of these instruments.

During the final advance the searchlights, or at least those of them that were mobile, were found to be invaluable for illuminating railway and bridge construction. No doubt such of the men as were trained Sappers were also useful to help in the constructional work.

November, 1918.—During the year the A.A. searchlights were reorganized into three-light sections—at no time does there appear to have been any unit higher than the section in France. By the Armistice, there were 95 sections comprising 285 lights with some 3,000 men to man them. The majority of the personnel were Territorials from the Tyne Electrical Engineers and the London Electrical Engineers; a small proportion were Regular Royal Engineers, and there were some 300 category "B" men transferred from the infantry.

The following extract from the final report is of interest, as it forms the foundation of much of our post-war training and organization:—

> "Experiences in France have shown that an Anti-Aircraft Searchlight Detachment requires the best equipment, a high standard of training, and, wherever possible, complete freedom in control of action. An elaborate system of central control, such as has sometimes been found necessary in connection with the defence of large ammunition depots, has undoubtedly hampered the working of the lights in action; and it is therefore suggested

that they should be developed independently of the anti-aircraft artillery, as their work in the future will lie more and more in co-operation with night-flying units of the R.A.F."

A.A. Organization at Home, 1914–1918.

1914.—Except for certain anti-aircraft guns and a few searchlights sent to co-operate with them in the East Coast defences, the early A.A. defences, particularly in the London area, were in the hands of the Admiralty. The equipment consisted of 60-cm. projectors, mounted on petrol-electric lorries, which could follow the guns, which were also mobile, into action.

1915.—The amount of A.A. equipment was very limited, and the tactics adopted appear to have been to wait in barracks in readiness, after the manner of a fire engine, until warning of an approaching raid was received. The gun, and attendant searchlight if available, would then run out to some point on the probable line of approach of the Zeppelin and come into action. Attempts were even made to pursue the enemy across country, coming into action if he were caught up. Effective interceptions of raids by these methods were rare, and it became obvious that many more guns and searchlights were required. The defensive measures were thereupon taken over by the War Office, and controlled later by Headquarters of the Home Forces in the Horse Guards. In December, companies of A.A. searchlights were formed by various Territorial Army units, including the London Electrical Engineers, Tyne Electrical Engineers, the Hampshire, Kent and Essex Fortress R.E. These companies were distributed between the defences of London and the industrial cities of the Midlands and the North.

1916.—Equipment was still mainly the 60-cm. projector, sometimes mounted on a mobile searchlight lorry and sometimes with stationary generating sets. Most of the lights were at first with the guns, to all intents and purposes forming part and parcel of the A.A. batteries; they were usually sited with one gun and one searchlight close together, on the principle that, whatever the searchlight could see, so could the gun. There was some discussion as regards this juxtaposition, which later experience proved definitely unsound for a variety of reasons.

Later in the year, however, the majority of the searchlights were organized into a rough belt some 25 miles from the coast, and they were already co-operating not only with guns but also with defending aircraft. The latter were not organized as special night-flying squadrons, but consisted of such aircraft as happened to be available, and of such individual pilots as had sufficient experience to take on a Zeppelin by night. The value of searchlight beams as pointers to

indicate the locality of a hostile raider to our aircraft was soon recognized, and during the year many enemy airships were shot down, often with the help of the lights. The Zeppelin menace was not serious after 1916.

1917.—This year saw a large increase in aeroplane raids on London and the South-East Coast, first by day, then by night, and reaching a climax in a series of big raids during the period of the harvest moon. More powerful beams were required than for dealing with airships, and large numbers of 90-cm. projectors were issued.

Inspectors of Searchlights were appointed for different areas, for in July there were 42 A.A. searchlight units scattered over the country, some of them still attached to A.A. batteries. General Ashmore took over control of the London Air Defence Area, and immediately began to reorganize and co-ordinate the whole system. In November these 42 units were reorganized into 12 companies, all independent of units of other arms. Before the end of the year the gun zones and defending fighter zones were definitely separated, and searchlight companies allotted to co-operate with each. Previously there was no co-ordination nor differentiation between the areas of the two active defence arms.

The London and Tyne Electrical Engineers assumed responsibility for all A.A. searchlight training, and took over the School of Electric Lighting at Gosport, which was temporarily renamed the School of Anti-Aircraft Searchlights and Sound-Locators.

Another step taken by General Ashmore was to reorganize the system of telephonic communications throughout the London defence. The effect of this was shown by one marked incident on the 19th October, on the occasion of the last big airship raid over this country. It was a very misty, cloudy night, and the Zeppelins were clearly finding navigation difficult; the searchlights were ordered not to expose as they could not penetrate the mist effectively and would only help to expose the defended areas. Many bombs were dropped on this occasion, but mostly in open country and hardly any damage was done.

1918.—The steady increase in quantity and efficiency of the A.A. defences continued; there was now less work for them to do, but their very efficiency was proving the best form of insurance. The sound-locator, first introduced in 1917, began to be issued in quantity, and proved its value; the necessity for quiet surroundings for it completed the movement for separating the searchlight from the A.A. gun. Most of the lights were now in more or less fixed positions, and it is interesting to note that, while in France the air defences started as fixed, they later turned over to mobile equipment, yet in England the procedure was reversed.

By April there were 17 A.A. searchlight companies, comprising 353 searchlights and 35 sound-locators. In November there must

have been nearly 500 lights and 200 or 300 sound-locators, employing some 4,000 men in all. New 120-cm. projectors were in the process of being issued to all stations, and this equipment has been in regular use by the Territorial Army ever since.

After the Armistice the main relevant recommendations from the Home Defences were that A.A. searchlights should co-operate with both the guns and with defending aircraft, but that these should be in separate zones; and that every searchlight should be equipped with its own sound-locator.

Post-War Development.

1st A.A. Searchlight Group.—In 1920 it was decided to form at Blackdown in the Aldershot Command the 1st Air Defence Brigade as part of the Expeditionary Force; it was to be composed of two anti-aircraft brigades R.A., one searchlight battalion R.E., and a signals company. It may seem strange, in view of the G.H.Q. recommendations after the war, that the searchlights were brigaded with the artillery, but it must be remembered that these recommendations were based on the experience of a national war, whereas the reorganized Expeditionary Force was designed for smaller wars, in which the gun would be the only anti-aircraft weapon available.

The original nucleus of the new battalion was formed from the remains of the 3rd A.A. Company from Leeds and the 17th A.A. Company from Biggin Hill, which arrived at Blackdown in November and December, 1920. They amounted to only eight other ranks in all, and by March 31st, 1921, the total had sunk to five. Not until September, 1922, when the battalion absorbed the personnel of the disbanded Mobile Searchlight Groups from Ireland, was there any considerable accretion of strength. In March, 1923, there were sufficient officers and men to form headquarters and one company, and in the latter part of 1924 the battalion reached approximately its full peace establishment of 20 officers and 557 other ranks.

The peace establishment originally was a small headquarters, two higher and two lower establishment companies. This actual organization was not completed until January, 1927, when the fourth company was formed, immediately after the battalion had moved into North Frith Barracks, a hutted barracks which had been reconstructed specially for its accommodation. In 1932 one of the lower establishment companies was abolished and a Headquarter Wing substituted, the other one being retained as a training company. This organization was more suitable to the increasing commitments of the battalion; as these latter tend to expand yet farther, there is every likelihood that more changes in the peace establishment may be necessary.

In May, 1935, the Battalion was re-designated the 1st Anti-Aircraft Searchlight Group. This followed a similar change in the designation of war establishments, as it was realized that the number of companies employed in any particular defended area would vary according to its extent and importance; the battalions would be nearly certain to be broken up to suit the defences, and the group organization is therefore more suitable as being more flexible. The strength of the group in peace will be four companies, but in war may vary from two to six companies.

The 1st A.A. Searchlight Group being essentially a mobile unit, it has been equipped throughout with 90-cm. projectors and generator lorries, formerly of war stock but latterly of new and more up-to-date pattern.

Regular Army Overseas.—The question of the anti-aircraft defence of stations abroad has but recently been taken up. In October, 1934, the 16th and 22nd Anti-Aircraft Searchlight Companies were formed at Malta and Hong-Kong respectively. These were re-named in May, 1935, in *Army Orders* announcing the formation of Fortress Royal Engineers at four stations abroad, which now include the following, of which the first three are entirely A.A. searchlight units, and the last two are mixed D.E.L. and A.A. searchlight companies.

30th (Fortress) Company at Malaya.
22nd (Fortress) Company at Hong-Kong.
16th (Fortress) Company at Malta.
1st (Fortress) Company at Gibraltar.
32nd (Fortress) Company at Gibraltar.

Hitherto no A.A. searchlight units have been formed for the Army in India, though at least one A.A. Battery R.A. is already borne on the Indian Establishment.

Territorial Army.—The whole of the air defence system of this country disappeared on mobilization, and the post-war reorganization became a responsibility of the Air Ministry. The Territorial Army, however, was entrusted with the provision of the ground units, and a start was made with the London defences in 1923–24. The London Electrical Engineers and the Tyne Electrical Engineers were naturally given the first chance of taking up the new work, having done so much during the war for its early development; moreover, they still numbered among their ranks many officers and men with considerable war experience. The Kent Fortress R.E. were also converted and fresh units raised in the counties of Essex, Middlesex and Surrey. Two battalions were formed from the L.E.E. as parts of the 26th and 27th Air Defence Brigades T.A.; the other units were organized as groups of independent companies for co-operation with fighter

squadrons of the Royal Air Force in the defence of London. The units still exist as then raised and are as follows :—

	Co. Numbers.
26th A.A. Searchlight Bn. (L.E.E.)	301, 302, 303
27th A.A. Searchlight Bn. (L.E.E.)	304, 305, 306
Surrey Group of A.A. Searchlight Companies	315, 316, 318
Kent and Middlesex Group of A.A. Searchlight Companies	313, 314, 317
Essex Group of A.A. Searchlight Companies	309, 310, 311, 312
No. 307 (Tyne) A.A. S/L Co.	307

These units are administered and trained by the Army, but for operational purposes they come under the command of the Air Officer Commanding, Headquarters Air Defence of Great Britain.

A few years later the defences of the Coastal Fortress areas were reorganized to include anti-aircraft, and again the job was entrusted to the Territorial Army. A.A. searchlight companies were formed, either by conversion of existing fortress units R.E. or by increasing their establishment and splitting them into two. The strength of these companies varied somewhat, depending on the size and importance of the fortress to whose defence they were allotted. They are trained and commanded through normal army channels. The following units were converted in 1932 to include an A.A. Searchlight Company :—

Carmarthenshire Fortress R.E.
Cinque Ports Fortress R.E.
Devon and Cornwall Fortress R.E.
Dorsetshire Fortress R.E.
Essex Fortress R.E.
Hampshire Fortress R.E. (two companies).

A year later, in 1933, the Aberdeen and Dundee Fortress R.E. also underwent conversion and were renamed :—

319th (City of Aberdeen) A.A. Searchlight Co. R.E.
320th (City of Dundee) A.A. Searchlight Co. R.E.

In June, 1935, it was announced that the following infantry battalions had expressed their willingness to be converted to A.A. Searchlight Battalions, Royal Engineers :—

6th City of London Regt. (City of London Rifles).
7th City of London Regt. (Post Office Rifles).
19th London Regt. (St. Pancras).
20th London Regt. (The Queen's Own).
21st London Regt. (1st Surrey Rifles).

These battalions will presumably each form three companies, the numbers and designations of which have not yet been published. They will supplement the units raised in 1924 in the task of the defence of the London Area, as part of the Air Defence of Great Britain.

CONCLUSION.

A little consideration shows the large proportion of the Corps absorbed into anti-aircraft duties, while further increase is being sought by absorption from outside sources. As regards the Regular Army there are five companies abroad, all or partially devoted to A.A. work, and but one A.A. Searchlight Group at home, but this is by far the largest R.E. field unit. An A.A. company is nearly 50 per cent. stronger than a field company; there are already twenty-six of them in the Territorial Army and fifteen more about to form. If we include these and compare the numbers of personnel employed on A.A. duties with those in field companies, we find that as regards the Regular Army the ratio is about 1 to 1 and in the Territorial Army 3 to 2.

Although in the last fifteen years the size of the Regular Army has suffered a general decrease, yet the air defence troops have steadily increased, and this tendency is likely to continue. Moreover, the R.A.F. are now committed to a big programme of expansion, including several new defensive fighter squadrons. These squadrons will require searchlights to make them effective by night; so will the new A.A. batteries which are being formed. Recent correspondence in *The Times* has already foreshadowed the formation of more Territorial air defence units, of which the announced conversion of five infantry battalions is but a beginning.

In the event of war in the next decade with any power within bombing range of this country, it seems that A.A. searchlight units will in the first instance make greater claims in numbers of personnel than any other form of R.E. activity, and public opinion will give those claims a high degree of priority.

THE RECONSTRUCTION OF AYUN BRIDGE.

By LIEUT. HON. R. J. NAPIER, R.E.

With Acknowledgements to "The Indian Concrete Journal."

GENERAL PROBLEM.

AYUN GOL joins the Kunar river some ten miles south of Chitral and has to be crossed by the road from Drosh to Chitral that runs on the right bank of the main river. This *gol* rises in glaciers in a branch of the Hindu Kush. In winter it is a stream a foot or so deep and 20 ft. wide, but in summer the water rises and rushes down with sufficient speed to take boulders half a ton or so in weight bumping along the bottom. Like most rivers in Chitral it is liable to mudslides. Heavy rain after a long dry period causes landslides and these dam up the river until eventually a mass of mud, boulders and water rush down the river, sweeping any obstruction away. Piers of even a temporary nature are out of the question from April until October, and hard frosts are to be expected after October.

PROPOSALS.

The old bridge, a suspension bridge of 168-ft. span with telegraph wire cables, had become dangerous owing to the rotting of both piers and road-bearers. The new bridge had to be made strong enough for infantry, pack animals, and two 30-cwt. lorries crossing at the same time; the problem of its construction was made more difficult by the fact that the site was 140 miles from railhead and a 10,000-ft. pass intervened. As early as 1928 the rebuilding of this bridge had been under consideration and a design had been prepared for two reinforced-concrete cantilevers 35 ft. long, supporting a 70-ft. timber girder bridge, the latter to be replaced by a permanent bridge at a later date. A concrete arch had been proposed, but the difficulty of supporting the centering had been considered to be too great, but it was thought that it would be possible to support the two 35-ft. cantilevers. A change in policy resulted in the postponement of the building of this bridge until 1933, when, in accordance with local custom, a design for a suspension bridge with a timber stiffening girder was prepared. It was estimated to cost Rs. 36,000. The Commanding Royal Engineer decided that for a little extra cost a reinforced-concrete arch bridge could be built. To overcome

the difficulty of supporting the centering, the reinforcement was to be made in the form of a steel arch of sufficient strength to carry the centering and the green concrete. The centering for the roadway could then be hung from the completed arches.

SOLUTION.

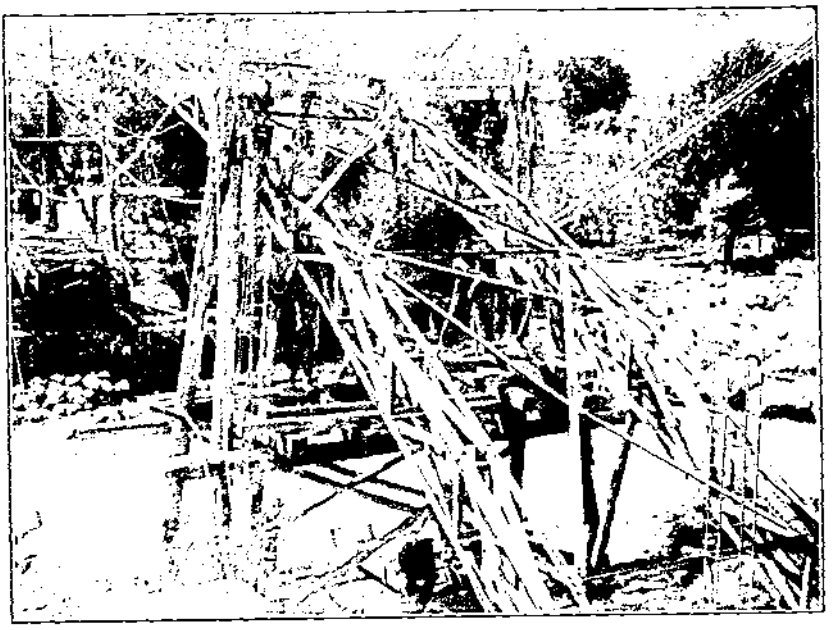
Messrs. J. C. Gammon and Co. were entrusted with the design and the provision of the steel. Their design provided for two reinforced-concrete arches of 140-ft. span spaced 10 ft. 9 in. centre to centre; the R.C. decking was 11 ft. 10 in. wide overall, supported by columns and hangers from the arches. This provided a roadway 9 ft. wide between kerbs and 154 ft. long. The order for the steel for the bridge was given on June 1st, and the Chitral Section, K.G.O. Bengal Sappers and Miners, to whom the task of construction had been allotted, moved to the site about twenty days later. A party lent by the contractors, consisting of an Indian assistant engineer, a mistry, a carpenter, a bar bender and two coolies, arrived with the plans of the skewbacks on June 24th.

FOUNDATIONS.

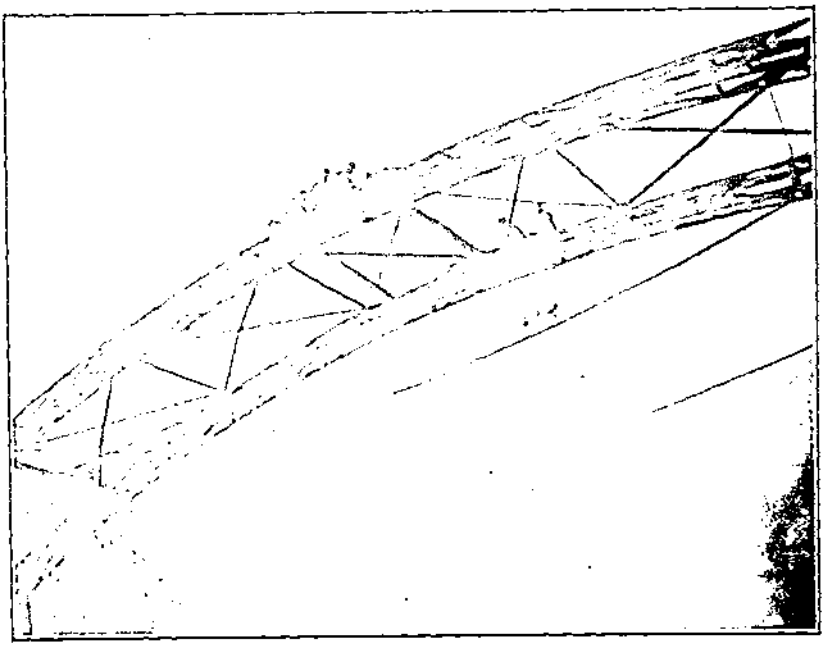
During July the section was fully employed on the excavations and on the construction of a cookhouse and guardroom, also the preparation of workshop benches, mixing platforms, stacking areas for aggregate, etc. Work on the centering could not be started until the middle of July, when the remaining drawings arrived. These had been delayed a fortnight owing to the lack of sufficient sun in Bombay to print them. The site for the new bridge had been selected on that of the old: this was the best site, also the old bridge was to be used for the construction. However, this site had its disadvantages, for the old bridge had to be kept open as long as possible. The skewback on the left bank came to within a foot of the line of the pier, so the pier had to be underpinned without hindering the traffic. This was accomplished by lifting on two 30-ft. spars lashed to the bottom of the pier and by lifting on wire ropes passed over an inclined trestle and fastened to anchorages.

Blasting could not be used to break up the huge boulders found during the excavation for the skewbacks. These boulders had to be laboriously lifted by jacks and a platform built underneath until they could be rolled clear without damage to the water channels that ran close by. When the last of the large boulders was removed on the right bank it revealed a large patch of sand. Further excavations reduced the size of the patch, but there still remained a pocket too large to excavate and fill with concrete. To increase the area of the foundation, the base of the skewback was stepped out, the extra area being slightly more than that of the sand pocket.

THE RECONSTRUCTION OF AYUN BRIDGE.

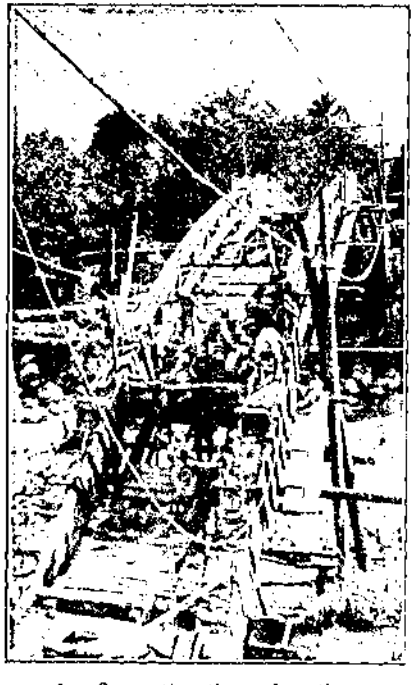


1.—Raising one half of the steel arch.



2.—Joining the steel arch.

3.—Fixing the extra reinforcement.



4.—Concreting the 2nd section.

5.—Fixing road slab reinforcement.

As a further precaution, six piles were driven into the sand. Five struck boulders and the sixth could not be driven more than six feet; all were extracted and the holes were filled with concrete which was joined to the base of the skewback.

Just after the completion of the foundations the specifications for the bridge arrived. The author's consternation can be imagined on reading the para. on foundations. "The ground should be such as to require cutting by hammer and chisel and to be capable of carrying a load vertically or horizontally of 10 tons per sq. ft." Hasty calculations showed that the pressure would not exceed two tons per sq. ft. and this was confirmed.

Composition of the Concrete.

There were three types of aggregate available locally, a hill gravel nicely graded and close at hand, a river shingle and hand-broken limestone metal. The latter was the most expensive and the former by far the cheapest. A large number of test beams were made up and these proved that the hill shingle was unsuitable, it was half-formed conglomerate and though the stones were separated many of them were coated with a skin which could not be washed off, but which broke away and destroyed the bond with the cement. A mixture of broken stone and shingle proved to be the best and was adopted. Void tests were taken to determine the best proportion of sand, which was found to be half that of the aggregate. A 1 to 6 mix was used for the foundations with ordinary Indian Portland cement, and the remainder of the bridge was completed with rapid-hardening cement, also of Indian manufacture.

Reinforcement and Centering.

During the second week in August the bar reinforcing steel began to arrive. This had been bent to facilitate carriage; the straightening out of these bars was commenced at once and it kept four men fully employed for over a month. The straightening proved a bigger task than the subsequent bending, which was carried out easily by an improvised bending machine. Meanwhile work on the centering was pushed on, the whole of the bottom of the two arches was completed, and sufficient side forms for three pairs of sections of each arch. For holding the bottom, hook bolts were made up from half-inch bars. These were in two parts joined by a nut of double length so that, after concreting, the lower portion could be unscrewed leaving a neat hole in the concrete. This contrivance worked well, but would probably not have been worth the labour expended in making up the nuts, had not the steel arch been delayed.

The whole programme of work had been based on the assumption of the arrival of the steel arch on site by 15th August, and it had been

estimated by the contractors that the work could just be finished before October 15th and the frosts. However, at about this time, they sent a revised estimate which gave December 1st as the probable date of completion. It was found out later that this was based on one set of centering for both arches. In spite of punctual delivery at railhead it was not till towards the end of August that the first parts of the steel arch began to arrive. Two bits were lost from the first consignment, and further losses seemed probable. The steel arch consisted of 1,300 pieces of about 70 different sizes, none of them interchangeable, and without spares.

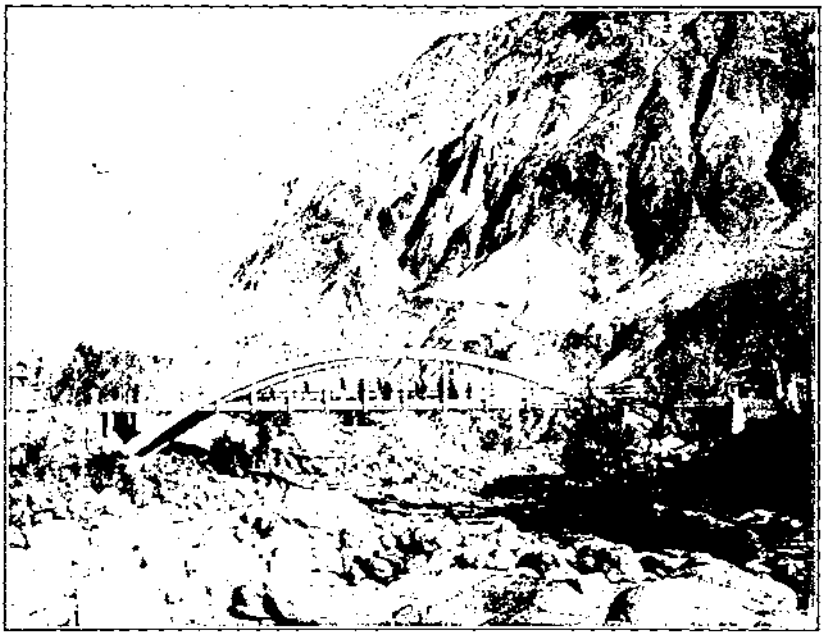
By the perseverance of Sjt.-Major Seamer and the M.E.S. the last consignment of steel arrived at Ayun on September 6th, having been unearthed from a Gujar camp on the road. On check it was found that only eight fish-plates were missing. Work was now 21 days behind programme and there seemed little hope of finishing before the frosts. Working hours were now increased to nine hours or more a day, and holidays were given after, on the average, ten days' continuous work.

LAUNCHING THE STEEL ARCH.

To facilitate transport it had been laid down that no member of the arch was to exceed 90 lb. in weight or 9 ft. in length. The manufacturers, Messrs. Dorman Long and Co., had suggested that the main members be 18 ft. long, as this would simplify construction and make a more rigid structure. The extra cost of carriage prohibited this, and the 9-ft. pieces were used involving the use of a large number of counter-sunk bolts. The half-arches were assembled on platforms on the ground. Each half-arch was painted a different colour and each joint was numbered; this proved a great assistance, but unfortunately the numbering did not quite coincide with that shown on the drawing. Further delays in assembly were caused by the necessity of counter-sinking some holes, re-drilling others and of re-threading some 400 bolts that had insufficient grip.

After assembly had been completed each half-arch was split into three parts: these were carried in turn on to the platforms built out on to temporary trestles on each bank (see diagram). Launching was done by booming-out the pairs of half-arches one at a time, the front being supported by two steel-wire cables slung from the old bridge piers. When the half-arches were far enough out the platforms were removed and the arch pivoted about the lower transom until it could be slid into the hinge. When fixed to the hinge the arch was pulled up by tackles from the temporary trestle and the old bridge trestle. When the second half-arch had been raised, both were lowered together joined in the centre. The joining was easily accomplished, the initial error in line was under three inches and a single bolt brought the whole in line. The erection took $4\frac{1}{2}$ days

6.—Completed bridge.



7 —Ayun bridge. Hills in distance run up to 16,000 feet.

and every available block and tackle in Chitral was used. The chain blocks gave great trouble, and a man had frequently to be sent up to hammer in a link. One old block, having no teeth on the gear wheel, was used as an adjustable sling in conjunction with a jack. During the launching of the first section of the south pier the leading chain block slipped, allowing the point to fall 12 ft. Fortunately, everything was very lightly loaded and nothing further gave way, but a severe twist had been given to the steel. When both arches had to be moved at once the whole section, including drivers, was insufficient to man all the tackles and a large number of the spectators were called on to help; they worked with a will, uttering the same cry that they use while beating *chikor*, or for that matter when they wish to intimidate a player at polo. With the shouting and the noise of the river spoken words of command were useless and all control had to be done by signal. From the foregoing account it may be thought that this method of launching involved the risk of damage by flood. In practice this was negligible for, except for the booming-out stages, the trestles could be dispensed with, and as at least two hours' warning of flood would have been received there would have been no difficulty in de-launching the steel if it was being boomed-out.

Concreting the Arches.

The fixing of the hangers, extra reinforcement, etc., now proceeded. The whole of the space between the arches was eventually filled in with scaffolding which speeded up the work considerably. At this point a local Notable on being asked what he thought of the bridge replied, "It is a marvellous bridge, far superior to any other I have seen, but I think loaded donkeys will find it a little steep."

At this stage the bulk of the cross-bracing between the arches was removed to enable the side shuttering to be fitted. This was an error, the bracing should have been concreted in and cut off after, though this would have undoubtedly left marks on the finished work. Before all the steel had arrived a small section had been erected to try out the shuttering. Owing to the large quantity of steel it appeared that great difficulty in pouring the lower layers of concrete would be experienced so the following precautions were taken:—

(*a*) The bottom clearance was increased from 1½ in. to 2 in.
(*b*) The sides of the forms were arranged so that they could be built up plank by plank.
(*c*) Half-inch aggregate was used for the bottom.

With these precautions and the help of vigorous ramming a concrete with a slump of 1½ in. to 2 in. was placed without a fault, and the use of a wet mix and extra cement was avoided.

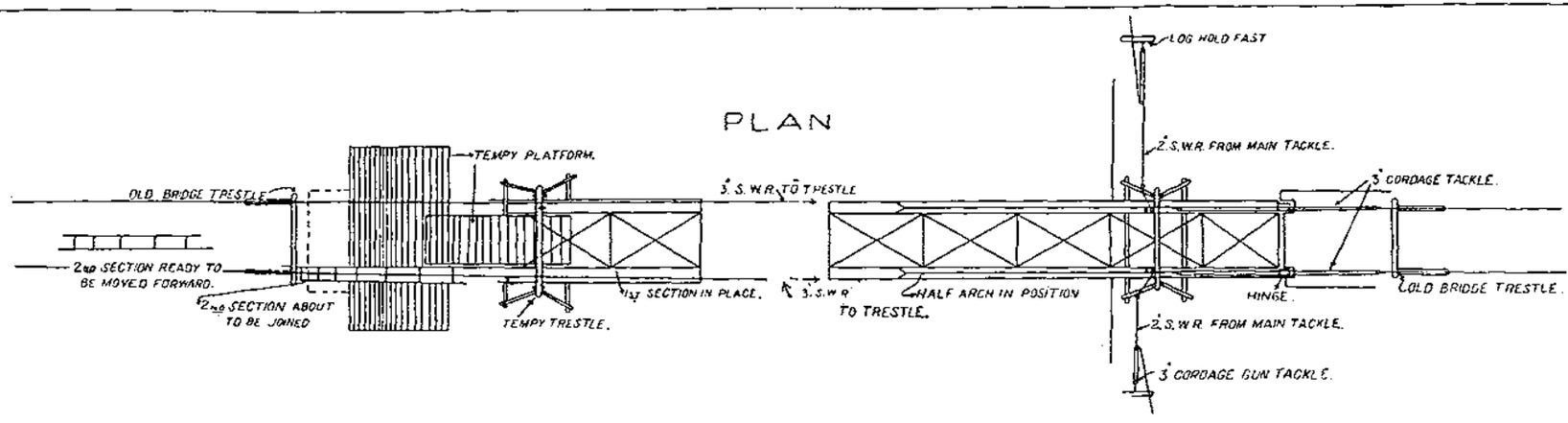
The mixing was carried out partly by hand, and partly by a small mixing machine driven by a home-made pelton wheel. One or two sections on each side of each arch were poured in a day, and top lagging was used for the lowest section. The order of pouring the sections is shown in Diagram 2. While pouring the fifth section the arch was found to have twisted at the centre; this had occurred after the pouring of the centre sections. Measurements showed that the arch had taken a slight lean as well, and tackles were fixed to try and correct this. They had little effect as it was considered risky to pull on them too hard, for fear of cracking the green concrete.

THE ROAD SLAB.

The completion of the arches had taken a month since the arrival of the steel. To avoid delay while the arch was setting, the centering for the portions of slab above the arch were now erected, supported from the launching trestles and struts from the ground. The pouring of these was commenced seven days after the last section of the arch had been poured. Centering for the suspended roadway was carried by beams attached to brackets made up and bolted to the hangers. With the centering released from the end bays sufficient forms were available for the centre eleven bays and the whole of this portion was concreted in one day, 800 cub. ft. in 8 hours.

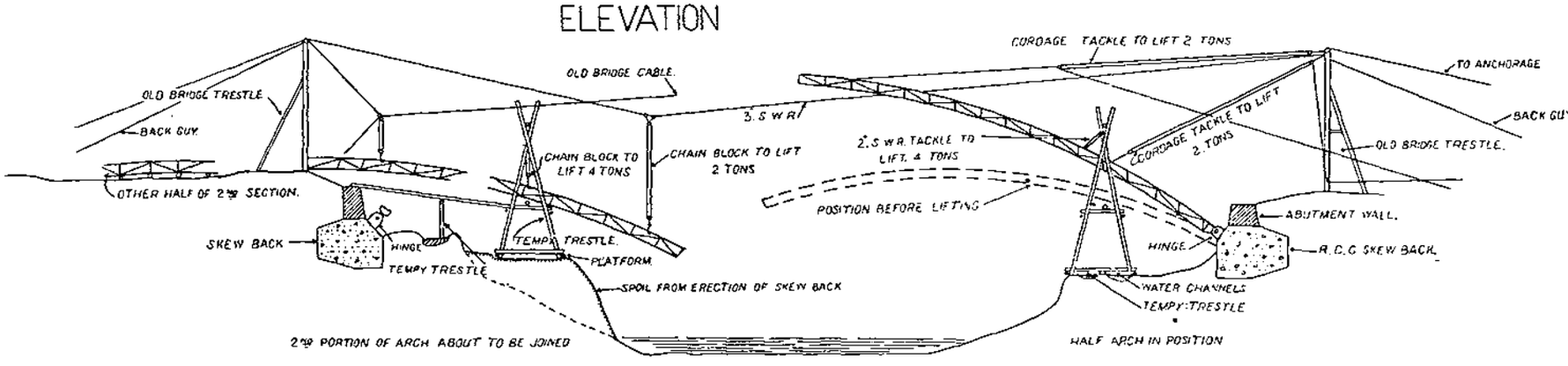
COMPLETION OF BRIDGE.

Seven weeks had now passed and fortunately the bulk of the concreting was completed, for a storm came and the weather changed to nightly frosts, so concreting had to be confined to a few hours in the middle of the day. There now remained the problem of pouring the hangers, it was feared that the shrinkage on setting would leave an unsightly crack at the top of the hangers. To avoid this a dowel $2\frac{1}{2}$ in. deep had been left projecting from the arches. The hangers were poured slowly, about 3 ft. per hour, and the forms were tapped well. The side through which the concrete was poured was built up stage by stage, the top sections being progressively smaller until the last section was only 3 in. wide. The last plank was so arranged that it acted as plunger compressing the concrete and it was only placed in position when all settlement had stopped. This system worked well and there are no signs of a joint at the top of the columns. The road surface was provided by a concrete slab $4\frac{1}{2}$ in. deep at the centre, falling to 2 in. at the sides; this large camber was to ensure no water should lie long enough to freeze on the bridge. Hexagonals of $\frac{1}{8}$-in. x 1 in. hoop iron, 2 ft. across, spaced 2 ft. apart, were used for crack control reinforcement. These are supposed to cause hair cracks all over the slab, thus



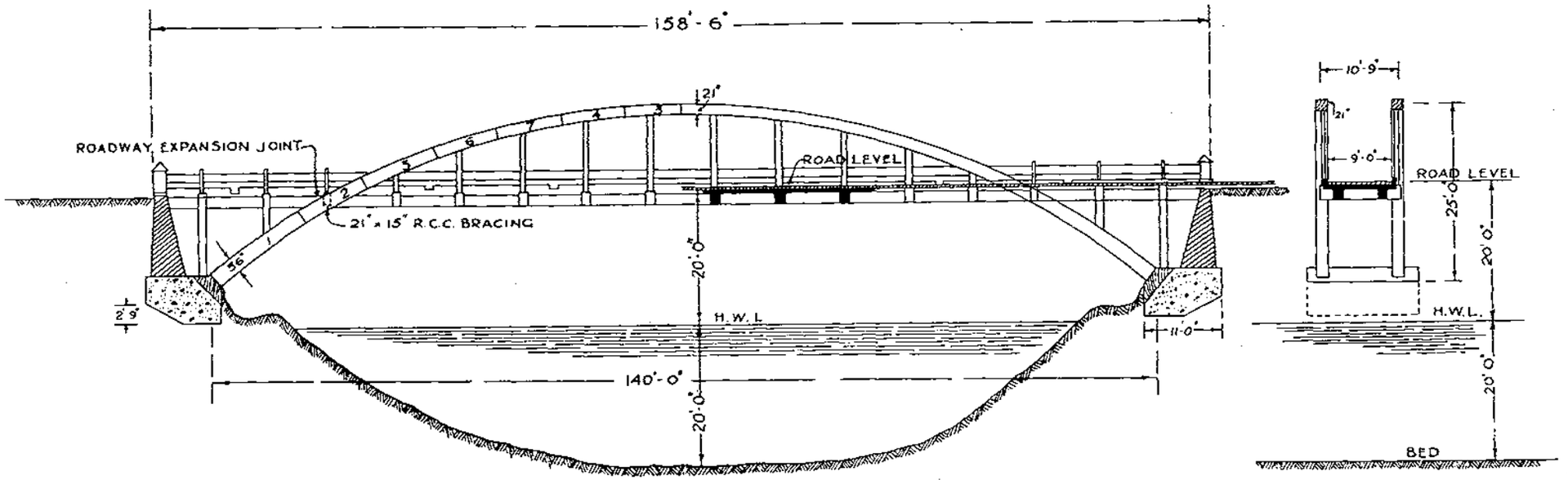
NOTE:-

W.T. OF 1/4 ARCH = 2 TONS - 13 CWTS = 1/2 W.T. OF HINGE + 12 CWTS. DISTANCE OF C.G. OF 1/2 HINGE FROM PIVOT = 2 FT. DISTANCE OF C.G. OF 1/4 ARCH (AND BRACING) TAKEN AS 37 FT (1/2 LENGTH OF ARCH).



LAUNCHING DIAGRAM OF AYUN BRIDGE REINFORCING ARCHES

AYUN BRIDGE



PART ELEVATION

LONGITUDINAL SECTION

SECTIONAL ELEVATION

preventing the formation of shrinkage cracks. The surface slab was poured continuous from end to end of the bridge.

The bridge was opened by His Highness the Mehtar of Chitral, on November 16th, and the next day the section left for Drosh, leaving a small party to concrete-in the hinges and to complete the surfacing. The rubbing of the surface had been neglected before, owing to the rush to complete the bridge, but now it was found an extremely laborious task rubbing down the hardened surface ; also, it was found that patches for closing the holes left by bolts would not stick. However, a mixture of re-mixed cement and sodium silicate was found to work well in spite of the nightly frosts.

Conclusion.

A word on the organization may not be out of place here ; the sub-section organization was not practicable for such a work and the section with civilians was split up into five parties, each under a suitable N.C.O. The supervision was also divided thus : the C.S.M. was in charge of the masons and blacksmiths, Mr. Kalra in charge of the carpenters and bar benders, and the Jemadar in charge of the erection party. The fact that this system worked smoothly was largely due to the tact of the members of Messrs. Gammon's staff. They were invaluable and proved cheerful and indefatigable workers during the whole of their stay with the section.

To sum up, the "Melan" system of construction, *i.e.*, using the reinforcing steel as a support for the arch centering, is a quick and practical method of construction. As the cost is about 25 per cent. higher than the normal method, its use is only economical where conditions prevent timber staging from the river bed and when the support for the centering cannot be used repeatedly. The cost of this bridge, Rs. 47,000, was only 25 per cent. more than the estimated cost of a stiffened suspension bridge with a timber girder, which would have had a maximum life of 20 years.

When considering the construction of another bridge of this type it would be advisable to make the main angles longer, or to employ riveted joints ; also the arch bracing should not be removed until after the arches have been concreted.

MORE SKEW GUNS AND MORE SURVEY.

By O's R. AND B.

IN the December, 1934, number of *The R.E. Journal* we were allowed, through the indulgence of the Editor, to publish an article rather similar in title to the above, putting forward for public consideration several questions which had been worrying us considerably. Having done so, we sat back, hoping that some knowledgeable F.O.O., C.B.O., L.C.C., or R.U.F.C. would come to our rescue and solve our difficulties for us. Great was our disappointment, therefore, to find on opening the March and June numbers of *The R.E. Journal* that we had provoked no one into supplying us with the answers we were seeking.

We refused, however, to be baffled by this silence, so we have sounded several people " in the know " as to the why and wherefore of these survey matters, of which we not infrequently hear on T.E.W.T's. Unfortunately we have been unable to get answers to several of the questions which we put in the previous article, but we have obtained some general information on the subject of " survey in war." Armed with this knowledge we have once more appealed to the Editor's finer feelings, at the same time promising not to let this sort of thing become a habit.

The first point of interest which we have unravelled is that there are *two* parties concerned in this " survey in war " business—the R.E. and the R.A. To officers in the army generally this may possibly come as a surprise, since on all the occasions when survey has been mentioned on T.E.W.T's not once have we heard the name of the Corps introduced in connection with it. To members of the Corps the surprise may not be so great. Most of us are familiar with the phenomenon of some of our friends disappearing from time to time into jungliest Africa and reappearing a few years later with a startling collection of tiger skins, bison heads, etc. Of survey in this form we have been vaguely aware for some time, but on the question of " survey in war " we are much hazier, since in no volume can we find out anything about it.

However, the fact remains that " survey in war " is the province of the Sappers and Gunners. During the last war the Sappers were responsible for the whole of it, but since then the part that most concerns the gunners has been handed over to them.

The second piece of information which we have elicited is that the

units responsible for this work are Corps Troops and are respectively the Corps Field Survey Coy., R.E., working under the instructions of the A.D.S. (a new one to most of us, = Assistant Director of Surveys) and the Corps Survey Coy., R.A., under control of the C.C.R.A. The work of these units, as we understand it, will be discussed in more detail later.

The principle of survey was introduced into gunnery questions for two reasons—surprise and effect. It enables us to mass our artillery in concealed positions, and then without registration or warning to put over a tremendous blast on to targets over which we may have no ground observation, but whose position has been fixed by other means. "The effect" is simple to understand. It is easier, provided the range is suitable, to hit a target with a 12 bore than with a rifle, and this is the basic principle used by small boys who throw stones in the street. It is noticeable that an indifferent shot, after tiring of missing his target with single bricks, will suddenly throw a handful at once, and almost invariably connect first time. With artillery the same principle applies. However accurate our gunners may be, it is in practice difficult to connect with the target at once. (Fifty per cent. zones, ballistics, old ammunition, new ammunition, and all that sort of thing.) They might guarantee a hit after, say, 20 rounds, but if the other fellow's luck is in there may be a premature finish to the action should he score on them after only ten rounds. In order to avoid risks like that, it is more satisfactory to concentrate a large number of guns on one target, and like the small boy with a handful of bricks we then have a very good chance of scoring with the first salvo. Survey enables us to put over that "handful" rapidly and effectively. It is, of course, open to the enemy to use survey as well and if he happens to put over his "handful" first. . . !

As far as we can discover, there is no definite line to show where the R.E. work finishes and that of the R.A. starts. In general terms the R.E. are responsible for the preparation and production of all necessary maps, and for supplying the R.A. with a trig. control from which they can start their work. The density of this control will usually be much the same as that required for mapping by air survey. From this point the R.A. take over, and are responsible for fixing the position of their guns and targets.

We will deal with the work of the Sappers first because they start the show going. It is also of more interest to us generally, since no doubt some of us are likely to find ourselves mixed up in it at some time or other. It is a work, also, for which some of us may feel as little qualified as we are for running a mammoth power station, or a soda-water factory, or any other of our rather specialized jobs whose name is legion. There is, however, one big difference between a survey job of this kind and most of the other specialized works.

When suddenly confronted in war with a super power station we may, if we are lucky, find that our pay corporal or messing N.C.O. has made a hobby of such things in civilian life, and has possibly designed and operated several. He will, therefore, feel quite at home in the maze of boosters, oil switches, dynamos and more boosters, and our part of the work will be correspondingly simplified. The military field surveyor, on the other hand, has no direct counterpart in civilian life and, because survey is one of the very few R.E. trades which does not require a long apprenticeship, it is one in which the officer can, and in fact has to, instruct his tradesmen.

The units responsible for the R.E. part of the work are the Corps Field Survey Coys., R.E., of which one, the 19th, exists in peace. Their work, as we have said, is the production of the maps required, and the supply of the necessary control to the R.A. If all the maps required already exist, then, of course, 50 per cent. of the unit can at once retire on extended leave.

On the other hand, an article entitled " Air Survey," in the March number of *The R.E. Journal*, showed only too clearly that the chances of leave for the survey companies are not unduly bright, since 1-in. maps for the infantry, etc., and 1/25,000 maps for the artillery are likely to be few and far between. Even those maps that do exist are not comparable with the O.S. productions which we use in peace. As an example one has only to remember the 1/50,000 sheets which some of us have used on tours in France, and the extreme difficulty of directing a frenzied French car driver along roads whose classification has wisely been omitted.

The reason for this difficulty is partly nerves, since all the instruments on the dashboard point steadily to 120, and partly because, as one reads on the maps, " Les travaux sur le terrain ont été exécutés par Messieurs . . . en 1831," since when, of course, several wars have altered the detail considerably. Other maps have, therefore, to be produced, which are accurate and which can be more easily read.

The position with regard to the trig. control is the same, only much more so. The up stations, usually church spires, alter in position and appearance with each war, whilst the down stations in an agricultural country like France have even a shorter life. The French farmer is very phlegmatic in his treatment of the chunks of concrete which mark the trig. stations. As soon as his plough strikes one of these annoyances he promptly digs it up and heaves it away with the same *sang froid* with which he disposes of unexploded six-inch shells. In general, then, the whole of their work will lie in front of the R.E. Survey Coys. and leave will have to be postponed.

These units are organized so as to enable them to compete with every stage of map production from beginning to end. It might

be as well, therefore, to cast our minds back to the hills of Devon and refresh our memories as to what those stages are :—

(i) This was more exhausting than technical, and consisted in climbing from the top of one mountain to another, muttering " Excellent view—well-conditioned triangles—rotten-conditioned lunch, etc., etc." This was known as *Trig. Reconnaissance.*

(ii) The first really technical stage which consisted of spending one whole day on a high hill beside a theodolite waiting for the fog to lift, another half-day succouring a beacon which had been sorely stricken in combat with a herd of cows, and yet another half-day contending with a theodolite, which had taken unkindly to cross-country travel in the dickey of a car. This was *Trig. Observation.*

(iii) The third process we missed completely owing to a defect in the design of our car, which allowed a wheel to detach itself in such a manner that its replacement was, by no stretch of the imagination, a running repair. We heard afterwards that this was called " *Measuring a Base.*"

(iv) The less said about this stage the better. It consisted of two days spent amidst books, lozenges, and forms galore out of which degrees, minutes and seconds emerged as metres, or, if one was not very careful, as feet. The official title for this process was " *Computations.*"

(v) Then followed a very pleasant period of recuperation in the open air, filling in detail between the plotted points which had emerged from stages (i) to (iv). This was " *Plane-tabling.*"

This completed our active part in the production of the map, but was followed, we understood, by the processes of *compilation, Vandyke or helio, litho* and *printing* which were carried out in the underworld of the S.M.E. Main Building.

To compete with this work the Field Survey Coy., R.E., is organized into an H.Q. and four sections :—

(i) Drawing Section.
(ii) Topo. Section.
(iii) Litho. Section.
(iv) Photo Section. (G.H.Q. Coy. only.)

Process (i), the reconnaissance, is usually the work of the officers. They are all in the H.Q., which includes also sundry tradesmen such as carpenters, joiners and electricians ; in fact, the usual selection found on all work with which the Corps is connected.

Process (ii) is the work of the Topo. Section, and this is the section which comes mostly in contact with the R.A., since the latter take over their own part of the job where the work of the Topo. Section finishes. They carry out their work hard on the heels of the reconnaissance party.

When it comes to process (iii)—that rare operation of survey, measuring a base—we are very vague, but presumably a good all-round team could be raised out of the company for this purpose without much difficulty. There appears to be no reason why a carpenter or machine-minder should not function excellently on the end of a spring balance or carrying trestles around. Incidentally, it would be of interest to find out how many officers of the Corps have actually "measured a base" in anger. The nearest we could get by questioning our friends was someone who knew someone who knew someone, who had just avoided measuring a base; rather like drawing a horse in the Calcutta Sweep.

Process (iv) can be done by the Topo. Section itself, assisted if necessary by H.Q. We are told that this is really a swift and simple process provided one knows at the start what one is trying to do!

To those of us who enjoyed our plane-tabling on the hills of Devon, it will come as a disappointment to hear that process (v) is a back number and has been superseded by air survey. Instead of green fields and sunshine (or rain and six-inch shells) and a comfortable plane-table off which to eat one's lunch, the modern plane-tabler lives indoors, pores over photos and stereoscopes and twirls handles on goniometers (? ? ?) and sterco-planigraphs (? ? ?). (See March number of *The R.E. Journal.*) This is the natural price one has to pay for progress, and this part of the work is done by the Drawing Section, assisted again, if necessary, by H.Q.

Thereafter the Photo Section, complete with its studio and dark room, sails into action, followed by the Litho. Section, who complete the mapping business.

The whole unit is, or is intended to be, mechanized and mobile, although portions of it, such as the Litho. Section with its printing press, which, in full war paint, weighs, we understand, about eleven tons, will hardly ever be mobile in the true sense of the word.

That, in brief, is the main work of the Corps Field Survey Coy., R.E., but probably in practice a multitude of subsidiary jobs will be allotted to it in addition.

The next question to consider is the work which the R.A. do in order to enable their guns to put over the necessary "handfuls." The unit responsible for their work is the Corps Survey Coy., R.A., and the similarity in names possibly accounts for some of the confusion of thought on this subject.

The survey problem confronting the R.A. is not such a rigid one as that of the R.E. The standard of accuracy aimed at by the latter

is necessarily a high one, whilst the former need not produce work of much greater accuracy than that to which their guns can shoot. The 50 per cent. zone of the 18-pdr. at 5,000 yards is, we believe, about 50 yards long by 10 yards wide. Our recollection of Devon is that errors of this description were looked upon not as gross errors, but as "conduct unbecoming. . . ."

The object of the R.A. survey is to ensure that the M.P.I. (think that one out !) of each "handful" should arrive within a few yards of the target. With this latitude for their accuracy there is no point in their using any very accurate (and therefore slow) methods, nor in their using instruments measuring to 5 seconds of arc, when the answer may be required only to the nearest 5 minutes.

The R.A. Coy. is organized into H.Q. and three groups :—

(i) Survey Group.
(ii) Flash-spotting Group.
(iii) Sound-ranging Group.

The party which takes over from the Topo. Section, R.E., is the Survey Group, and as the former carries forward the trig. control, or checks the trig. already in existence, the Survey Group, R.A., can get from them the values for the trig. in the particular area in which they wish to work. If the control, as it exists at the time when it is needed, is too sparse, it is supplemented by the R.E. and then handed over to the R.A.

Having taken over values for the trig. from the R.E., the R.A. then continue their own survey down into the brigade areas in which the guns are going into action. The answer they produce takes the form of a picket, the co-ordinates of which they hand over to the brigade survey officer (R.A.) together with a bearing from the picket.

The Flash-spotting and Sound-ranging Sections are rather parallel institutions, whose work in life is to locate the positions of guns which cannot be seen from the ground or air. The former work by night only, and the latter by day and by night.

The principle on which these two groups work is simple. They lay out a base, the ends of which are fixed from the trig. supplied by the R.E. or their own Survey Group, and at these ends the Flash-spotters install a pair of eyes, and the Sound-rangers a pair of ears and the job is done. We have reason to believe that in practice the process is slightly more complicated, but this is the fullest description we are competent to give. Both groups can also function off a short base or a long base, and a forward base or a rear base. This we understand is rather technical and depends to a certain extent on the frame of mind of the group commander.

This more or less completes the work of the Survey Coy., R.A.

From this point the brigade survey officer and his party take over and continue the line of pickets and bearings down to batteries, at which stage everything is set to deliver the "handful," provided, of course, that the enemy is still occupying more or less the same position as he was when the survey started!

The survey, we are told, takes six or more hours to complete, but is not intended to be a *sine qua non* for a gun to fire. The guns can, in fact, come into action at any time by using the more simple method, of "trial and error" combined with ground or air observation. By doing this, however, they disclose their position to the enemy, and put themselves well in the running to receive a "handful," whilst at the same time they are not in a position to give a "handful" back. A point we find very difficult to understand is the precise moment at which it is advisable to commence the survey. If there is an opportunity to complete the survey before the guns are required to fire and the necessary large-scale maps are available, then it appears to be excellent. But if the survey cannot commence before the gun trails hit the ground, then the value seems doubtful, since so much can happen in the first six hours of an action in mobile operations. It seems possible that the R.A. survey party might find themselves well behind the R.A. brigade areas, or if the worst has happened, well behind the enemies' lines, before they could complete their survey. Once the survey party has been deployed for action, it takes some time to reassemble it and move it to another sphere of activity.

We have not yet mentioned the last stage which is completed by the gunner himself, who likes to be sure that everything is in working order. By way of a check on the survey which he has seen going on all round him, he likes, if possible, to fire a few guns to "register" just prior to zero hour. The value of this check is difficult to understand. If the survey has been properly carried out, it will have taken cognizance of the second cardinal rule of survey—"the independent check"—and there is no point in firing registration guns. If the survey has not been checked, then the application of a rough check by gun-fire a few minutes before zero hour leaves no margin of time for the correction of errors. This question of registration will be referred to again later.

The last point on which we have tried to obtain some information is that almost household article, the "Temporary Grid." The information we got on this subject showed us what a violent misconception we had of this aid to gunnery. Further enquiries convinced us that this misconception is shared by a great majority of officers. The name "Temporary Grid" itself has that technical sound about it which suggests that it is someone else's job to understand its workings, but certainly no concern of ours. In some way also "Survey" and "Temporary Grid" have become closely associated

in our minds, when, in fact, they have only a nodding acquaintance. In practice " map reading," as well as survey, is introduced into the " Temporary Grid."

With the object of trying to clear up this misconception, we propose to describe the technique of the " Temporary Grid " as we understand it, confident that if we have still got it wrong, someone will be sure to point out our errors to us.

The " Temporary Grid " was originally introduced as a *temporary expedient for use in emergency only*. Such an emergency might arise when the R.E. survey parties are absent (possibly urgent private affairs) or when speed is of the utmost importance. Its main object is speed, speed and more speed. It dispenses, therefore, with the assistance of the R.E. and generally speeds up the processes of the R.A. In the end it produces a different answer from the permanent grid for the brigade pickets and, consequently for the gun positions, neither of which has actually moved. In fact, it gives a different range from gun to target, and, more important still, a different bearing from gun to target, both of which have, in practice, remained constant. This sounds so odd as to suggest that we have already gone off the rails. This, however, is apparently not the case, and these discrepancies are due to several " *Inherent Weaknesses* " in the " Temporary Grid " which it has so far been impossible to eliminate.

The " man behind the gun " is a modest fellow and puts his requirements as follows :—

(i) The co-ordinates of his gun position and of the target.
(ii) A bearing laid out on the ground from which he can lay off his gun.
(iii) The heights of his gun and target.

Firstly he wants the co-ordinates of the gun. Speed being the essence of the " Temporary Grid," we have to read the co-ordinates as accurately as we can off the maps that are available. It is hopelessly optimistic to suppose that we will have a 1/25,000 map when, in fact, we shall be lucky if we have got an ancient 1-in. edition with us.

We tried our hand at this apparently-simple-co-ordinate-reading game and at once struck " *Inherent Weakness No.* 1." We took stance in a large field armed with a 1-in. map and endeavoured to read off the co-ordinates of our boots. Our individual results showed amazing discrepancies, and savoured more of stupidity than inefficiency. Clearly we were not the men for the job, so we consulted two of our most jungly friends, all hot and dusty from the " Outposts of Empire," led them out into the open and asked for their views of the same co-ordinates. They were much more

business-like, and straightway produced a full outfit of dividers, scales, set-squares, tin-openers and corkscrews with which to tackle the job.

We catalogue the results as being of interest. For the sake of decency we give only the mean of our own results :—

	Eastings.	Northings.	Height.
(i) Mean of O's R. and B.	230	847	325
(ii) First Jungly One ..	622930	184550	325
(iii) Second ,, ,, ..	622910	184750	315

Our empire-builders' spate of figures left us badly shaken. Where they came from we haven't the remotest idea—probably a natural reaction to an overdose of seven-figure logs. The interpretation of the results which they gave us was that our result was not worth considering, but that theirs were pretty good and differed only by 40 metres in Eastings and 200 metres in Northings. These errors were apparently due to the difficulty of fixing their correct position on a 1-in. map in the open, but led them to suggest a trial with a position near some plotted point of detail. . . . That, they thought, might give a more useful result.

Off we went to *two* points near some plotted detail where the same drill took place, and this time the co-ordinates agreed almost exactly (still with a lot of mysterious figures produced from nowhere). This looked almost like complete success, and by way of a check we asked them to compute the distance between the points. Nothing was too much trouble in the interests of science, and after some intensive work with an india-rubber, borrowed from us, the answer was given as 50 *metres*. The paced distance on the ground was 15 *yards*.

Somewhat bewildered, we retired inside one of the plotted points of detail to discuss this new situation in the friendly atmosphere of hops. The last error was then found to be due to the fact that the points selected were on opposite sides of a road, and roads to be marked at all on a 1-in. map have to be much exaggerated in size. The same applies to most other detail plotted on the 1-inch map. Moreover, the pencil points marked on the map were 30 yards in diameter and the grid line from which the measurements had been taken was 30 yards wide.

Inherent Weakness No. 1 is therefore that the gunner starts with a probable error in his gun position of anything from 30 to 60 yards. If this error is in such a direction that it affects the range only, it is not very important. But there is no means of ensuring that the displacement is not a lateral one.

Now for bearing. The Sappers are absent and the sun or stars may easily be missing as well. We, therefore, fall back on the compass fitted to the Director Mark X, or to the officer. This, of course,

fits in well with the conception of speed and more speed. It appears reasonable to allow for an error of 15 minutes of pointing and reading the instrument. Throw in the individual error of the compass, Magnetic North, Grid North, True North and Frozen North, and the error may well be 30 minutes. In addition there are the usual unknown factors, " double it for active service conditions, and double it again because it is snowing." In fact, the gunners themselves appear to take rather a gloomy view of this and the best information we could get was that the error should not as a rule exceed 2°.

We will therefore allow for an error of 1°. This error is rather unfortunate, since although the guns may sometimes behave queerly as to range, there can be no doubt that they fire very accurately for direction. Firing at 6,000 yards, an error of 1° will produce a lateral displacement of about 105 yards. This error in bearing may be called *Inherent Weakness No. 2.*

The gunner wants his heights to within about 20 feet, so we understand. Using an O.S. 1-in. map even, we can get within this limit by intelligent guesswork. The Ordnance Survey does not unfortunately function in Europe, where maps are often of a more pictorial nature, and hill features are often shown only by hachuring with infrequent spot heights. Determination of heights under such conditions becomes the wildest form of guesswork. This can be called *Inherent Weakness No. 3.*

The " man behind the gun " has now got his gun position (error, say, 50 yards) bearing (error, one degree) and his height (very vague). He is now, in fact, " on the Temporary Grid," and prepared to go ahead. The only snag is that his targets are not yet on the " Temporary Grid " with him, and in spite of his survey he is still in a position to fire only on those targets which are visible from the O.P. connected on this " Temporary Grid " to the gun.

The only other way in which targets can be given to the gun is by co-ordinates taken from the map by ground observers possibly two miles from the target, or air observers two miles above the target. The difficulties of fixing accurately the co-ordinates of a point in the open, when one is actually on the spot, have already been referred to. When the observer is some distance from the actual spot these difficulties must obviously increase, and there is no reason to suppose that the co-ordinates handed to the gunner will be of any great accuracy at all. This is clearly *Inherent Weakness No. 4.*

With this collection of errors at his disposal the gunner has little hope of hitting the target until he has taken steps to correct some of the errors. This he does by firing a number of trial shots, made up of combinations of range, difference of height, and bearing suggested by his observers in the air or on the ground. As soon as his shots begin to arrive close to the target he can plot the position of that

target on his Temporary Grid by range and bearing, and is in a position to deliver a "handful." The target meanwhile has had full notice of his intentions, and if sensible (and mobile) will rapidly change its position. The process must then be repeated.

How long it takes to plot individual targets on the grid by this means is not very clear, and we have been unable so far to borrow an 18-pdr. gun to try it out. It does not appear, however, that the process can be a very swift one, and the speed, which was the outstanding feature at the start of the Temporary Grid, appears to tail off rather badly when it comes to the actual business of shooting. It seems clear also that we have long since passed out of the sphere of surveyed gunnery, and that the "Temporary Grid" has a large amount in common with our old friend the "observed-trial-and-error" method. Whereas, however, the limitations of the "observed-trial-and-error" method are fairly generally known, the name "Temporary Grid" having become, somewhat erroneously, associated with survey, holds out to large numbers of us, a strong suggestion of efficient "predicted shooting" on any target within range, and an entire absence of registration. This, as we see it, is by no means the true state of affairs, but is probably the reason for the misconception of the functioning of the "Temporary Grid" to which we have already referred.

Having completed this involved and somewhat incoherent description of "laying down my own grid," one is now in a position to consider the effect on different brigades of R.A.

For the sake of speed, each brigade, as it comes into action, goes straight away on to its own grid, which has its own individual collection of errors due to the series of "*Inherent Weaknesses.*" Thus any one brigade, having used its guns as survey instruments to plot its targets on its own grid, is not in a position to hand the co-ordinates over to the neighbouring brigade, and ask for a helping hand. This is because the co-ordinates are true only for the grid on which they were plotted originally. There can, in fact, be no liaison and no concentration of neighbouring brigades—*Inherent Weakness No.* 5.

In order to get the brigades on the same grid (still temporary) it is necessary to select one grid (any good grid), then traverse between brigades and recompute, not only the positions and bearings for the guns, but also the position of all targets of the brigades whose grids are now being changed. This computation is not, as might appear at first glance, a question of simple addition and subtraction, since, owing to errors of bearing, a clockwise or counter-clockwise swing has been produced in the grid. The recomputation has therefore to commence from first principles. Once this has been done the brigades concerned will all be on the same grid and in a position to work together. The time taken for this change-over from grid to

grid we do not know, but we should very much like to find out. Unfortunately our rating as computers is " unlikely ever to. . . ! " so we have to leave this to someone else.

When everyone has settled down on a comfortable grid, this is usually the moment chosen by the R.E. to return from leave, and a fresh outcrop of beacons appears on the countryside, showing us that the " Permanent Grid " is with us once again and that the emergency or need for the Temporary Grid has passed. This is an invitation to the R.A. to do some more survey, and to recompute once more the position of their guns *and* targets. In fact, whoever else may be enjoying this survey, it seems tolerably certain, that to the R.A. computers these frequent changes from grid to grid must be positively nauseating.

The " *Permanent Grid* " by reason of its accuracy supplies a remedy for all the *Inherent Weaknesses* connected with the gun positions. Since, however, we are still left with only a 1-*in.* map in our hands, it does not supply any remedy for *Inherent Weakness No.* 4 ; the error in the estimated position and height of the target unless the target can be observed from at least two survey stations, either visually or by sound-ranging. This brings us back once more to the question we asked last time we were allowed to burst into print : " Will not 75 per cent. of the value of any survey be wasted if large-scale maps of the battle area are not available ? " In addition, it is apparently generally agreed that, with a 1/25,000 map, the gunner's requirements (i) and (iii) can be taken direct off the map by simple map-reading. This apparently does not apply to requirement (ii) since this bearing taken off the map is not comparable with the accuracy of the gun for direction, and a trig. or astronomical azimuth is required. If, however, the gunner likes to fire registration guns before zero hour, it would appear that with the large-scale map available, all that is required is to accept a value for requirement (ii) from the map, let the gunner register, and then apply a correction as indicated by the fall of shot. In fact, if this reasoning is correct, we have, with a large scale map available, done away with the six hours for a survey, and substituted simple and rapid map-reading in its place. This sounds such a revolutionary idea, that it seems as though we must have got something wrong after all.

THE UNIFORMS OF THE CORPS OF ROYAL ENGINEERS UP TO 1914.

By the late LIEUT.-COLONEL P. H. KEALY, R.E. *(retired)*.

PART III.

THE DRESS OF THE RANK AND FILE, 1772 TO 1856.

THE first company of Engineer rank and file in the British service was raised in 1772, though the men were not known as "Engineers" till 84 years later. The company was raised at Gibraltar, and the Warrant dated 6th March, 1772, calls it "The Military Company of Artificers." It was almost immediately afterwards known as "The Soldier Artificer Company," though the original name cropped up again later. The following information as to the dress of the rank and file up to 1856 is derived almost entirely from the pages of Connolly's *History of the Royal Sappers and Miners*.

Captain Connolly evidently had some official orders, etc., to help him, but, as he never quoted these, it is impossible now to disentangle the different sources of information and check his statements. There can be no doubt, however, that his version is as correct as he could make it, and it is doubtful if material will ever come to light which will enable his descriptions to be checked.

The Dress is divided into Uniform and Working Dress.

1772–1786. UNIFORM.

Coat.—Red, double-breasted, with two rows of flat brass buttons 2 inches apart, $1\frac{1}{4}$ inches in diameter, bearing the Ordnance device of three guns and three balls. Buttoned at the pit of the stomach, with lappels above. Cuffs and roll collar orange-yellow, laced round with narrow red ferreting, and collar ornamented with a red rectangular loop at each side. Down the front of the coat to the end of the skirts narrow yellow ferreting, also on the inside edges of the skirts: the skirts very broad descending to the leggings, and buttoned back at the bottom to show the white lining. Small plaited frills at the breast 5 inches long, and full ruffles at the wrists. A black leather stock, with white false collar.

Waistcoat.—Long, white, bound with yellow ferreting. Pockets slashed, each slash 2 inches deep and bound round. Buttons small and flat, similar to the coat buttons.

Breeches.—At first blue; later white, secured below the knee with three small buttons.

Leggings.—Black, at first banded above the knee; later, reaching to the knee and strapped under the shoe, buttoned on the outside; buttons as on waistcoat.

Hat.—Cocked; cock in front with black cockade to left of cock supporting a black feather.

Belts, etc.—White leather cross-belts; black cartouch box with frog, musket, and bayonet. The serjeant-major and serjeants armed with carbines and bayonets, and silver-mounted swords with plain guard of one bar only and white leather knot.

Breast plate.—Brass, oval, bearing the Ordnance device with "Gibraltar" above and "Soldier Artificers" below.

Ranks.—*Sergeants:* Dress of superior materials, and gold lace on their coats. Crimson sashes with tassels, worn under the coat; laced shoulder straps. *Corporals:* Dress as for the privates, but with gold-fringed shoulder knots. *Lance-Corporals:* One gold knot, worn on the right shoulder.

WORKING DRESS.

Coat.—Long, of white duck.

Trousers.—White, "mosquito" cloth, with gaiters attached. White serge in winter.

Hat.—Round felt, white, with yellow band and yellow edge to brim.

By 1786 the following working-dress had been introduced:—

Coat.—Plain long red jacket in winter, and a linen one in summer. Single row of large brass buttons far apart; large pocket each side on hips with broad slash; two large buttons at small of back. Roll collar and cuffs, of yellow cloth.

Waistcoat.—Plain white; same cut as the regimental one. Linen in summer and flannel in winter.

Pantaloons.—White, as for waistcoat.

Gaiters.—Black, spat length.

Neckwear.—Black, of material according to taste.

Hat.—Round, white, with straight poll 6 inches high. One inch yellow band, and broad brim with yellow edging.

By a Warrant dated 10th October, 1787, a corps of Royal Military Artificers and Labourers was raised in England, quite distinct from the Gibraltar companies, which kept their separate organization till 1797, when they were amalgamated with the Royal Military Artificers. It is not known whether the Gibraltar companies kept their red coats till 1797, or went into blue in 1787.

1787. UNIFORM.

Coat.—Blue, with long skirts looped back, roll collar, black cloth facings, and white shalloon linings to the skirts. The lappels, cuffs and hip pockets laced with rectangular loops of yellow braid with a button on each. Buttons brass. Frill at breast and ruffles at wrists. Stock, black leather with false collar.

Waistcoat.—White cloth.

Breeches.—White cloth.

Gaiters.—Black cloth, reaching to knee.

Hat.—Cocked, worn transversely; with a binding of gold lace, short red feather, horse hair rosette, gold loop and button.

Distinctions of rank.

Labourers.—Clothing coarse, and yellow tape on coatee and hat.

Artificers.—Clothing of finer material, and gold lace on the hat.

Drummers.—As for artificers, but instead of yellow lace, broad livery lace, woven with the Ordnance arms, extending from the collar downwards in parallel stripes.

Corporals.—As for artificers, but with small gold-fringed knots on shoulders.

Serjeants.—Crimson sashes worn under the coat; swords; gold lace on coats; no knots on shoulders, but laced straps.

Serjeant-majors.—Sashes and swords; gold lace on coats; bullion epaulettes, and silk velvet facings.

WORKING DRESS.

Coat.—Long white duck or canvas frock almost to the ankles; roll collar and brass buttons.

Waistcoat.—White duck.

Pantaloons.—White duck, tongued, and buttoned at the bottoms.

Hats.—Plain black felt.

Corporals and serjeants wore a gold-laced band about an inch broad round the bottom of the poll of the hat.

Notes.

It appears probable that, though the Gibraltar companies retained their independence, they conformed to the dress of the English companies and went into blue at this time.

The new corps was regularly armed originally, whatever was the policy in this matter later; the rank and file had the usual firelocks, pouches and cross belts of buff leather pipe-clayed. The serjeants carried pikes, and long narrow thrust swords purchased at their own expense. The grip of the sword was steel with a single gilt guard; the scabbard was black leather with a gilt tip, top and boss, and the shoulder belt, with a frog to hold the sword, was pipeclayed. The serjeant-majors wore swords and belts, but did not carry the pike.

The drummers were armed with brass-handled swords, short in the blade and broader than the serjeants', and the scabbards were black with brass mounting. All ranks wore a square brass breast-buckle to their belts, those of the superior ranks being gilt.

The following changes were made:—

1792. UNIFORM.

Hat.—The cocked hat was replaced by a round one of black felt.

Drummers.—The lace was now a mixture of black, red, and yellow worsted, the Ordnance device being omitted from it. Worsted wings of the three colours were now worn.

WORKING DRESS.

Coat.—A plain raven duck jacket was substituted for the long frock, worn without a waistcoat: this was for summer wear. For winter wear, the jacket was blue with black cuffs and collar, a flannel waistcoat was worn and serge trowsers of the same style as before.

1794. WORKING DRESS.

Coat.—A plain round blue jacket for winter, and a duck jacket of the same pattern for summer.

Hat.—This was changed from black to white.

1795. WORKING DRESS.

Coat.—The jacket was now given broad skirts with pocket slashes; a yellow triangle was sewn between the two buttons on the back of the waist, and a frog was added to each side of the collar. These ornaments were of gold lace for the serjeants.

Hat.—This was changed again from white to black felt; the serjeants wore a rosette and crimson plume in addition to a gold band.

1797. UNIFORM.

Coat.—Long skirts were abolished, and the coat became a half coat with short skirts. The lappels with yellow lace looping were abolished and yellow frogging was introduced.

Sash.—The serjeant's sash was now worn over the coat.

Hat.—This year the cocked hat was revived, the pattern being described by Connolly as "an adaptation of the pinched-up Nivernois hat and the ample Ramilies," worn transversely. The flaps were edged with broad black binding instead of gold lace. Cockade and loop, and a white hackle 8 inches long. Rose-shaped ornament of gold lace on each of the shoots.

Drummers.—Scarlet coats with livery lace.

This year the Gibraltar companies were amalgamated with the Royal Military Artificers in England.

1801. WORKING DRESS.

Coat.—The canvas jacket was abolished, and there was only the blue cloth jacket with skirts. Two serge waistcoats were issued, provided with sleeves.

Trowsers.—Blue serge.

Hat.—Black, round.

Gaiters.—Black, half length.

1802. UNIFORM.

Hat.—The cocked hat was superseded by the shako of army pattern, known as the "smoke-jack." The white hackle feather was retained. The shako subsequently changed its shape from time to time in accordance with the fashions in the rest of the army.

1813. UNIFORM.

Coat.—Colour changed from blue to red; no material alteration in cut and frogging.

Trowsers.—In the Peninsula, grey trousers and ankle gaiters were worn; elsewhere, white breeches and long gaiters.

Hat.—Shako, much higher in front than behind, decorated with yellow cords and tassels. A short white feather on the left side.

WORKING DRESS.

Coat.—Plain red jacket with short skirts.

Trowsers.—Grey, with red stripes, short spats, and shoes with brass clasps.

Hat.—Of leather, set square on the head, like a cocked hat without the peaks. R.M.A. in brass on the front, and later a "crown and garter ornament."

Notes.

In 1812 the name of the corps had been changed to "Royal Military Artificers or Sappers and Miners." In 1813 the name was shortened to "Royal Sappers and Miners."

In 1812 the dress of the Royal Engineers was changed to red, and in 1813 the Royal Sappers and Miners followed suit. An additional reason for the change was that the men working with the infantry working parties in the trenches at the various sieges in Spain were very conspicuous in their blue coats.

The arming of the corps had fallen into a very bad way, as the idea had grown up that a working corps did not require firearms. This led to protests from the officers in the Peninsula, as the companies had to be sent out under escort when in hostile country. Connolly states that in 1817, during the occupation of Paris, there was not a single firearm amongst 1,000 Sappers paraded at St. Denis nor amongst the whole pontoon train, which occupied two miles of

road space. Thereafter the matter was put on to a proper footing, and since 1817 the dismounted Sapper has always been uniformly armed in the same way as the Infantry.

By General Order of 1st October colour-serjeants were appointed to the Corps, to wear the badge prescribed for the Army, viz., above the chevron the honourable badge of a regimental colour supported by the cross-swords.

1817. UNIFORM.

Hat.—The high-fronted shako was replaced by a lower one, with yellow cords and tassels. The serjeants and staff-serjeants wore white hackle feathers, gold bands and cords, with gilt scales and ornaments.

1823. UNIFORM.

Breast or Belt-plate.—A brass buckle had hitherto been worn on the white shoulder belt, except in the Gibraltar companies, where a plate was worn (see page 403). This year a universal brass plate was sanctioned, carrying a device consisting of the royal cypher surrounded by the garter bearing the name of the corps, the whole surmounted by a crown.

1824. WORKING DRESS.

Cap.—The leather forage cap introduced in 1813 was replaced by a dark blue cap, called the Kilmarnock bonnet, with a yellow band manufactured in the web, and a peak and chin-strap. The crown was some 12 inches across. The corporals wore the chevrons of their rank above the peak. The superior ranks had blue cloth caps, with peaks, chin-straps and gold lace bands.

1825. UNIFORM.

Coatee.—This now lost the frogging on the front, and the skirts were lengthened and provided with slashes sewn transversely on the loins. White turn-backs were added to the skirts, and were joined near the bottom of the skirts by brass grenades. This was the first appearance of the grenade in the dress of the men as it had been in that of the officer (see *R.E. Journal*, June, 1934, p. 198).

Trowsers.—Breeches, long gaiters, and shoes now definitely disappeared, and light-blue trousers with scarlet stripes 2 inches broad and short wellington boots were worn instead.

Hat.—The low shako of 1817 gave place to one 10 inches high, with a goose feather 12 inches long held by an exploded grenade. It had a flap behind to protect the neck. It was ornamented with scales secured by lions' heads, and a plate bearing the same device as the breast-plate and below it a cluster of forked lightning winged, taken from the Ordnance arms. The shakos of the staff-serjeants and serjeants were provided with superior fittings and white hackle feathers.

WORKING DRESS.

Coat.—The collar of the jacket was changed from the open to the closed Prussian fashion.

Trowsers.—These were of a deeper grey than formerly.

1829. WORKING DRESS.

Cap.—The yellow band disappeared, but the staff serjeants retained the gold band.

1830. UNIFORM.

Hat.—The shako was reduced in size, and decorated with yellow lines and tassels, which were looped to the centre of the breast. The brasses comprised a radiated star with three guns, carriages, and sponges, surmounted by a crown. The scales were worn under the chin, and a goose feather 10 inches long was held upright by an exploded grenade. The back flap was removed and a patent leather band substituted. The ornaments worn by the staff-serjeants and serjeants were fine gilt, the guns, carriages and sponges being of silver. The lines and tassels were of fine gold cord, worn only on special occasions.

Oilskin cases for the feather were worn by all ranks in wet weather.

G.O. 78 of 23rd April, directs that white linen trousers shall be worn from 1st May to 14th October, and cloth trousers from 15th October to 30th April.

1832. UNIFORM.

Coatee.—This was made double-breasted. The colour was changed from scarlet to brick-red, except for the bugle-major and buglers.

Trowsers.—Dark Oxford mixture, with a red stripe 2 inches wide; laced boots.

Hat.—The shako-plate device was altered to that of the royal arms and supporters, with the motto "Ubique quo fas et gloria ducunt"; this device was also worn on the breast-plate. The lines were abolished.

WORKING DRESS.

Coat.—A round jacket, with bell buttons bearing the corps device, replaced the jacket with short skirts.

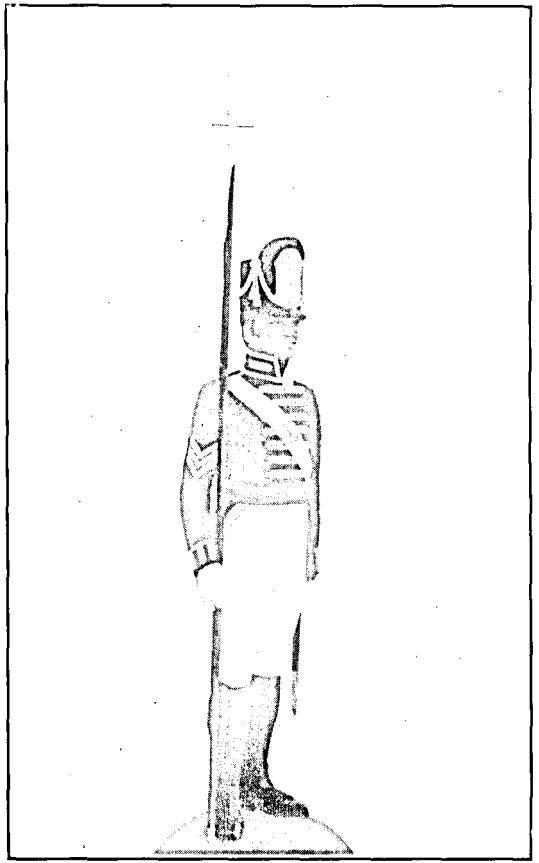
Trowsers.—Dark Oxford mixture, with red stripes ½-inch wide.

Cap.—The staff-serjeants wore instead of the forage cap a silk oilskin shako of the same size and shape as the uniform shako.

Note.—This description of the device worn on the shako plate is interesting as, if Connolly is correct (I. 292), it points to the fact that the motto was originally granted as one and not two; also the gun, which formed part of the grant to the Royal Artillery and Royal Engineers in 1832, was not given to the Royal Sappers and Miners.

THE UNIFORMS OF THE CORPS OF ROYAL ENGINEERS UP TO 1914.

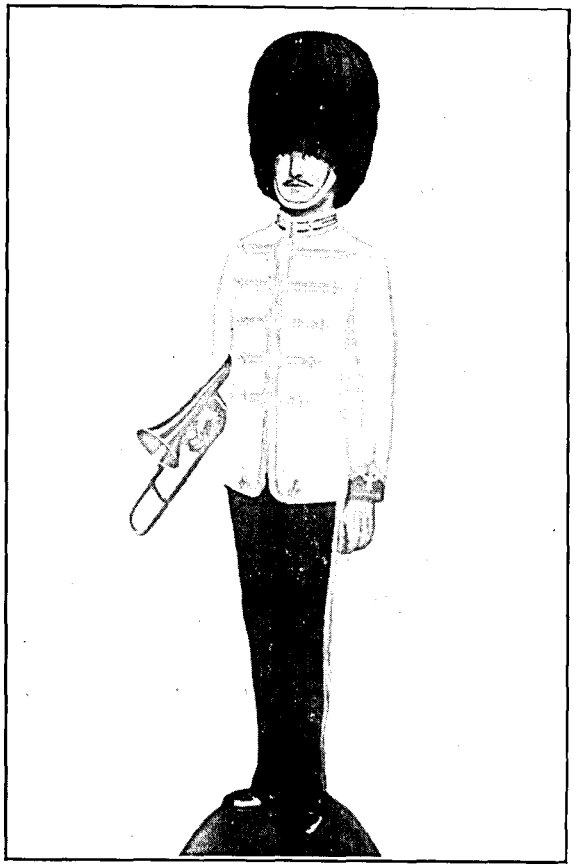
Private, Royal Military Artificers, 1787.



Serjeant, Royal Sappers and Miners, 1813.

From a silhouette in R.E. Museum.

Serjeant, Royal Sappers and Miners, 1854.



Musician, R E. Band, 1865.

From a silhouette in R.E. Museum.

1837. UNIFORM.

Coatee.—The colour was changed back to scarlet from brick red, the dye of which had proved very unsatisfactory.

WORKING DRESS.

Cap.—The Kilmarnock bonnet was replaced by a blue cloth cap, stiffened, with peak and chin-strap. The staff-serjeants wore a gold oakleaf band, and a gilt crown within laurel leaves. The serjeants' caps were distinguished by black oakleaf bands and gilt ornaments consisting of a grenade encircled by a laurel wreath surmounted by a crown and three chevrons. Other N.C.O's wore chevrons according to their rank.

1841. WORKING DRESS.

Frock Coat.—This was introduced as " undress " for staff-serjeants. It was plain, single-breasted, of dark Oxford mixture, with regimental buttons and a Prussian collar.

1843.

This year the Corps was re-armed, which led to certain alterations being made in the belts, etc. The flint-lock musket and bayonet were replaced by the percussion carbine and sword-bayonet. The shoulder-belt for carrying the bayonet was abolished for all ranks, and a waist-belt two inches broad, with cap-bag and sliding frog, substituted. The belt-plate bore the royal arms without supporters, within a " union wreath," with " Ubique " underneath and a crown above. The shoulder-belt to carry the cartridge pouch was unaltered.

The swords of the serjeants were withdrawn, and they were armed in the same way as the other ranks. On the pouch-belt they wore a grenade bearing on the swell of the bomb the royal arms and supporters; underneath was a scroll inscribed " Royal Sappers and Miners," to which was attached a ring with a chain carrying a whistle; the whistle and its case were in the shape of a Martello tower, the whistle itself forming the battlemented crown, inscribed with the motto " Ubique."

The bugler's short sword with three guards was replaced by one with a hilt in the form of a Maltese cross fleury, and on the flat between the horizontal limbs an exploded grenade. The blade was straight, two feet ten inches long, and the mounting on the scabbard was chased and embellished.

Note.—To give the men practice in firing the old flint-lock, it had been a standing order in 1818 at the R.E. Establishment that the men coming off guard duties should fire three rounds of ball at a target.

1846. UNIFORM.

Coatee.—The epaulettes were altered from a small blocked pattern to one with loose twisted cords three inches long suspended from a raised corded crescent. Staff-serjeants and serjeants wore a gold

fringe and a gilt crescent. The shoulder strap of serjeants and other ranks was of blue cloth faced with gold lace. The strap of the staff-serjeants was a full-laced gold strap with raised embroidered wire and a gilt crescent.

The collar was now of blue cloth all round, with rectangular laced loops as before.

1852. WORKING DRESS.

A General Order of 17th August gives particulars of the forage cap.

Cap, blue cloth.

1. Diameter of crown, $7\frac{3}{4}$ inches to $9\frac{1}{2}$ inches.
2. Wall, $8\frac{1}{8}$ inches to $8\frac{3}{8}$ inches.

These dimensions should vary with the size of the head; $8\frac{3}{4}$ inches for 22 inches circumference.

3. Band constant, $\frac{1}{2}$ inch.
4. Depth of peak constant, $2\frac{1}{8}$ inch, lined and bound with seal leather.
5. Length of peak constant, $10\frac{1}{4}$ inches.

The peak must be cut so that it may project from the lower part of the forehead at least one inch.

6. Piping round crown and bottom of band, and below latter a binding of glazed calf-skin.
7. Cap lined with black calico and the band with roan leather made elastic to fold for packing.
8. A narrow patent leather chinstrap attached to the cap with buttons.

Serjeants' caps should conform in shape and other details, except that round the band will be worn black lace of oakleaf pattern, and in front of the cap the Corps device and chevrons as at present.

1853. UNIFORM.

Great-Coat.—This had been grey for nearly 50 years; it was now changed to blue, and the cape was made smaller. Cuffs were abolished, and the serjeants now wore scarlet collars.

1855. WORKING DRESS.

Forage cap.—Early in the year the Kilmarnock bonnet was revived, but of more modest dimensions than before. It had a yellow band with a plain yellow ornament on the crown, and the previous small peak was replaced by one, known as the "war peak," affording much more protection to the eyes.

In May of this year the Board of Ordnance was abolished, and the General Commanding-in-Chief, Viscount Hardinge, assumed command of the Royal Engineers and Royal Sappers and Miners. Late in the summer of this year considerable alterations in dress were introduced.

UNIFORM.

Coat.—The coatee disappeared and was replaced by the modern tunic. Scarlet, single-breasted, with facings and edgings of dark blue

plush. Collar with rounded points and bound all round with yellow cord; cuffs pointed and ornamented with an Austrian knot of yellow cord. Skirts plain about 12 inches long, lined with white shalloon and ornamented up the back with two upright pocket slashes with blue edgings having three points and as many buttons. Double cords were worn on the shoulders; the buttons remained the same as before, and were sewn two inches apart as low as the waist; two small buttons were worn on the cuff.

The drivers, introduced this year into the Corps, wore shorter skirts.

Staff-serjeants and serjeants wore finer cloth and royal gold cord instead of yellow worsted cord. Ranks were shown by the following gold lace chevrons worn point downwards above the elbow: lance-corporals one stripe on the right arm; second-corporals, one on each arm; corporals two on each arm, and serjeants three and an embroidered crown. Colour-serjeants wore the "honourable badge" above the three stripes, and staff-serjeants wore above the cuff knot four stripes of broader lace with the point up and an embroidered crown. The staff-serjeants also wore facings of garter blue silk velvet, shoulder knots of treble twisted gold cord with blue eyes bearing silver embroidered grenades; the sleeve knots traced in and out with Russia gold braid, and the skirts lined with white kerseymere.

Trowsers.—Dark Oxford mixture, with 2-inch red stripes. The driver troop wore strapped trousers of regimental quality.

Hat.—The shako was retained unaltered, but as it was too top-heavy to ride in, the driver troop wore the forage cap for all purposes until the busby was introduced in 1857.

WORKING DRESS.

Jacket.—Of red cloth, loose and suitable for work, coming down to the hips; with pointed cuffs of blue cloth, blue cloth rounded collar, and shoulder-cords of yellow worsted single-twisted. Buttons small and convex, bearing the "garter device," and worn about an inch apart. All N.C.O's wore gold chevrons and gold single-twisted shoulder-cords. The serjeants wore an embroidered crown above the chevrons, and the colour-serjeants four stripes and the crown. The staff-serjeants wore on parade scarlet jackets with the badges of their rank, gold studs down the front, and dark blue silk velvet cuffs and collar, both trimmed with gold Russia braid and finished with crows' feet. There were no buttons except two on each cuff and two for the shoulder-cords. The front fastened with hooks and eyes. Off parade, the staff-serjeant wore a plain blue surtout with rounded collar.

This working jacket, or another of similar cut, was now worn in drill order and on orderly duty as well as on working parades. The working jacket is described by Connolly as "red," and the other as "scarlet."

Forage cap.—A small Kilmarnock bonnet with chin-strap; of dark blue wool banded with a yellow stripe manufactured in the web, and decorated with a brass boss in the centre of the crown. Corporals and superior ranks wore small dark-blue cloth caps with large projecting peaks, trimmed with scarlet piping and gold lace bands.

The carbine introduced in 1843 was discarded, and the Lancaster percussion-musket introduced in its place. This was bored elliptically without a groove, and fired an elongated bullet at ranges exceeding 1000 yards. The carbine was inaccurate at 200 yards, and hardly ever hit the target at 300 yards. It got foul very quickly, and "many a man broke the ranks to find a brickbat or other rude assistance to hammer the ramrod into the barrel."

The drivers had no rifles or muskets, but were armed with light Prussian swords having half basket-hilts and buff leather tassels. The grip was partly of black japanned wood, ridged; all else, with the scabbard, steel. The sword was suspended from a narrow buff waist-belt with a plain brass waist-plate. The N.C.O's wore a buff pouch-belt, with a small plain black leather pouch, and a brass slide instead of a buckle.

The other accoutrements remained the same as before, except that those of the staff-serjeants now consisted of a white patent buff waist-belt with slings and gilt waist-plate bearing the royal arms, and a pouch-belt, both plain and two inches broad. To the latter was attached a black leather pouch carried by gilt rings and mountings, having on the flap the royal arms and supporters with the corps motto. They carried swords with steel scabbards and a gold acorn knot.

BAND.

The Band was officially recognized in 1856, though a brass band had been in existence long before. The uniform, designed by the Prince Consort, was as follows:—

Head-dress.—Bearskin with gilt curb chain for the chin.

Tunic.—White cloth, cut on the model of the Sappers' tunic, except that the skirts had no slashes and the fronts were curved. Facings and edges of bright blue silk plush. All lacing $\frac{1}{2}$-inch wide gold, and tracing worked with Russian braid. Collar laced all round and traced on the inner edges with eyes in the angles and a crow's foot at the centre. The cuffs similarly laced and traced on both edges with a series of eyes and finished with crows' feet. Front edges and back seams traced in and out and figured at the (lower) terminations with crows' feet. The back seam lace finished at the top with crows' feet and relieved at the waist by an "ornithological" device.* Square entwisted cords with buttons at the shoulders. Down each breast five bars of gold braiding traced on both edges, having eyes at the corners and terminating at the points with crows' feet. Closed at the front by hooks and eyes.

Trowsers.—Scarlet cloth with a stripe of gold lace $\frac{1}{8}$-inch wide on the outer seam.

Belt.—White patent leather, with plate as worn by staff serjeants; short sword with hilt in the shape of an ornamental Maltese cross bearing the device of a bugle horn; black leather scabbard with brasses ornamentally shaped.

* Technically called a plume.

Undress.—Forage cap similar to serjeants. Trowsers, as privates. Jacket, as privates with an addition of twisted gold shoulder cords, blue cloth edgings, and blue cloth piping down the hind arm and back. Seams terminating with blue cushions in lieu of buttons.

BANDMASTER.

Tunic.—Scarlet without breast bars. Facings and edgings of garter blue silk velvet. The collar is traced with a series of eyes on the inner edges of the lace; the shoulder cords treble-twisted and ornamented with embroidered grenades. In all other respects laced, traced and figured like the tunics of the musicians.

Trowsers.—Dark Oxford mixture with a stripe of rich gold lace, one-and-three-quarter inches wide, down the outer seam.

Undress.—Dark blue cloth surtout, single-breasted, hooked up at the neck, with upright rounded collar and five loops two inches wide of mohair braid down the front, which are further ornamented by the addition of a row of netted barrels and flags. All the rest of the trimming similar to that on the surtout of the quartermasters. Trowsers—As for quartermasters. Forage cap—As for quartermasters. Accoutrements as for staff-serjeants, except that instead of the sword is substituted a scimitar, short and light, in a brass scabbard, the hilt being composed of masks and foliage of the "cinque cento" period. The curve of the grip issues in a lion's head, with ring attached, bearing a flowing treble fret-work chain united to a ring in the guard.

This completes Connolly's descriptions of the dress of the men. The Royal Sappers and Miners, as a separate corps of Engineer rank and file, ceased to exist and were absorbed into the Royal Engineers. From 1857 to 1870 the *Regulations for the Dress and Appointments of the Corps of Royal Engineers* are available.

1857. The *Dress Regulations* of this date have already been quoted in the case of the officers. The section dealing with the dress of the non-commissioned officers and sappers gave the following instructions, the most notable alteration being the substitution of the busby for the shako.

Tunic.

To be precisely of the same pattern as that previously described for Subaltern Officers of Royal Engineers (with the exceptions hereafter named), the cord on the edge of collar and collar seam and the Austrian knot on the cuffs to be :—

For Staff and other Serjeants.—Gold.

For Rank and File.—Yellow worsted.

The Austrian knot on the cuff to be $7\frac{3}{4}$ inches deep, and 3 inches wide at the knot.

Shoulder Cord.

For Staff-Serjeants.—Round edge gold, treble twist, with embroidered silver grenade.

For Serjeants.—Square gold double, not twisted.

For Rank and File.—Yellow double worsted, not twisted.

Chevrons.

For all Ranks.—Gold lace, and to be placed as follows :—

Staff-Serjeants.—Four chevrons on each arm just above the sleeve knot, points downwards, surmounted by a crown; and, in addition, the Bugle-Major to wear a rich embroidered badge above the elbow.

Colour-Serjeants.—Four chevrons on each arm above the elbow, surmounted by a crown.

Serjeants.—Three chevrons on each arm above the elbow, surmounted by a crown.

Corporals.—Two chevrons on each arm above the elbow.

2nd-Corporals.—One chevron on each arm above the elbow.

Lance-Corporals.—One chevron on the right arm above the elbow.

Badges for good conduct.

For Rank and File—Non-commissioned Officers.—To be gold lace (½-inch).

For Sappers.—To be ½-inch worsted lace.

To be worn in each case point upwards, the top point to be one inch above the knot on the right arm.

Facings.

For Staff-Serjeants.—To be garter blue velvet.

For other Ranks.—To be blue worsted plush, edged with yellow worsted binding.

Collar.—From 2¼ to 2⅝ inches in depth and rounded in front.

Working Jacket.

Scarlet cloth, single-breasted, to button down front. Buttons, 16 in number in front, and 2 on each sleeve band, and one on each shoulder for shoulder cord.

Collar.—Blue cloth, rounded in front, from 2¼ to 2⅝ inches in depth.

Cuffs.—Blue cloth, pointed, 5 inches deep.

Chevrons.—As described for tunic.

Shoulder Cord.—For Serjeants, gold, round; for Rank and File, yellow worsted, round.

Trowsers, Uniform and Working.

Dark Oxford mixture, a scarlet stripe 2 inches wide down outer seam, with pocket at top of waist-band. White linen of Russia drill on foreign stations in summer.

The Bugle-Major, instead of a scarlet stripe, to wear a gold lace stripe (Staff pattern).

Forage Cap.

Staff-Serjeants.—To be the same as that described for officers of Royal Engineers.

Serjeants.—To be the same as the above, with the exception that the lace is to be 1½-inches bias and stand, instead of the Corps pattern, and that the button is to be of the basket pattern, instead of being netted.

Rank and File.—Dark blue Kilmarnock; breadth of crown 8½ inches; depth 4¼ inches, with a yellow band (Corps pattern), and metal beehive button on centre of crown.

Chevrons for Corporals.—Gold, on scarlet cloth, according to rank.

Busby.

According to pattern.

Great-Coat.

Dark blue cloth, with cape and sleeves, and upright collar.

For Staff and other Serjeants, the collar to be of scarlet cloth.

Chevrons of yellow worsted, according to rank, above the elbow (for Rank and File, Non-commissioned officers only).

Stock.

Black patent leather, with strap and buckle.

Gloves.

White leather, pipe-clayed.

Boots.

Blucher, black leather, polished with blacking.

Knapsack.

Of the pattern approved for the Infantry.

Bag.

Of vulcanized india-rubber, 2 feet 4 inches long, and 18 inches diameter of end, with a covering of same material at mouth, to protect the contents.

Dress to be worn on the following occasions.

Church parade.—Tunic ; Busby, with plume ; Waist belt ; Uniform trowsers ; Sword (i.e. Bayonet) ; Gloves.

Garrison duty and Review order.—Tunic ; Busby, with plume ; Waist belt ; Cross-belt and pouch ; Uniform trowsers ; Carbine and sword.

Marching order.—Tunic ; Busby, with plume ; Waist belt ; Cross belt and pouch ; Uniform trowsers ; Carbine and sword ; Knapsack, with great-coat folded at the back of the pack, and mess tin on top.

Orderly duty.—Working jacket ; Forage cap ; Working trowsers ; Waist belt ; Sword ; Gloves.

Drill order.—Working jacket ; Working trowsers ; Forage cap ; Waist belt ; Cross belt and pouch ; Carbine and sword ; Gloves (in winter).

Working dress.—Forage cap ; Working jacket ; Working trowsers.

Notes for Non-commissioned Officers and Sappers.

1. *In "Marching Order."*—The plume may be taken out of the busby in bad weather, or when on the line of march.

2. *Staff-Serjeants* are allowed to wear, as a working dress, a plain blue frock-coat, single-breasted, an upright collar, rounded in front.

The facings and edging of their tunic to be blue silk velvet, the Austrian knot on cuffs to be traced with gold braid ; the shoulder knot as ordered for Subaltern Officers.

Their fatigue jacket to hook-and-eye, with studs, and the collar and cuffs to be edged with small gold braid, and with chevrons on each arm, as directed for the tunic.

Only Staff-Serjeants who habitually attend parades are required to provide themselves with this jacket.

3. Waist-belts, when worn, to be complete with cap-bag and frog.

4. Out of barracks, in whatever dress, waist belt and gloves to be worn.

5. Straps to trowsers are to be discontinued.

6. When ordered for service, and blankets, canteens, and havresacks are issued, the great-coat is to be folded 12½ by 11½ inches, and strapped to back of knapsack; the blanket rolled 14 by 8 inches on top of knapsack, and the mess-tin secured to it. The havresack to be worn on the right hip, and the canteen on the left. (Note: the canteen was the waterbottle.)

The working jacket, forage caps, knapsack, etc., are shown on the plate opposite, which is taken from *Army Equipment; Part III, Sec. I—Engineers*, 1866.

In the *Regulations* dated 1st April, 1861, the following alterations were made:—

Busby.—This was reduced from 8 inches high in front and 9½ behind to 7½ inches in front and 8⅝ inches behind. The plume always to be worn.

Working jacket.—Scarlet cloth, single-breasted, to button down front. Buttons, 10 in number in front.

Forage cap.—Rank and File: Dark blue Kilmarnock; breadth of crown 8 inches; depth 3½ inches, with a yellow worsted band, 1¼ inches wide, yellow button on centre of crown, leather chin strap and brass buckle.

Great coat.—Dark blue cloth, with cape and scarlet collar. Chevrons to be ½-inch yellow worsted lace, according to rank, put on point downwards, the point of the lower chevron being 7 inches from the bottom of the sleeve.

Gloves added to Garrison duty, Review order, and Marching order.

By an order dated 16th November, 1869, the leather stock was superseded by a "tab."

1870. The following alterations were made by the Regulations of this year:—

Tunic.—Collar to be 1¼ inches to 1¾ inches in depth, according to the man's height: to be rounded in front, without lace or device except for Staff-Serjeants, whose collars will be traced round with gold braid inside of cord.

Working Jacket.—Shoulder cord for Serjeants, gold round, twisted: for Rank and File, yellow worsted, square, not twisted.

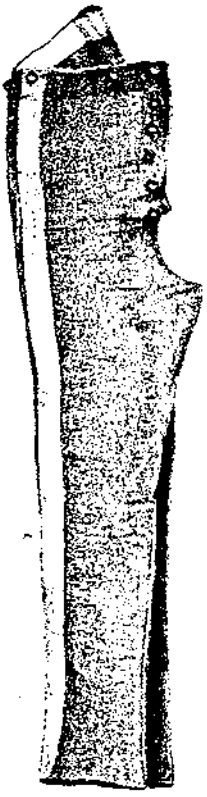
Trowsers.—Oxford mixture, with frog-mouth pockets. Blue serge or tartan will be worn at certain foreign stations in summer.

Forage cap with horizontal peak. Staff-Serjeants, as for officers, but the lace 1¼ inches wide of universal pattern. Serjeants, lace 1 inch wide; button of basket pattern. Oil-skin covers will not be worn. Rank and File, without peak, of blue cloth and cylindrical in shape: circumference of crown and lower edge to be the same: yellow worsted band 1 inch wide, yellow covered button in centre of crown, leather chin-strap with black buckle: height 2⅝ inches. (This marked the introduction of the "pill-box," which lasted up to 1903.)

CLOTHING KNAPSACK &c

JACKET

TROWSERS



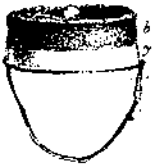
FORAGE CAPS

Sergeants

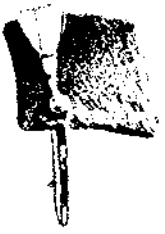
1st Corporals

2nd Corporals & Lance Corporals

Privates & Buglers



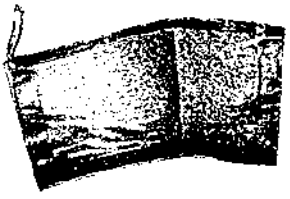
BUSBY



Badges for the different ranks and good conduct badges similar to those on the tunics are worn on the jackets

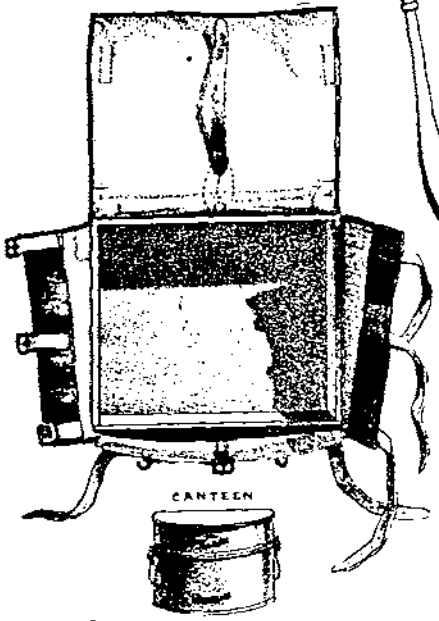
BOOT

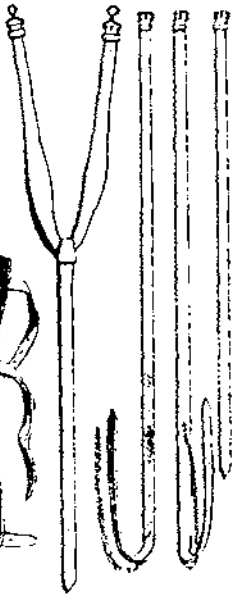
LEGGING



KNAPSACK & STRAPS

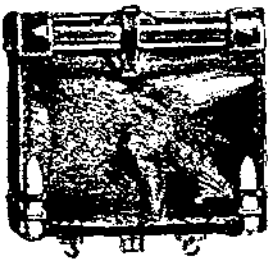
Open





Front

Back



CANTEEN

SCALE ½

THE UNIFORMS OF THE CORPS OF ROYAL ENGINEERS UP TO 1914.

Rank and File Uniforms about 1868.

Drill Order. Church Parade Order.

Busby.—Similar to that described for officers, but the plume to be of horse-hair, and the line of blue worsted cord: the chain for Staff-Serjeants and Serjeants to be of gilding metal, and for the Rank and File of brass.

Ankle boots and leather leggings of Infantry pattern to be worn.

In *Army Equipment—Engineers* 1866, the great-coat is shown without the scarlet collar, but with red piping to the shoulder and waist straps. (This coat still had the cape attached.)

Mounted rank and file wore the same clothing as dismounted, except that booted overalls and wellingtons were worn instead of trousers and ankle boots. Pantaloons and knee boots were introduced in 1881 for full dress, and continued till 1914.

* * * * * *

Colonel Kealy did not carry his researches beyond 1870. After this date, no description of the dress of the rank and file is to be found in regulations, nor has it been possible to obtain specifications. The following notes show the principal changes, which occurred between 1870 and 1914.

Badges of Rank.—In 1881, the grenade was introduced instead of the crown above the chevrons of serjeants and higher ranks.

Full Dress.—The tunic remained unaltered.

A new pattern busby, known as the "Shah," was introduced in 1873. It was one inch higher all round than the 1870 pattern, and without the twisted blue cord in front. This was replaced in 1879 by the helmet, which resembled that of R.E. officers and continued till 1914.

Band.—The white tunic was replaced by the present scarlet tunic in 1873. At the same time the scarlet trousers were replaced by blue with gold (later red) stripes.

The Great-Coat remained unchanged till the introduction of service dress, but the cape became a separate article.

Drill Order and Working Dress.—The working jacket was replaced in 1872 by a scarlet serge frock. First-class staff-serjeants, however, continued to wear the blue frock coat till 1887. The scarlet frock was rather shorter than the tunic: it fastened in front with five buttons. The collar was blue, with flat yellow braid round the base, the cuffs blue, edged with flat yellow braid terminating in a plain loop. The shoulderstraps were of yellow braid fastened at the inner end to small buttons.

This continued for drill and week-day walking-out purposes till the introduction of service dress; a blue frock was introduced in the '70s for men employed in the Postal Telegraphs and was continued in the 2nd Division of the Telegraph Battalion when it was formed (climbing creosoted telegraph poles spoilt the scarlet frock).

By the early '90s it had been extended to submarine mining and railway companies, and in the late '90s it became the working dress-coat of the corps generally.

Caps.—The pillbox continued till the introduction of service dress. In 1894, a blue field-service cap with grenade badge was brought in, for wear with working dress.

Service Dress was introduced in 1902. The R.E. (letters) shoulder badges, which had been worn with khaki drill in the 'nineties, came in at Home with service dress. The grenade collar badge was introduced after the war. Otherwise, service dress has not materially varied since its inception. The trowsers were originally worn with leggings, not puttees. The S.D. great-coat was introduced at the same time.

The original headgear with service dress was a flat peakless cap, known as the Brodrick, blue with a red patch in front, holding the Corps badge (similar to the present badge, but, of course, with a different Royal Cypher).

The service dress cap replaced this in 1905, and at the same time a blue peaked forage cap with the corps badge was introduced. About 1910, this latter was abolished.

The Band, before 1914, never wore the khaki cap. They wore the blue forage cap while it was authorized. Before and after, they wore the blue field service cap.

An interesting variation of R.E. dress was that of the submarine-mining companies during their existence from 1863 to 1905. They wore as working dress, a naval pattern cap bearing the words "Royal Engineers," a peajacket, blue jersey, blue trousers, and seaboots. Sou'westers and oilskins were worn in rough weather. Full dress was as for the rest of the Corps.

After the abolition of the submarine companies, Royal Engineers employed on Electric Light duties wore blue serge frocks, jerseys and trousers, and peajackets.

The Royal Engineers were armed during this period with the same rifles as the infantry, the Snider rifle being introduced in 1865, the Martini-Henry in 1875, the magazine rifle (Lee-Metford) in 1890, and the short Lee-Enfield in 1905.

Accoutrements.—Pipeclayed waistbelts and frogs continued to be worn with full dress till 1914.

The 1883 marching order consisted of two black leather pouches on the belt, supported by shoulder straps, crossed behind, which supported a black polished valise on the small of the back with the great-coat inside, and mess-tin resting above the valise. The haversack was worn on the left side and the water bottle on the right. In the 1888 pattern, the valise was carried on the shoulders, with the mess-tin on top, and the cape suspended, rolled, below. All the straps were pipeclayed. After the South African War, brown leather accoutrements came in, with four pouches on the belt carrying 50 rounds, and a bandolier carrying the same. There was no pack, and the great-coat was carried on the shoulders.

MODERN BRIDGING EQUIPMENT—WHAT OF THE TANKS?

By CAPTAIN E. V. DALDY, R.E.

I.—INTRODUCTION.

A STUDY of history shows that wars are normally followed by periods of recuperation, excessive industry, and then stagnation. The length of these periods is variable, depending on the magnitude of the war just ended, and the period of stagnation may never be reached if the time between wars is sufficiently short.

The period of recuperation needs no explanation. It ends when someone says, "We were caught bending badly at the beginning of the last war. This must not happen again," and the industrious period begins. This period has for its guide three main things :—

(*a*) *The Lessons of Previous Wars.*

These are concrete facts obtained by study, and the remedies can usually be supplied fairly easily. For that reason most of the energy is spent in this direction.

(*b*) *Progress in Civil Life.*

This is usually faster than in military life, as there are experts at work with a definite object in view, with no influences, such as the effect of enemy action, to distract their attention. The civilian product does not always fit the military need, and sometimes, owing to lack of expert knowledge or imagination, things are jettisoned as useless which could easily be adapted to military use.

(*c*) *Imagination.*

A man's imagination may foresee a new weapon or form of warfare, but it is limited. It boggles at the task of working out the full effect of the new thing on every phase and operation of war. Also, although a man may convince himself that the figment of his imagination is good, it is exceedingly difficult to make others, perhaps not so imaginative, agree. The reception of the tank in its early stages is an excellent example of the wet blankets which are always flapping in the wind.

The military engineer can get no assistance from the civilian with regard to bridging. It therefore follows that, once the lessons of previous wars have been dealt with, a saturation point is reached, beyond which any advance must be the result of imagination. The Army, being conservative, and largely owing to lack of funds for experimental work, advances beyond this point with difficulty. Stagnation sets in, and in due course we are caught bending again.

The period of stagnation has not yet arrived, and it is essential that it should not be permitted to do so. Our representative in the

march of progress is the R.E. Board, and it is on account of the concluding paragraph of Colonel Sayer's lecture, published in *The R.E. Journal* of September, 1934, that I have written this article.

II.—THE PROBLEM TO BE SOLVED.

In his lecture, Colonel Sayer shows clearly the evolution of modern bridging equipment. At various stages the R.E. Board appears to have been asked to design bridges to meet specified requirements, mainly based on the load factor. In each case, a satisfactory answer has been found.

It seems, however, that those responsible for the "specified requirements" have overlooked the fact that not only can tactics affect a bridge design, but a bridge design may be the ruling factor in a major operation. Once the design of a tank has reached a stage when only slight variations are probable, the military engineer can easily design a bridge to meet the load requirements, as he is dealing with facts.

Owing to the fact that tanks have had no actual experience in mobile warfare, their tactical use is purely theoretical, a matter of imagination which has had no proof. Their effect on bridging requirements was, therefore, not foreseen.

Since the formation of the Tank Brigade in 1934, all eyes have been focussed on the subject of tank tactics, and the results have been very noticeable. The writer has attended many T.Es.W.T. and three battlefield tours in the last few years, and the change of outlook in the last year has been remarkable. Instead of wanting to know, "How soon can the infantry support weapons and light artillery get across a river?" the commander now asks, "How soon can the medium and 'I' tanks get across?" The answer to this question often governs the timing of the whole operation.

The problem of the military engineer is, then, no longer, "Can you build me a bridge to take tanks?" but has become, "Can you get the medium and 'I' tanks over with the infantry or immediately after them?"

III.—CONSIDERATIONS AFFECTING THE PROBLEM.

(*a*) With the advent of the tank the water obstacle has increased in importance, and it is likely that an enemy retiring will fight just as hard to hold a river line as he did for the high ground in the past. It is unlikely that a river crossing will ever be a peaceful business. Any bridge to take tanks is bound to be a heavy affair, requiring time and reasonable conditions for assembly.

It is essential, therefore, that bridgeheads should be established with the aid of light equipment, so that heavy bridging can be freed from machine-gun and light automatic fire. After the proposed re-design of the folding-boat equipment has been carried out, the

light bridging position will be very good. It will be possible to take across rivers all infantry weapons and vehicles, light artillery, 30-cwt. lorries and light tanks, on equipment carried in the division. The quality need cause us no worry, but only the quantity.

At present the Field Park Company can provide material for only two light bridges over a gap of 120 ft., or one over 180 ft. (where only one trestle at each end can be used). The light bridge is essential where many vehicles have to cross, as ferrying takes far too long. Will this satisfy the needs of a division ?

(*b*) The infantry and light tanks may be strong enough only to make slight progress on the enemy's bank. In this case, heavy bridging in close contact will be necessary, and it will probably have to be done at night. It is essential, then, that the design should be very simple. This cannot be said of the existing heavy bridge with its compound joists, and the great difficulty of manœuvring heavy rafts at night.

(*c*) Apart from actual demolition of bridges, the enemy is likely to concentrate his " hates " against the area around the demolished bridge, to prevent bridging operations near convenient roads. If this is the case, the only alternatives are, either to make the Field Companies work in the area and suffer casualties, or to cross elsewhere where there are no roads. The first alternative is to be deprecated. The second is satisfactory and has the advantage of surprise, but it limits the traffic to tracked vehicles. This is not such a disadvantage as it may seem, as heavy wheeled traffic is not required forward in the early stages. This traffic is bound by roads to the areas about the demolished bridges, and the formation of a tank crossing elsewhere leaves this area free for preparation of semi-permanent bridging. It also removes the bugbear of the military engineer making approach roads against time.

(*d*) If tank crossings are to be made distant from roads, the bridging vehicles themselves should be tracked, or have a high cross-country performance. It would be a further advantage if the trailer could be scrapped. One lorry with a trailer is more nuisance, especially in the dark, than several lorries by themselves.

(*e*) No mention has been made of medium bridging which forms an important part of present-day training. This form of bridging was essential when bridges were made in the order of their heaviness, but now that tank crossings are the first need of a force, its erection and dismantling are pure waste of man-power. It may well give way now to the heavy bridge. In addition, the engineer officer making an appreciation before a river crossing is faced with many permutations and combinations of types of bridges which can be made. It is not a very satisfactory answer to a commander to say, " I can provide three heavy bridges, or two heavy and two medium, or one heavy and three medium, or four medium bridges. Take your choice," which is what happens now. All this confusion would

be removed if the pontoon equipment was reduced to terms of heavy bridges only.

(*f*) The present equipment also leads one to toy with the idea of using medium bridges and then converting them to heavy ones. This is a long and arduous operation at night, not the sort to be undertaken where accuracy of timing is of paramount importance.

(*g*) Tanks will probably be used in battalions or brigades. A slight calculation of the time necessary to get a battalion across a river by means of the heavy ferry will show that this takes too long to be of practicable value, and that the bridge is essential.

(*h*) Semi-permanent bridges of the stock span-type should be available shortly, so that there need be no worries in this direction. After working out many working-party tables on T.Es.W.T., it is clear that any such bridge must be very simple, and almost as speedy in construction as pontoon equipment in order to replace it quickly.

IV.—CONCLUSION.

From these few considerations it appears that what the Army now requires is :—

(*a*) Light bridging equipment.
(*b*) Tank crossings which can be turned into heavy bridges by construction of approach roads, and
(*c*) Semi-permanent bridges to take heavy loads.

The former and latter will shortly be well up to date, but our existing pontoon equipment does not quite seem to fill the present-day needs. These needs are a bridge of simple construction, easy to build and manœuvre in the dark, carried on vehicles with high cross-country performance, and without trailers if possible.

Whether it is possible to produce this from the present equipment, which has a lot of the necessary attributes, by re-design of the pontoon to increase buoyancy and so do away with the double pier in heavy bridge, I am not prepared to say. Being in the position of the man who does the work with the goods provided, and not that of the provider, I submit these suggestions, timidly, with the hope that they may be of some use, even if they only cause discussion.

I have touched on the subject of " quantity " of equipment only very slightly. Quantity is governed very largely by " road-space," which is a question of high policy. With the increasing importance of the heavy bridge, the quantity in the Pontoon Bridge Park appears to be quite inadequate for Corps needs, when faced with crossing such rivers as the Marne or the Aisne, which cannot be considered to be " outsize." This leads one to think that the question has now become one of re-design, as no further conjuring with the present equipment is likely to reduce road-space.

SIMPLICITY AND FLEXIBILITY FOR OUR SERVICE PONTOON EQUIPMENT.

By J. A. C.

1935.

I.—Introduction.

Recent bridging exercises have brought out discussion on the difficult requirements of an ideal floating bridge equipment for our mechanized army.

The object of this paper is not be to belittle the achievements of those who, in the face of great difficulties, successfully evolved the workable post-war pontoon equipment which we use to-day, but to see whether altered conditions do not now point towards the necessity for a change in design and to stimulate discussion on the lines that such a change might take.

Our pontoons have been designed to be constructed of material (consuta wood) that would be available in war and to carry normally, when in bridge, " medium " loads. The result is that, although we have a perfectly sound equipment, it is not very flexible, nor at all simple to use for heavy loads, particularly when the bridge is built at night.

Mechanization of the army is becoming very complete, tactics are also being modified, a medium load is, therefore, no longer a sufficient objective—a heavy tank may indeed be wanted across a river with the leading troops.

Again it would appear to be a mistake to suggest that mechanization should be restricted on account of the bridging equipment of the army, and so we must, if possible, not only allow for a super-heavy load, *e.g.*, 20 tons, to be carried by the normal bridge but, if possible, introduce some flexibility to meet still heavier loads in case of emergency.

The light box-girders give a considerable degree of flexibility when dealing with a deep gap, as the number of girders, which are of variable length, can be increased in emergency to take an unusual load. Would it not be possible to follow up this principle as regards the floating bridge by having an equipment with which we could increase the floats in case of emergency ?

2.—REQUIREMENTS.

Put very broadly, the requirements for a floating bridge come under two general phases :—

(*a*) Assault crossings to form a bridgehead in the face of active enemy interference.
(*b*) Heavy crossings constructed as soon as the bridgehead has made real bridging possible.

For (*a*) above, a light equipment combining simplicity with ease of handling is essential, the primary object being to get "men" across the obstacle.

For this phase we have the Kapok and Folding-boat equipments which may be considered reasonably adequate and will not, therefore, be dealt with further.

For (*b*) we have our trestle and pontoon equipment—the pontoon being designed to provide for a medium bridge as a normal state of affairs ; and unfortunately the design of the equipment is such that it can only be adapted with skill and difficulty to take anything heavier than its normal load.

The saddle-loading design of the heavy pontoon prevents modification of the existing material to provide for heavy bridge as a normal, instead of an emergency, construction, unless the buoyancy and weight of the pontoons are to be considerably increased.

The equipment must, therefore, be re-designed, not merely modified, even if this is to be at the expense of losing some of the original features which it now possesses. In this paper, the re-design of the pontoon equipment only, not the trestle, will be considered, because the latest form of trestle is probably as satisfactory as such a thing can be and something in the way of a trestle must be accepted as a necessary complication and evil to go with any pontoon equipment.

3.—CHARACTERISTICS OF POST-WAR PONTOON EQUIPMENT.

Where re-design of equipment appears necessary, it is sometimes possible to draw inspiration from an examination and comparison of the gear adopted by other people who have a similar object to our own in view. The table in Appendix I gives a summary of some of the main characteristics of the post-war pontoon equipment adopted by four leading foreign military powers at the present day. Although each country must naturally design its war material for its own peculiar needs, it is interesting to see that British practice departs rather sharply from that of these nations in certain basic characteristics which will now be dealt with.

(*a*) *Material.*—All powers, except ourselves and the Italians, rely on a metal pontoon. The main advantages claimed for our ply-

wood construction as compared to metal are: availability as a commercial product in war, elimination of corrosion, and facility for speedy repair.

Now as regards these points, research in the field of light alloys has been active in the years since our pontoon was introduced and reliable light metals of great strength are becoming available as commercial products.

Some of these metals, as, for example, those containing a very high percentage of magnesium, may be unsuitable for military purposes owing to the risk of fire.

Others with a smaller percentage of magnesium, etc., are, however, promising. Aluminium-magnesium and aluminium-silicon alloys are now being made that are very free from corrosion, very strong and very light. The makers claim, for example, that an alloy known as Birmabright, consisting of aluminium with $7\frac{1}{2}\%$ Mg and small additions of Mn, is being successfully used as a material for the entire construction of sea-going vessels, hull plates, frames, etc. This alloy is roughly one-third of the weight of steel and of comparable strength. The table at Appendix II gives a few characteristics of this and similar alloys for general comparison. It is believed that a pontoon of similar buoyancy to our present pontoon and little extra weight could actually be constructed of mild steel: a real saving of weight without loss of strength or buoyancy, therefore, appears possible by the use of light alloys.

The point concerning repair need not cause undue apprehension because small holes in a metal pontoon could be stopped by an adaptation of the device, sold by enterprising popular stores, for the repair of tin kettles, and major repairs would also be possible as nearly all of the commercial light alloys are susceptible to welding.

It appears, therefore, that the substitution of metal for plywood as the material of which the pontoon is composed would be a real step forward. We should be able to get a lighter and stronger pontoon, points of great importance. It is possible also that a metal pontoon might be made strong enough to take its load when grounded, and if so, great advantages might accrue as the trestle often required as a shore bay with all its uncertainties might then be largely eliminated.

(*b*) *Decked Pontoons.*—The British pontoon is the only decked pontoon. This has the advantage of enabling us to work to a smaller freeboard, but it is probable that even after making due allowance for freeboard, undecked and decked pontoons are about equal in weight for an equal allowable net maximum buoyancy. The decking of our pontoons has, therefore, little real advantage except that it fits in conveniently with saddle loading. Decking introduces complications in construction and difficulties when boats

are used as ferries; consequently it might well be dispensed with in the future, in the cause of simplicity.

(*c*) *Saddle Loading.*—The British equipment presents the only example of saddle loading, all other pontoons being made for some form of gunwale loading.

There are many pros and cons—but very broadly it is claimed that saddle loading provides the simplest form of articulation; derives the maximum benefit from available freeboard, as the pontoons are kept on an even keel; and gives designers a sense of security, as stresses are straightforward and easily calculable.

As against these advantages—saddle loading involves heavier superstructure, as the unsupported length of roadbearers is greater between saddles than between gunwales; heavier pontoons to carry the heavy superstructure, and, above all, it reduces flexibility.

Heavy superstructure is a serious item in these days of heavy loads. The superstructure of our existing heavy bridge, for example, weighs approximately $3\frac{1}{2}$ tons per bay, so that nearly the first ton of buoyancy of each pontoon in bridge is used up in carrying superstructure before any useful load is taken at all; anything that tends to reduce this is, therefore, of real value.

Our existing pontoon weighing 1,350 lb. is a difficult load to manipulate at night and could with advantage be lightened. Saddle loading makes this possibility remote. As regards flexibility a bridge using saddle loading, once designed, cannot readily be adopted to carry in an emergency a heavier load. Complicated piers have then to be constructed which are slow to make and not at all suitable for service conditions where work will probably have to be carried out at night with partially trained personnel.

Where gunwale loading is used extra pontoons can be inserted, in emergency, under the roadbearers with comparatively little difficulty, provided the waterway is not unduly restricted. In spite of articulation problems, it seems, therefore, essential that we should give up our originality in this respect for the future, and adopt gunwale loading.

(*d*) *Clear Water between Boats in Bridge.*—Although Continental nations do not put their boats touching each other, and there is little reliable data on which to work, it seems that we alone appear to consider this feature, of clear water between boats, really seriously. In our heavy bridge clear waterway amounts to about 47 per cent. of the width of the gap, whereas in the French reinforced bridge it amounts to only about 10 per cent.

The Continental argument is, in effect, that the water goes under the bridge, not through it and, as a load crossing a floating bridge depresses the boats in turn and not all simultaneously, there seems to be a good deal in this argument. Perhaps, therefore, we need not be so particular as to the space required between boats in bridge,

and so find a further means towards securing greater flexibility. As has already been noted, the neglect of this factor would enable additional boats to be inserted in bridge in case of necessity to take emergency loads.

Conclusion.

From a consideration of the changed conditions that have come with the last few years and an examination of Continental practice, it seems, therefore, that it should be possible to re-design our pontoon equipment to give greater simplicity and flexibility. The ideal will be to have a simple bridge designed to carry normally the heaviest expected load, say 20 tons, and not " medium " loads. In addition there should be the possibility of easy adaptation to take either a still heavier load over a short gap, or alternatively, a lighter load over a wider water gap in case of emergency, on the same principle that the light box-girders are adaptable for unusual conditions.

Complicated piers which take time to make up and are difficult to construct at night must also be eliminated without the introduction in their stead of excessively heavy pontoons.

It is suggested that this ideal can be most nearly approached if the following changes are tried out and introduced :—

(*a*) A light metal alloy to be substituted for consuta wood in the construction of the pontoon—with the object of giving increased strength without additional weight.

(*b*) Decked-in pontoons to be abandoned in favour of simpler open boats—this would facilitate a change to gunwale loading and simplify equipment.

(*c*) Gunwale loading to be substituted for saddle loading. Such a change should make the design of a bridge to take heavy loads, and not medium loads, possible without any increase in the weight of the equipment. In fact, it should be possible to decrease the weight of the pontoon and particularly of the superstructure by making such a change. Complicated piers with the waste of time involved in their construction would also be avoided.

(*d*) To make such a decrease of weight more certain we should disregard restrictions which insist on a percentage of clear water being left between boats in bridge. The lifting of this restriction should give much greater flexibility to the pontoon equipment, and give a margin for abnormal loads.

These suggestions may involve the taking of some risks, but it appears that conditions have changed since our pontoon equipment was designed and experiments on the lines indicated should now be justified.

APPENDIX 1.

COMPARISON OF BRIDGING EQUIPMENTS.

Information from S.M.E., 1935.

		France.	Italy.	U.S.S.R.	U.S.A.	Great Britain
1. Pontoon	Dimensions	28′ × 5·7″ × 2′ 8″			26′ 6″ × 5′ × 2′ 6″	21′ × 5′ 6″ × 2′ 8½
	Open or decked	Open.	Open.	Open.	Open.	Decked.
	Material	Steel.	Wood.	Steel.	Aluminium alloy.	Consuta wood
	Weight	1850 lb.	(Metal pontoon used during Great War.)	about 1,900 lb.	1,400 lb.	1,350 lb.
	Buoyancy			12·7 tons (2 parts)	18,000 lb.	6½ tons.
	Transport (on the road)	H.T.		H.T. and M.T.	Trailer towed by 30-cwt. lorry.	M.T. lorry and trailer
	Transport (during launching)	22 men.			16–20 men.	24 men
2. Superstructure	Gunwale or saddle loading	Gunwale.	Gunwale.	Gunwale.	Gunwale.	Saddle.
	Span of bay	19½ ft	16 ft.	40 ft. (?)	16 ft.	21′ 2½″.
	Number of roadbearers	9	6			7 to 11.
	Dimensions of roadbearers	4½″ × 4½″				6″ × 3″.
	Dimensions of decking	13″ × 1½″			2″ planks.	9″ × 3″ × 11′
3. Loads	Classification	4-ton.	8 tons.	12·7 tons.	7·5 tons.	9 ton load using 2 pontoons per bay.
	Arrangements for extra heavy load	By inserting additional boats in bays capacity is raised to 9 tons. There is also a special heavy bridge for loads 16 and 21 tons.	With pontoons coupled stern to stern and 12 roadbearers, loads up to 18 tons can be carried.	Special pontoons are available for rafts to carry 20 tons.	The 7·5-ton bridge can be reinforced to carry 15 tons. There is also a heavy bridge to carry 23 tons.	Special piers of 4 pontoons per bay can be built to take a 19-ton load.
4. Clearance	Existing clear water-space between pontoons	About 45% normal 10% in reinforced bridge.			7·5 ton 69% reinforced 37½% 23 ton 59%	Medium bridge 73½% Heavy 47%

APPENDIX 2.

COMPARATIVE TABLE SHOWING RELATIVE PROPERTIES OF TYPICAL ALLOYS.

Alloy. 1	Composition. 2	Specific gravity. 3	Weight, lb. per cu. ft. 4	0·1% proof stress for hard sheets in tons per sq. in. 5	Approximate cost for sheets 18 S.W.G. per lb. 6	Remarks. 7
Mild Steel		7·8	485	13—15	About 2d. or 3d.	
Duralumin	Al. about 94% Cu. 3·5 to 4·5% Mn. 0·4 to 0·7% Mg. 0·4 to 0·7%	2·8	175	13—15	2s. 6d.	Subject to corrosion, but a special form known as Aldural can be produced in which sheets of Duralumin are coated on both sides with a layer of pure Aluminium as a protection against corrosion.
Duralumin—H. ... (Magnesium Silicide alloy)	Al. and approx. 0·5% both Magnesium and Silicon.	2·7	170	10—12	?	High resistance to corrosion.
M.G7 ... ... (Aluminium Magnesium alloy)	Al. with 6·5% Mg. and 0·3 to 0·6% Mn.	2·63	165	14	3s.	Extremely high resistance to corrosion, sea water and marine atmosphere.
Birmabright	Al. with about 7½% Mg. and additions of Mn.	2·7	167·3	14—16	?	Do. Do. The figure in column 5 is for hard sheets; strength of soft is 6—8 only.
Elektron	Al. 6·15 to 6·45% Zn. 0·8 to 1·2% Si. 0·0 to 0·2% Mn. 0·2 to 0·5% Mg. the remainder.	1·81	113	6—8	5s. 5d.	High resistance to corrosion. Probably not suitable for military purposes owing to risk of fire.

NOTE.—*Proof Stress.* In the schedules of properties, the definition of proof stress is that laid down in the British Air Ministry Aircraft Specifications, viz.:—

"The proof stress shall be defined as that stress at which the stress/strain curve departs by 0·1 per cent. of the gauge length from the straight line of proportionality."

"For the purpose of this Specification, the material shall be deemed to have passed the proof stress test if, when the proof stress is applied to the specimen for a period of 15 seconds and removed, the specimen shall not have received a permanent set greater than 0·1 per cent. of the gauge length."

PORTUGUESE EAST AFRICA, 1918.

By LIEUT.-COLONEL W. E. BRITTEN, O.B.E., R.E.

IN January, 1918, the 14th Company, 2nd Q.V.O. Sappers and Miners, was on detachment at Quetta, when it received orders to mobilize for East Africa. Mobilization proceeded smoothly, and the Company left Quetta on January 20th, arriving on January 24th at Bombay, where two B.O's, both I.A.R.O., and a number of I.O.R., joined it from Bangalore, to bring it up to strength. The Company, less its 18 first-line mules, promptly embarked on H.T. *Royal George*, which sailed at mid-day. The first-line mules were left behind, to follow in another ship; no chargers or second-line mules were taken.

After an uneventful voyage, the *Royal George* arrived off Mombasa on February 1st, and on February 4th dropped anchor in the harbour at Dar es Salaam.

During the Company's stay at Dar es Salaam, awaiting transport down the coast to Port Amelia in Portuguese territory, it was possible to find out for the first time what really was happening in this theatre of war, and it is necessary to describe the situation in some detail in order to render the rest of the narrative intelligible. (See sketch map at the end of this article.)

By October, 1917, the situation in the Lindi area in German East Africa had become that of stalemate. After three years of almost continuous fighting, which had ranged all over German East Africa, neither side found itself in a position to bring about a decisive action. Our own L.-of-C. with the coast was extended to its limit, and was overworked at that. The Germans, on the other hand, had fallen back on their last dumps, and were running short of supplies, S.A.A. and medical necessities. They had, in fact, only six weeks' supplies in hand, and one month's supply of quinine; the latter alone was serious, as without quinine, Europeans soon lose all fighting value in this malaria-ridden country. The total strength of the German forces at this time was 25,000 rifles, 50 M.G's, 2 mountain guns with 400 rounds of ammunition, but only 400,000 rounds of S.A.A. Of this latter the bulk was of black powder, for the old pattern rifles, whereas the majority of the troops were now armed with modern rifles; the M.G's also required modern ammunition.

The situation of the German forces, at bay on the last corner of German soil, daily fighting severe patrol actions which ate up their

ammunition without bringing a decisive action any nearer, was therefore apparently hopeless, but the German commander, von Lettow Vorbeck, was a man of great determination, and he had every intention of carrying on the war, thus retaining a large number of our troops in this theatre of operations, with the consequent expenditure of valuable shipping transport.

It was evident to him that the only way to carry on the war was to evacuate German soil, and to invade Portuguese East Africa with a force so greatly reduced that it might hope to live on the country, and re-provide itself with arms and ammunition from the Portuguese posts known to be scattered over the country.

The decision was a grave one, but he made it. All those in the force, European and African, who were no longer physically or temperamentally fit to carry on, were left behind, with permission to surrender to the British forces, and on November 21st he marched south for the Rovuma, the frontier between Portuguese and German territory, with 300 Germans, 1,700 Askaris, and 3,000 porters and camp followers.

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This decision of von Lettow's, to cut himself adrift from his dumps, and to move at will wherever the country could support him, led to a complete re-distribution and reorganization of our own forces.

It is interesting to note that at this time the English newspapers were speaking of the campaign in East Africa as over, as if the surrender of large numbers of German troops, and the flight of the remainder across the border into Portuguese territory meant the end of a satisfactory though long drawn-out campaign. In reality, although it had now become a "small war," the affair was by no means at an end. The German force could not be allowed to range undisturbed over Portuguese territory, since the Portuguese would at once, and in fact did, demand help on the grounds that all their available resources were already at our disposal on the Western Front. There was also the danger that the Germans would invade Nyassaland and Rhodesia, with the worst possible effect on our prestige in Africa.

On the other hand, it was clearly impossible to follow up the German forces from our L.-of-C. on the "Lindiline," already too long and expensive in transport. It was therefore necessary to reduce our own forces, and to attempt to get on terms with the Germans from a new sea-base farther south, with smaller and much more mobile columns.

An appreciation of the situation at this stage would perhaps be profitable. Our object was obviously to wear down the Germans by bringing them to battle wherever and whenever possible. But they had no important positions to capture, no L.-of-C. to cut. Their columns were light and very mobile, with few impedimenta. The

country everywhere was thick bush, and the visibility usually measurable in yards. The Portuguese maps were most misleading, and the Portuguese themselves distrustful. The natives were hostile, since we were the allies of the Portuguese, for whom they appeared to cherish no very strong feelings of affection. All British and South African combatant troops had now left the country, and the remainder were entirely African, very largely bereft of their best fighting men and veterans, used up in the previous three years of war. The African troops had little or no experience of living on the country, and had in fact learnt to rely solely on the L.-of-C. with the coast. They had none of the amenities of life, no loot, no drink, no women, only their rations, these often scanty. They were also hindered by our traditional scrupulousness in the treatment of the native inhabitants, particularly in the matter of requisitioning both supplies and porters. (Incidentally, these scruples greatly disgusted our Portuguese allies, who, when we paid for what we took, promptly objected on the grounds that we were putting ideas into the natives' heads.)

The German object, on the other hand, was to compel us to keep the maximum number of troops in this theatre of war. The obvious way to do this was to force us to extend our L.-of-C. as far as possible, thus diminishing the size and mobility of our columns, since the L.-of-C. had to be guarded against raids by their highly-efficient long-distance patrols; then, when the L.-of-C. had become extended, to switch a hundred miles or so north or south, thus necessitating the opening up of a new line of communications with the coast.

The German force was well suited for such a rôle. It had been fighting for three years, and all ranks were expert in bush lore and bush warfare. Both white men and natives had attained a remarkable degree of skill in improvisation. They could make their own boots and clothing, make bread from almost any edible grain, preserve meat killed by their hunting parties, make edible lard to supply the fat essential for Europeans, from any animal from the hippopotamus downwards, and could find grain however cleverly concealed by the inhabitants of the country. The Europeans were all resigned to privations, such as the lack of European food, and of mails, although they had no touch with the outside world except through their wireless set, which was capable of receiving messages from the high-powered station at Nauen in Germany. They had a certain number of Europeans who knew the country slightly. They had no bases nor L.-of-C. to guard, and hence no scruples in requisitioning supplies. They were, in fact, a band of marauders free to come and go wherever the country could support them. In addition, they had now eliminated their weaklings and faint-hearts, and in the remainder, the feeling that they were cut off from all

support, as well as the absolute certainty of their ultimate fate, had produced a feeling of fatalistic callousness.

It is obvious from this comparison that the advantages from a military point of view lay strongly with the Germans. As long as food and ammunition could be found, they could carry out their rôle. Whenever things got too hot for them in one locality, they could split up and disappear into the thick bush, to reappear several hundred miles away where they were least wanted or expected.

The course of the subsequent campaign fully justified these conclusions.

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In November, 1917, von Lettow, leaving only a rearguard in touch with our columns, marched up the Rovuma and crossed it by a ford near its junction with the Ludjenda; he had chosen this locality partly because he had heard that the country here was fertile and therefore contained food supplies, but chiefly because he knew that somewhere in this neighbourhood there must be a Portuguese post, from which he might re-arm and re-equip his little force.

The crossing of the river was unopposed, but on the south bank the force at once came under fire, and it was soon obvious that he had found the hoped-for Portuguese. Von Lettow at once went for the post bald-headed, and quickly stormed the position, which was only partly entrenched. In fact, the Portuguese troops had only just arrived, in the futile hope of preventing the crossing of the Rovuma.

It is interesting to read von Lettow's description of the action, since it was typical of many others fought against the Portuguese.

"From all sides we charged the enemy, who was badly shaken by our concentrated fire. Scarcely more than two hundred of the enemy force, about a thousand strong, can have survived. Again and again our Askaris, in search of booty, threw themselves upon the enemy, who was still firing; in addition a crowd of porters and boys, grasping the situation, had quickly run up, and were taking their choice of the pots of lard and other supplies, opening cases of jam and throwing them away again when they thought there was something more attractive in another case. It was a fearful mêlée. Even the Portuguese Askaris already taken prisoner joined in the plunder of their own stores. There was no alternative but to intervene vigorously. I became very eloquent, and to make an example, dashed at least seven times at one porter I knew, but each time he got away, and immediately joined in the looting somewhere else. At last I succeeded in restoring order."

Von Lettow's hopes were amply fulfilled. He captured valuable medical stores, several thousand pounds of European stores, large numbers of rifles, six machine-guns, and he increased his rifle ammunition to one million rounds by the end of December by similar captures.

He was therefore once again in a position to continue the campaign.

But the necessity of obtaining food for 5,000 natives drove him on, and he continued up the Ludjenda river. The force moved in three columns in depth, a day's march apart. Patrols would go into the bush in search of grain, and hunting patrols in search of game, but with no great success. After proceeding eighty miles he was forced to split up his force. A detachment was sent off westward through the Mkula mountain, where he came into contact with small forces of General Northey's, which were based on Lake Nyassa. The main body continued its march south, and other Portuguese posts fell in quick succession.

It should here be explained that these Portuguese posts or *bomas* were in time of peace the headquarters of the revenue farmers. They were occupied by white troops of poor morale and physique, whose rôle was to keep the natives quiet under a somewhat oppressive civil régime, and the posts themselves were not designed for defence against European weapons. They were usually sited on some small hill, from which the bush had been cleared for several hundred yards all round. The buildings were of mud-brick, and whitewashed, and thus untenable against artillery. The troops in them were completely immobile at short notice, depending as they did on porters who had to be rounded up from surrounding villages by surprise patrols at night time. It is therefore not to be wondered at that their resistance was not great, though von Lettow credits them with considerable bravery in some cases, and with refusing to give their parole not to fight again after capture, although this would have led to their immediate release. Von Lettow was therefore considerably embarrassed by them as prisoners on his march, particularly as they were unfit and unused to privation.

The Germans were now in possession of ample S.A.A. and stores, but the necessity of collecting food supplies from the villages scattered at wide intervals through the bush forced them to remain split up, and to move continually from one fertile district to another as supplies became exhausted. One column moved eastwards, and it was with this that "Pamforce," consisting of some 2,000 African troops, with one Indian Mountain Battery, which had landed at Port Amelia, first came into contact.

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The 14th Field Company, 2nd Sappers and Miners, was destined to follow up "Pamforce" and join up with it, and after kicking its heels in Dar es Salaam for a month was finally ordered to embark for Port Amelia in Portuguese East Africa. It received the orders with acclamation. One month's stay in the country had been sufficient to show all ranks that East Africa was something very different from India. Virulent malaria had already taken heavy toll of the Indian

ranks; "jigger" fleas, which burrow unostentatiously under one's toe-nails, and there lay their eggs to hatch out later in festering sores, flies which quickly and painlessly lay eggs under one's skin to hatch out into large white maggots, were among the causes which had persuaded all our volunteer "followers," such as Indian cooks, and bearers, that Africa was no place for them; they had been returned to India, and their places taken by Africans engaged at standard rates of pay through the local Labour Company. (Incidentally, ex-German officers' "boys" were in great demand, and served us as faithfully as they had served their German masters.)

There were then very few European troops left in Dar es Salaam. A Boer general, van Deventer, was in supreme command, many of his staff were South Africans, and transport was almost entirely run by South Africans. In fact, Afrikaans and Swahili were heard more often in the streets than English. As South Africans are not slow to show their dislike for Indians, the situation was not altogether happy, and it was with considerable relief that the Company embarked on a small tramp steamer for Port Amelia, three days' journey down the coast.

The voyage started badly. The sole means of cooking food consisted of one rusty range lashed in the scuppers of the well-deck, whereas the troops and followers to be provided with hot food consisted of some half-dozen officers, about a dozen British N.C.O's, half of them South Africans, two hundred Indian troops, comprising equal numbers of Hindus, Mohammedans and Madrassi Christians, about three hundred African porters, and lastly, an unknown number of Chinese, partly Labour Corps, and partly the crew of the little tramp steamer, the *Chow-tai*, which had been chartered for war service whilst pursuing a peaceful trade on the China seas. Of all these, the African porters alone offered no problem, they would cheerfully eat anything with anybody, whether rice or chupatties cooked for the other Orientals, or British rations of bully beef and biscuit, served *au naturel*. Next in order of reasonableness came the officers and N.C.O's who would at a pinch content themselves with bully beef and biscuit. After them came the Madrassi Christians, too recently converted from Hinduism to eat bully beef, but who would, under protest, eat biscuit.

But if one Chinese were to lay his hands on that rusty stove, the Indians would rather starve than cook their rice or chupatties on it, and if a Mohammedan touched it, the Hindus would gladly suffer martyrdom rather than cook on it, and in all probability the reverse was also true.

Altogether, it was a pretty problem that confronted the O.C. Troops on board, and he promptly informed the Naval Transport Officer that he would not permit the ship to sail until better cooking

arrangements had been provided. There followed a heated argument. The N.T.O. suggested that the O.C. Troops, just arrived from India, had not heard that there was a war on. The O.C. Troops riposted that the war ashore would be child's play to the war afloat if communal trouble started. The N.T.O. had not apparently heard of caste and its attendant evils, and the situation was a deadlock. It was finally settled after much argument and persuasion, helped out by the broaching of a case of whisky from the Company's mess stores: two field cookers were brought out in a lighter and lashed on the opposite side of the well-deck forward.

The *Chow-tai* then sailed, but only after the N.T.O. had handed the O.C. Troops a heavily-sealed envelope, marked "Secret," to be opened at sea. This proved to be an order to place sentries in the various holds, and to ensure their vigilance during the voyage.

As this is normal routine, the receipt of special instructions appeared strange, but the mystery became deeper when some weeks later the O.C. Troops, then in the heart of Africa, received a blueprint of the *Chow-tai's* internals, with instructions to mark on it the position of the sentries posted during the voyage. This he did to the best of his recollection, and officially he heard no more about it. Unofficially, he later learnt that the *Chow-tai* had formed the irritating habit of arriving at her destination seriously deficient of War Department Stores, particularly onions (in that country a very valuable anti-scorbutic), but with the seals on the holds all intact. The skipper of the *Chow-tai*, chance met in Bombay after the Armistice, finally solved the mystery. In the China seas, the smuggling of opium and everything else dutiable is the Chinese crew's pet "racket." Chinese carpenters are clever, and it was his, the captain's idea, that Houdini's vanishing trick was child's play compared with what a law-abiding skipper had to put up with with a "bunch of Chinks forrard."

Which perhaps accounts for the prevalence of onions in the diet of all ranks in our four days' voyage down the coast. Even in the cabin, we had them at all meals, including breakfast; the ship reeked of them day and night, the sentries on the holds would come off duty with their eyes streaming, talking darkly of strange noises heard behind the bulkheads during the night-watches.

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After landing at Port Amelia, the Company equipment was carefully weeded out, and a few days later the Company marched inland, its establishment then being 4 B.O's, 1 B.N.C.O., 150 Sappers, 350 Africans, and a Ford box-car. The Africans were to act as porters, and in their spare time as pioneers, for which purpose each was provided with a *panga*, or large bush-knife, carried on the belt like a bayonet. A week later the Company reached Force H.Q., then seventy miles inland, and its work began. This was, and continued

to be until the end of the campaign, the task of making the bush track behind the force passable for Ford box-cars, in order to economize porters, who were all required as first- and second-line transport for the fighting troops.

The work was hard and monotonous. Long stretches of swamp had to be corduroyed, the small *nullahs* ramped and bridged, and in addition camp had to be moved on almost daily, and new grass huts built for all ranks, since no tents were carried. The bridging was of the most simple: trestles made from trees cut at site, road-bearers from small trees, decking from saplings covered with grass and a few inches of earth.

The African porters soon showed their worth as pioneers, but needed considerable supervision. When sent off into the bush to cut saplings for corduroy work, or for grass for hutting, they would, if left to themselves, disappear for hours and return at length with a large smile and the smallest possible number of saplings or bundles of grass. The Madrassi N.C.O's placed in charge of small gangs were powerless to supervise them, lack of a common language and mutual dislike being the principal difficulties. The Indian looks down upon the African as a savage, while the African resents the assumption of superiority which he considers quite unjustified by the respective colours of their skins.

However, a means was found of stimulating the porters. Every man was provided with a small square of paper, and each N.C.O. with a pencil. For every suitable sapling or bundle of grass brought in, the N.C.O. marked a stroke on the paper. At the end of the day, those with the largest number of strokes on their papers received a bonus in the shape of extra sugar, whilst those at the bottom of the scale a little less than the standard; but after a few days there was very little to choose between the two ends of the scale, which had been averaged up. In other words, the porters had become good trade unionists.

By this time, the strength of the Company had been increased by the posting to it of two extra B.N.C.O's from the Labour Corps, to look after the porters, and the officers' tasks were considerably lightened by their advent. One, a Cockney to the bone, had been in civil life an elephant hunter, and his stories would have filled a book. He, too, bore no love for the Portuguese. They had some years before caught him on their side of the boundary. They promptly confiscated his rifle and all his gear, collared his porters, stripped him naked except for a pair of shorts, and turned him loose in the bush, and it was only by a miracle that he got back to British territory alive. To hear this worthy mustering or adjuring his porters was entertaining, but not instructive. He spoke fluent Swahili with a dreadful Cockney accent, and found it necessary to introduce his favourite English epithets into every Swahili sentence, often in the

middle of a word. His best effort was probably an Anglo-Swahili negative, "*Hapana,*" which has much the same omnibus meaning as "Napooh." Our Cockney friend, if he wished to emphasize his negative, would make it "*Ha* b——y *pana !*"

The trouble was that Swahili is the *lingua franca* of Africa, and many of the porters knew only a few words of it. In a month or two their speech was also interlarded with strange oaths, used quite unconsciously, and the effect was sometimes startling.

The other N.C.O. had also his language difficulties. A quiet young Boer from the *back-veldt*, his trouble was that he possessed only a very slight smattering of English, but he quickly picked up a working knowledge of English, Swahili and Tamil. To this gentleman bully beef, biscuits and ration jam were luxuries of the first water, since all his life he had been used to a diet of mealies, as are apparently all *back-veldt* Boer farmers. It was a marvellous sight to see him sitting outside his hut in the evening devouring a large meal of bully beef, biscuit and jam, eaten all together, his fingers his only table implements, and carrying on a conversation at the same time with three or four porter headsmen, squatting on the ground round him, with the same expression on their faces that one sees on the dogs at a shooting luncheon in the open.

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To revert to the work. This being the dry season, very little bridging had to be done. The force usually followed some clearly-defined bush track, and little other than widening, removing boulders and tree-trunks was necessary to render it passable to light box-cars. On normal sections the Company would march at dawn, covered by a small advanced guard, since German long-distance patrols had an unpleasant trick of skirting the main force and getting round on to the L.-of-C. where they would either lie up in ambush for the first convoy, or else lay "booby traps" in the road. Then parties would be dropped to deal with the work as it appeared necessary. Here a section of Sappers and forty porters to bridge and ramp a small *nullah*, there a couple of Sappers and half-a-dozen porters to remove some trees, and so on, until Company H.Q. had marched perhaps some ten miles. There camp would be made, and the cooks set to work. Each detachment dropped had the duty not only of completing the job for which it was left, but also of removing all obstacles up to the next working party. A subaltern invariably brought up the rear, to see that no snags had been left. When a bigger river was encountered, the Company would halt for several days, and run a trestle bridge across. There was very little water in the rivers, but owing to boulders or mud they were usually unfit for cars to ford.

One bridge in particular deserves mention, as it was built entirely

without engineer stores. This was two hundred miles from the coast, and the force was moving rapidly. All transport, cars and porters were required for rations and first-line loads alone, and the Company had run completely out of dogs, spikes and wire. Transomes were accordingly spiked down to trestle legs with trenails, road-bearers and cross-bracing lashed with creepers or home-made rope twisted up from bark and creeper by the Madrassis, who proved very clever at this work. The result proved entirely satisfactory, and carried several car-convoys safely, when, perhaps fortunately, the force switched off in another direction, and a fresh road was opened behind them cutting out this particular bridge. The length of the bridge was 312 ft.

Occasionally, when the force had temporarily lost touch with the Germans, the Company was actually ahead of the force and unescorted, working on a road or a bridge on the most likely line of advance. On these occasions all military precautions had to be taken. Camps were entrenched, and protected by outlying picquets in the bush. There were several night alarms, but whether caused by German patrols or by lions and other big game will never be known.

Lions were particularly dangerous in those districts where German shooting parties had driven off the small game. The Germans made a regular business of this, constructing very ingenious contrivances looking rather like kilns, in which they smoked and thus preserved the meat of the various buck shot by the hunting parties. When our troops had to pass through such a district, the lions were hungry and correspondingly dangerous, so dangerous that the troops and porters were more frightened of them than of chance enemy patrols, and lit big fires at night to keep them off. Even then there were several casualties from lions. On one occasion they attacked an outlying picquet of the K.A.R. The Corporal in charge woke up in time to see a lion carrying off the sentry. He quickly ran to the Lewis gun and fired it in the direction of the lion, whereupon another lion sprang on him, pulled him away from the gun, and carried him off into the bush also.

On two occasions working parties of the Company were fired upon by German patrols in ambush, and in each case there were several casualties, but nothing was seen of the aggressors, who made off after firing several bursts of machine-gun fire.

These patrols were apparently composed of a couple of German N.C.O's, half a dozen Askaris, and a dozen porters. They were very skilfully led, and lived on the country for weeks at a time, many miles from the column which had sent them out. As the latter was constantly on the move, it was little short of marvellous how the patrols managed to join up again in the thick bush and in unmapped country, a task only possible to men who had been living continuously

in the bush for nearly four years, and had thus acquired an instinctive sense of direction.

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By the end of May, " Pamforce " had penetrated two hundred and fifty miles inland from the coast, and as this month was typical, the following extract from the Company's diary may be of interest.

" Summary for the month. Marched 97 miles. Built 474 ft. of M.T. bridge, laid 2,430 running feet of corduroy, cut 6 miles entirely new road through thick bush."

By mid-June the force had reached the Lurio river, 315 miles from the coast, but by then the German forces were discovered to have moved so far south that it was decided to close the Port Amelia L.-of-C. and to make use of another from Mozambique, which, being a main Portuguese road, was already passable to motor-cars in most places. The Company was accordingly ordered to march south on its own to Ribaue on the Mozambique line. This was an eighty-mile trek, and it was completed in six days, the Company acting as escort to a Field Ambulance, a somewhat unusual role for a Field Company. On arrival at Ribaue, the Company was ordered off again another eighty miles to the south-west along an existing old motor-road, from the end of which it was to push the road on another forty-five miles to the south.

During the next month the Company did considerably more marching and counter-marching than roadwork. The reason for this was that portions of " Pamforce " had come into violent contact with strong German detachments, and it was uncertain which way the main German force was heading—whether von Lettow was aiming south for the Zambesi, west for Nyassaland, or intended at last to come to grips as a gambler's last throw. Actually, he had no definite plan, and was moving wherever he suspected, or friendly natives told him, that the country was rich in supplies. He reached Kilimane, found a large Portuguese supply depot guarded by a detachment of K.A.R. and Portuguese, attacked them with his usual vigour, and after heavy fighting threw them back into the river, in which many were drowned, including the commander of the force, Major Gore-Brown.

Unfortunately, the nearest British column was miles away to the north, for during the night after the action the whole German force lay at the mercy of any assailant—dead drunk. The supply depot contained large supplies of liquor—Portuguese red wine and British rum—and the German troops, after systematically looting the depot as a routine matter, settled down to the serious business of consuming what it could not carry away, including the liquor. If von Lettow is to be believed, this was not through lack of discipline, but a matter of policy. He says that he considered that his force had had a very bad time in the preceding month, that no British forces were

within striking distance, and that a thorough debauch would be good for everybody.

When it had recovered from this, the force set off in a north-easterly direction, fought a heavy engagement with a detachment encountered at Namirrue, and surrounded and captured it; but then von Lettow took fright from captured documents which warned him of important concentrations near the coast. He accordingly broke south, and then turned westwards to get clear of his pursuers.

It was during this period that the Company carried out its marching and counter-marching, interspersed with short bursts of energetic roadmaking in the directions in which the enemy might be expected, or in the construction of hasty defences of posts containing supply dumps.

This period lasted until mid-September, when it became clear that the German forces had again gone northwards, and it was necessary once again to switch back to Pamline, as the line of communications with the coast at Port Amelia was called.

Back on Pamline, the company resumed its work of improving the road for M.T., also opened up water-supply for several small posts on the line. By this time the streams everywhere were drying up, as it was the end of the dry season, and the water problem was sometimes serious, the only visible water being slimy and evil-smelling water-holes. Lieut. Littlejohn, a Company officer, found a leopard in possession of one of these, and was promptly attacked by it, but saved himself by clubbing it with his rifle. The leopard made off, and Littlejohn was unscratched, an unusual end to such an encounter.

By the beginning of October it was clear to all ranks that the German forces had left that part of the country, and gone north. Von Lettow had, in fact, come to the conclusion that the chase was getting too hot, and had broken clear. With his entire force he had re-crossed the Rovuma, marched unopposed right through German East Africa, round the northern end of Lake Nyassa, and at the end of October he invaded Northern Rhodesia. On the signing of the Armistice in Europe he surrendered his entire force at Bismarckburg, and the campaign was at last over.

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On October 3rd the Company received orders to march back independently to Port Amelia, a distance of a hundred and sixty miles from its present camp. The order was accompanied by semi-official intimation that the Company's days in East Africa were numbered—news which very quickly reached the ears of the Indian ranks, who showed no great regret, for reasons which will be summarized later.

The march down the original L.-of-C. was uneventful, but of

considerable interest to the Company, who could see how their original work had stood up under seven months of heavy motor traffic. It was a little disappointing to find that most of the original rough and quickly constructed trestles had been replaced by equally rough-and-ready piled bents. The latter had been put in by the South African Pioneer Companies, whose composition appeared to be about two hundred African natives with about ten South African white officers and N.C.O's.

A detachment of one of these was actually at work as the Company passed, and advantage was taken of the mid-day halt to watch them at work. The procedure was simple, quick, and obviously effective. A tree was cut down, sawn into piles of a little more than the required length, and one end pointed with an axe. An auger hole was then made in the other end, a tube-driving apparatus of the Norton tube-well type let into the end, and the whole up-ended, and held steady in position by four natives. Four more pulling on the two ropes attached to the monkey got to work, and with a very harmonious " chanty " had the pile several feet into the ground in a very short time. The sister pile quickly followed, and the two piles were then sawn off roughly to eye from a bamboo platform, the transom spiked on, and the bent was complete. Its construction had certainly been quicker than that of a similar trestle, and it possessed the advantages that it was not subject to unequal settlement in muddy ground of various degrees of softness, it needed no cross-bracing or strutting, and was certainly more proof against small spates in the *nullah*-bed. The Company metaphorically took off its hat to the South Africans and continued its march.

The trek proved trying in the autumn drought, as all ranks were feeling the weakening effects of repeated bouts of East African malaria, which appeared far more severe than the Indian variety, and in addition held the threat of the deadly " blackwater " over one's head. Water was also scarce, and often barely fit to drink.

On October 16th the Company caught its first glimpse of the sea, and the sight was so welcome after six months of the monotony of the bush that the Indian ranks cheered loudly. The cool sea-breezes and sea bathing at Port Amelia where the Company was detained for a week awaiting a ship, considerably improved both its health and its morale.

On arrival at Dar es Salaam in the *Ingoma* the news was confirmed that the Company was to return to India forthwith. There was little news of the campaign, probably for the good reason that no one knew exactly where von Lettow's little force was. It was known to be in the Lake Nyassa district, but contact with it was intermittent and mostly unsatisfactory, since, wherever encounters took place, the Germans had considerable local superiority of force and organization, particularly in the matter of collecting supplies.

It was somewhat discomforting to find that Dar-es-Salaam had not improved in the interval between our two visits. When we had first seen it, the Germans had not long quitted, and the native inhabitants had treated us with considerable respect, probably as the result of German discipline. Hotel and rickshaw " boys " had been polite, but by no means obsequious or cringing. On our return they were cheeky, grasping and decidedly familiar.

The Company spent a week in Dar-es-Salaam, re-equipping itself. This proved an unsatisfactory business, chiefly owing to the fact that in those days much of the equipment of an Indian Field Company was made in its Corps workshops, and was therefore of its own private pattern. This particularly applied to pack saddlery. Most of the Company saddlery had " gone missing," owing to the fact that we had been separated from our mules and their equipment on the day we left India and had never seen them since. They had remained on the coast, and been used for general transport purposes, and had only rejoined the Company on its return to Dar-es-Salaam. The pack saddlery held by Ordnance was of entirely different pattern, unsuited to our first-line mules, and totally incapable of carrying many of the first-line loads. It was in vain that we protested against being obliged to carry useless equipment back to India. We were told that unless Ordnance sent us back to India as complete as on the day we had left, a confusion would be caused in the accounts as between the Indian and Home Governments that would never be cleared up. So we duly loaded it aboard the H.T. *Magdalena*, and in due course delivered it at Bangalore. History does not relate what became of it thereafter.

The Company finally embarked for Bombay in the *Magdalena* on November 4th, and all ranks were in the best of spirits. But although out of the bush, we were not out of the wood, and the voyage was to prove a tragedy, completely dwarfing the minor losses and hardships of the brief campaign. Two days out from Dar-es-Salaam the young and inexperienced Medical Officer came to the O.C. Troops with a long face, and reported that a new and strange disease had broken out. He said that his sick bay was full of men, mostly of the Company, suffering from strange symptoms, high temperatures, much distress, and in several cases alarming lung complications. The first death occurred almost immediately, and the number of sick went up enormously. It became necessary to utilize the whole of the boat-deck as an open-air hospital. This was quickly filled with coughing and in many cases delirious Indians—Punjabis, Sikhs, but mostly Madrassis of the Company. Thereafter, and for the rest of the voyage, the ship slowed down two, three, and even four times a day, whilst men, forty-eight hours before in seemingly good health, were buried over the side. In the brief voyage, one B.O. (Lieut. Dunne, the Company's senior subaltern)

and twenty-five I.O.R. died of the virulent disease, one Punjabi jumped overboard in delirium and was drowned, and probably seventy-five per cent. of the ship's company were affected to a greater or lesser extent.

News of the Armistice reached us by wireless during this period, but owing to the general depression and lack of facilities in what was virtually a hospital ship, there were no festivities to celebrate it.

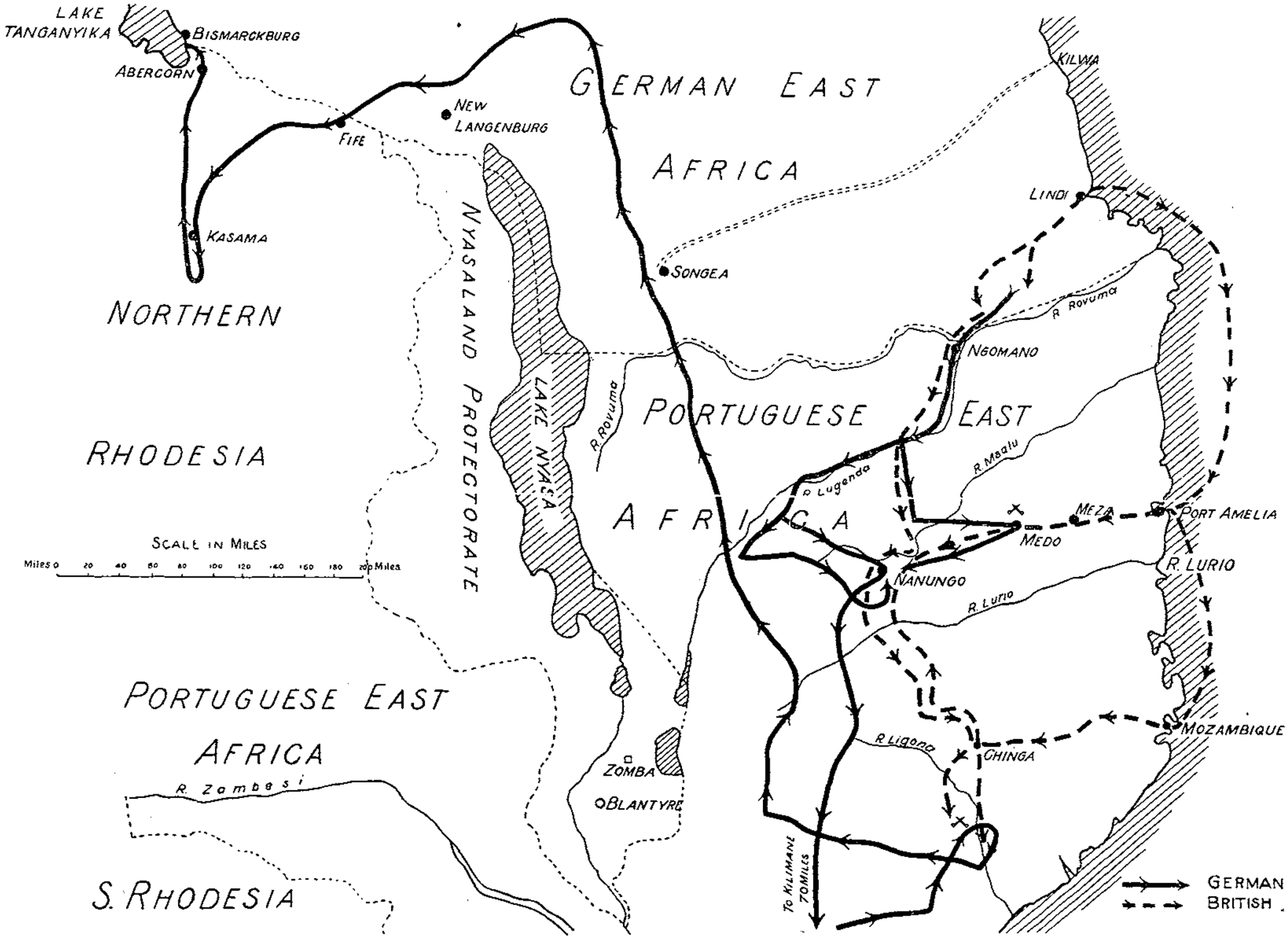
On arrival at Bombay we learnt that the disease was influenza, and not as we had thought some form of plague, and that it had preceded us to India. The deaths in Bombay were said to be numbering five hundred a day, and corpses, in some cases blackened by a too hasty burning at the *ghats* by the water's edge, were floating about the harbour. The Parsee burial places, the Towers of Silence, were said to be choked with dead, and the city authorities were at their wits' end to deal with the disastrous epidemic.

The military medical authorities, who were quickly on board, were not satisfied that all our cases were influenza, and suspected cerebro-spinal meningitis. The Company, less its B.O's, was consequently quarantined at Elephanta Island for nearly a month. There, no more cases occurred, and on December 10th the Company entrained for Bangalore.

* * * * * * *

In retrospect, the brief stay in East Africa was regarded very differently by the British and Indian ranks. For the British officers the work had been interesting, fever not too severe, and there had been a certain amount of big and small game shooting in the evenings to break the monotony. But the Indian ranks had probably few pleasurable memories. They had all suffered very severely from malaria, in spite of mosquito nets and regular quinine. The work and marching had been hard, especially for the many suffering from the after-effects of malaria. The diet, although ample, had been entirely lacking in variety, and there had been no amenities dear to the Indian heart.

It is to be feared that the disaster of the voyage appeared to most of them as only the climax of a most unpleasant expedition.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MODERN ROADMAKING PRACTICE IN GREAT BRITAIN.

By CAPTAIN C. M. SINGER, R.E.

DURING the past year or two there has been a decided lull in road-making activity in Great Britain. The financial crisis of 1931 was followed by a slowing down of road work throughout the country: many projected schemes for new roads and improvements were abandoned, and few fresh works of any size have been begun since. Works that were then already in hand have for the most part now been completed.

At the same time an insistent demand for increased economy in maintenance arose, which led road engineers to examine very closely the methods and materials then in use, with a view to prolonging the life of existing road surfaces and to reducing maintenance costs. The results of this study, together with the experience of highway engineers from many other countries, are made public at periodical International Roads Congresses, the most recent of which was held at Munich in September, 1934.

The present is thus a convenient time for a general survey of modern practice and tendencies. Much of what follows will no doubt be familiar to those living in Great Britain and connected with road work, but it is thought that such a survey may be of interest to officers who are out of touch with recent road work on a large scale. It must be realized that expert opinion still differs on many points, and there is by no means uniformity of practice throughout the country. The most interesting developments have taken place in connection with main roads carrying much traffic, and it is this class of road which is chiefly dealt with in this article.

THE LAYOUT.

The ever-increasing volume and speed of modern motor traffic has resulted in much attention being paid to the most suitable widths, gradients, curves, etc., for main roads, particularly in connection with the problem of road safety.

Width.—It has been realized for some time that when the volume of traffic demands a very wide road, it will be more satisfactory, and much safer, to construct the road with a double rather than a single

carriageway. Experience on the Great West Road out of London soon showed the dangers of a single carriageway of excessive width, and it is now considered that no single carriageway should be more than 40 feet wide. If the traffic requires a greater width, a double road is provided where possible. It is claimed that not only will two 30-foot widths carry more traffic than a single 60-foot width, but that the double road is much safer; it acts as a pair of one-way streets and largely eliminates the glare from headlights of approaching cars.

Many examples of double roads exist in various parts of the country, the best-known instances near London being on sections of the North Circular Road.

Gradients.—On modern arterial roads gradients are kept extremely low. The Liverpool–East Lancashire road, for example, has a maximum gradient of 1 in 40 in flat country. On the Guildford By-pass, which passes through the North Downs, the maximum is 1 in 25.

In more hilly country, one would expect to find these gradients exceeded, but in two notable examples of main roads in mountainous districts, viz., the Glencoe Road and the Perth–Inverness Road through the Grampians, the maximum gradient is only 1 in 20: these roads can be taken as typical of modern practice.

In main road work, changes of gradient are almost invariably effected by means of accurately levelled vertical curves, which often begin and end with transitional vertical curves. These may seem unnecessary refinements, but they do undoubtedly make the road more pleasant to ride over.

Such easy gradients, and such gentle curves as are described below, naturally necessitate a large amount of earthwork. The extra expense that this involves is, however, considered to be justified by the reduced wear and tear on both vehicles and road surface. This conception of the relation between the layout of a road and the wear on its surface is particularly worthy of R.E. officers' attention, in view of the tendency to advocate the adoption of rapidly-constructed surfaces of low-wearing value in wartime work.

Curves.—In flat or undulating country a minimum radius for curves of 1,000 feet is aimed at, and where conditions are particularly favourable an even greater minimum is adopted: on the Liverpool–East Lancashire Road no curve has a radius of less than one mile.

In hilly country, sharper curves are naturally necessary. The Perth–Inverness and Glencoe Roads may again be taken as examples: in each case the sharpest curve has a 300-foot radius.

Great importance is attached to securing a long, uninterrupted line of sight round all curves, and over vertical curves at the tops of hills. The minimum line of sight is frequently fixed at 300 feet from

points 5 feet above road-level. In some cases the specification for the layout of a road has required that a minimum line of sight be adhered to rather than a fixed minimum radius of curvature, on the grounds that, so long as a driver can see what is coming and the curve is adequately banked, the sharpness of the curve is immaterial.

Though there is general agreement that some banking is essential at curves, there is much difference of opinion as to the amount of banking that should be given. In Great Britain there is relatively little slow traffic, compared with some parts of the world, yet the amount of super-elevation found on most main roads is decidedly small. Excessive banking, it is considered, is undesirable, as it tends to throw vehicles moving round the outer side of the curve towards the middle of the road, especially if they happen to be held up and travelling slowly. Many people, too, object to more than a minimum of banking on the grounds that it would tend to convert the road into a speed track. The actual amount of banking varies in different cases; on the average, curves are given the super-elevation that is theoretically required for speeds of about 20 miles an hour.

Cross-roads and Road Junctions.—In view of the numerous accidents which occur at cross-roads, it is not surprising that much ingenuity has been displayed of late in devising layouts which make for safety at these points. Many devices have been adopted with varying success. Complicated crossings such as are found in America, where one road is carried over the other by a bridge, with spur roads giving access from one to the other, have not yet been generally adopted in Great Britain on account of the expense involved. Without some such device, intersecting lines of traffic cannot be avoided. A satisfactory layout should force one, if not both, of the intersecting traffic streams to slow down on approaching the crossing, and provide each stream with a good view of the traffic in the other stream. If possible, also, the two streams should be "interwoven" for a short distance before they separate again. It is interesting to see how some recent layouts fulfil these conditions.

Flashing lamps situated in the centre of important cross-roads, which are so familiar to those who motor between Chatham and London, have not proved altogether successful. While they warn traffic of the existence of an important cross-road, they do not force it to slow down: what is worse, they appear to confer equal precedence on traffic in each road. This ambiguity was the cause of the serious accident to the R.E. Band last year.

Roundabouts are now constructed at all important new cross-roads. They both force vehicles to slow down, and also secure "interweaving" between the intersecting streams. The central island is best made circular, with a minimum diameter of about 100 feet. Where two roads of unequal importance cross, the island

may be elongated into an ellipse with its major axis in the direction of the most heavily-trafficked road. Square islands were at one time popular, but they have lost favour on account of the waste space of carriageway which occurs close along the straight sides of such an island, due to traffic being unable to turn the corners sufficiently sharply.

Where a minor country road crosses a main road, it is common practice to stagger the junctions, so that traffic crossing the main road has to travel a little way down it before turning off into the minor road again. An interesting point arose in connection with such crossings on the Kent Coastal Road which has recently been completed. In one of the first sections opened (Faversham–Whitstable), the junctions were staggered to the left, so that minor-road traffic could enter the main road by an easy left turn, weave through the main-road traffic, and turn to the right off the main road with a clear view of the traffic in both directions. It was found, however, that when the main road was carrying much traffic, the minor-road traffic was unable to make the right turn across the stream, and so tended to increase further the congestion in the main road. Consequently, in the later sections of this road, such crossings are staggered to the right, so that the minor-road traffic is held up, if at all, before entering the main road and not on it. At the same time, the minor road is given a sharp kink on approaching the crossing to force traffic to slow down.

EARTHWORK AND DRAINAGE.

A particularly noticeable feature of recent work is the care taken over the drainage and preparation of the road bed. It is generally recognized that time and money spent on such preliminary work is rarely wasted. Modern road surfaces are too costly to risk early failure due to inadequate consolidation and drainage of the formation. The high banks often necessitated by easy gradients and curves need careful construction if settlement is not to occur after the road is open to traffic. Such banks are generally laid in layers 1 foot or 2 feet thick, each layer being thoroughly rolled as it is laid. The completed bank is then left for as long as possible before the road surface is put on. In the Guildford By-pass, for example, some banks were left for two years before surfacing began, and in almost all main roads one winter's exposure to the weather is given. If a new road is urgently required for use before the road bed has thoroughly settled down, it may be opened with a temporary surface, when the traffic will itself help to consolidate the formation. Some readers may perhaps remember bumping over a temporary surface of this type on the Glencoe road in the summer of 1933.

Drainage of the road bed is carried out in the normal manner by means of side drains supplemented, if necessary, by subsoil drains running underneath the carriageway. On marshy ground special forms of construction are necessary, one of two methods being usually adopted :—

(*a*) A heavily-reinforced concrete surface is laid, to act as a raft " floating " on the marshy subsoil. An excellent instance of this is provided by the approach road to the Ford Works over Dagenham marshes, which has been used by heavy traffic now for several years without failure.

(*b*) The surface is bedded on a layer of gravel or similar porous material some 4 ft. or 5 ft. in depth. This layer is found to provide a cushion thick enough to distribute the load from the surface over a sufficient area of marshy ground. This method has been successfully used over peat bogs in Scotland, but unless an ample supply of suitable material exists nearby, it is likely to be expensive.

Foundation and Surface.

There is still a surprising difference of opinion as to the relative merits of concrete and macadam (or asphalt) surfaces on heavily-trafficked roads. In the south of England the majority of new main roads have been surfaced with reinforced concrete. In the north, concrete surfaces are not so common : more reliance is placed on tar—or bituminous—macadam, or asphalt, laid on the traditional foundation of 12 inches to 15 inches of hand-packing soling : on some roads carrying a great deal of traffic, such surfaces are found laid on concrete foundations. To some extent this may be due to the relative prevalance, and consequently cheapness, of suitable stone in counties such as Northumberland and Cumberland, as compared with Kent or Surrey. Generally speaking, though, there is probably not a great deal of difference in the cost of the two types of road in the long run, especially when the low maintenance of a successful concrete road is taken into account. The difference in practice arises rather from the varying opinions held by the road engineers concerned.

The advocates of concrete roads consider that concrete is the only material which will stand up satisfactorily to fast modern heavy traffic, even on a good well-prepared formation. They therefore aim at constructing a concrete surface which will last for many years without serious wear, and claim that any additional initial cost compared with other types of surface will be more than saved by

reduced maintenance charges later on. If concrete is to be employed at all, they prefer to make an all-concrete road, rather than incur the extra expense of a concrete foundation combined with a macadam or asphalt surface.

Many of the objections once raised to concrete surfaces have now been overcome. For example, the tendency to slipperiness, noticeable on some of the earlier concrete roads, can be overcome by carefully controlling the mix of concrete employed and by tamping the surface so as to leave it slightly rough. It is sometimes said that concrete surfaces produce an unpleasant glare: it is doubtful, however, whether they are any worse in this respect than other surfaces, and the trouble may be mitigated by using coloured concrete, *e.g.*, the stretches of brownish concrete on the Oxford–Cheltenham road.

Those who favour macadam roads doubt the possibility of constructing a concrete surface that will really stand up to heavy traffic for long. Should a concrete road fail, it is extremely expensive to repair. In this connection the practice has grown up of relegating a concrete surface which has failed to the role of a foundation, coating it with tar macadam or asphalt. This has been done extensively on the Dover road, between London and Chatham, and many R.E. officers will know that such a surface frequently does not remain smooth for long; unevennesses in the broken concrete foundation soon cause corresponding irregularities to appear in the surface above. Tar macadam and asphalt surfaces are relatively easy and cheap to renew, and, by virtue of the plasticity of these materials, seem to be capable of giving, when freshly laid, an easier running surface than is possible with concrete. A " non-skid " surface is readily ensured by methods described later.

The use of concrete roads in newly built-up areas has increased enormously of late. It is, in fact, becoming the almost universal practice to make new service roads in housing estates of concrete. Such roads carry little traffic and are of light construction. Their low maintenance costs are evidently considered to be an overwhelming factor in their favour.

In recent years many developments have taken place in the details of both concrete and macadam roads, as well as in other less usual types of surface: the main features of modern practice in each case are given below.

CONCRETE ROADS.

Thickness of Concrete.—On arterial roads taking the heaviest traffic, the concrete may be as much as 12 inches thick. On through roads carrying general traffic (2,000–5,000 tons a day), 8 inches or

9 inches is a usual thickness. Lightly-trafficked service roads on housing estates have a thickness of about 6 inches.

Reinforcement.—Very few concrete roads have recently been laid without some reinforcement. In general, reinforcement is placed about 2 inches from the bottom of the slab, the weight of steel being about 7 lb. per sq. yd. Where much traffic has to be catered for, or where subsoil conditions are bad, reinforcement (at 7 lb. per sq. yd.) 2 inches from the top is also added, and the weight of the bottom layer doubled.

Other variations are sometimes met with, such as the provision of a top layer only, or of sheer reinforcement between the two layers, but these are rare. The tendency appears to be definitely towards the more or less standard designs described above.

Mix of Concrete.—In nearly all cases, except for service roads taking light traffic, the concrete is laid in two courses having different mixes. The bottom course, which extends to some 2 inches below the surface of the road, is of 1 : 1½ : 3 or 1 : 2 : 4 mix with an aggregate not exceeding 1½-in. gauge. The top course is composed of a richer mix, 1 : 1 : 2, with a hard granite aggregate probably not exceeding ¾-in. gauge.

The Wearing Surface.—Concrete roads were originally made homogeneous throughout their thickness, and it is interesting to note the development of the idea of a wearing course distinct from the main bulk of the concrete. The adoption of this two-course work arose from a desire to provide a hard surface that would withstand the wear and tear of traffic, without the expense of continuing such a special mix of concrete throughout the thickness of the road crust. Even where this is done, however, the surface will eventually show signs of serious wear and will require patching or renewal, and engineers are now considering the possibility of laying the wearing course independently of the concrete underneath, to facilitate its renewal without disturbing the lower course. Up till now this practice has not been generally adopted, and the two courses of concrete are laid in quick succession with the aim of bonding the two together. In one or two patent types of " jointless " concrete road, however, the wearing course is laid independently of the foundation course.

Joints.—Joints are apparently a source of weakness in a concrete road, since the majority of serious cracks occur near the joints. Consequently much ingenuity has been expended on devising joints which will enable adjacent slabs of concrete to give each other some mutual support, or which will not be unduly complicated or costly to construct.

At transverse joints, vertical ends of the concrete slabs are finished off plain, with dowels of 1-inch steel bars, some 3 feet long and spaced

at about 2 feet intervals running across the joint from one slab to the other. The dowels are embedded in one slab, but can move freely in the other to allow for its expansion and contraction. This is achieved by greasing the free end, or covering it with paper, while the concrete is being laid.

Longitudinal joints are generally of simpler construction, consisting of a plain tongued and grooved joint.

The plain bitumen or asphalt fillers that were once common have now been replaced by some composition which avoids the difficulty of the filler being squeezed out in hot weather and not running back into the joint again in cold weather. A typical filler consists of a felt strip impregnated with bitumen, which fills about three-quarters of the depth of the joint, leaving the upper quarter to be filled with a mastic asphalt.

However carefully the road is laid, there tends to be some unevenness at the joints, which is apt to cause a periodic vibration in vehicles travelling along the road. This vibration may become very pronounced if its periodicity coincides with that of the springs of the vehicle. To avoid this trouble, various devices have been adopted: transverse joints are sometimes made diagonally across the road to avoid both wheels of an axle crossing the joint together: on the recently-opened Guildford By-pass road and on other new roads in Surrey joints are spaced at unequal distances apart.

The practice of staggering slabs so that transverse joints do not run continuously across the road is being abandoned, as it has been found to cause cracks in the slabs in line with the joints.

Slab Dimensions.—There has been a distinct tendency recently to reduce the width of slabs to 10 or 12 feet. Thus a 30-foot carriageway is now more often constructed in three strips than in two. The length of slab varies a good deal: between 30 feet and 50 feet is now the most usual size.

Laying.—Great trouble is taken to ensure the densest mix of concrete, by careful grading of the aggregate, close control of the water-cement ratio, and by proper tamping of the concrete during laying. A layer of waterproof paper is often placed over the formation before concreting is begun, in order to prevent water and fine material being drawn out from the wet mix into the subsoil.

The practice of treating the surface of newly-laid concrete with sodium silicate in order to harden it appears to be dying out. This is probably because concrete wearing courses are now so hard in themselves that it is considered unnecessary to attempt to harden them further.

Macadam and Asphalt Roads.

In almost all cases in Great Britain the aggregate for the surface coat is pre-coated with the binder in a central mixing plant, often situated alongside the stone crushers near the quarry. Grouting is seldom employed. In remote country districts such as are found in the north and west of Scotland, where the laying of pre-coated material might be impracticable on account of the long distances from a mixing plant, roads usually carry so little traffic that a simple sealing coat on a water-bound macadam surface is sufficient.

Tar and Bitumen.—The relative merits of tar and bitumen (and products containing them) as roadmaking materials are still the subject of much controversy, into which it is not within the scope of this article to enter. The manufacture of both has improved to such an extent that it is now possible to obtain a suitable grade of either for practically any type of work : most of the objections that were once raised against one or the other have disappeared. Both are used equally commonly, but it is usual, when using tar as a binder for macadam or as a surface dressing, to add a small proportion (say 5 per cent.) of bitumen to it. Binders used to-day have a considerably higher viscosity than was common a few years ago : consequently the old form of mechanical brusher, which was once used in surface dressing, has now almost disappeared, its place being taken by a sprayer tank from which the binder is often sprayed under pressure.

Bituminous emulsions have a particular interest on account of the ease with which they can be laid, and their suitability for use in damp weather. Much progress has been made in recent years in their manufacture, and emulsions designed for all purposes are now on the market : in Great Britain their commonest use at the present time is probably for surface-dressing work. An international agreement on the testing of emulsions (initiated and sponsored by leading British firms) has recently been concluded, which should ensure a certain degree of uniformity in these products in different countries.

Specification of Surface Coat.—The old water-bound macadam surface depended for its cohesion on the thorough consolidation by rolling of a broken stone aggregate from which fine material was excluded. The earlier tar macadam surfaces were designed on the same principle. Lately, however, there has been a distinct tendency to use an aggregate containing a definite proportion of fine material, in order to obtain a dense surface coat by filling the voids in the coarser material, rather than by consolidation only. The grading of stone in modern tar macadam resembles closely, in fact, the grading of aggregate in concrete. Where bitumen instead of tar is used as a binder, the resulting material is often almost indistinguishable from

some of the numerous proprietary asphalts now on sale. These latter consist of a stone or clinker aggregate of various gauges, but graded to leave as few voids as possible, coated with a bituminous binder: they are designed to be laid hot or cold according to the type of binder used. Macadam and asphalt surfaces are usually laid about 3 inches thick, either in a single course or in two courses, the lower being of coarser grading than the upper. Thicknesses much in excess of this are unusual: it is realized that the strength of a road is improved more by increasing the strength of the foundation rather than the thickness of the surface coat.

With the present demand for non-skid surfaces, the final treatment of the surface has received much consideration. The adoption of the closely-graded aggregates mentioned above has to a great extent done away with the necessity for a final sealing coat, since the surface coat is watertight in itself. Asphalt surfaces practically never require sealing, and are left as laid except for occasional surface dressings for later maintenance.

It is still quite common practice to seal macadam surfaces with a tar or bituminous binder and large chippings, the latter being usually of $\frac{3}{4}$-in. gauge or over. Many macadam roads, however, are now left "unsealed" in order to give a better non-skid surface. Such stretches usually have a sprinkling of pre-coated $\frac{3}{4}$-in. chippings incorporated in the surface while laying.

OTHER SURFACES.

No developments of interest have taken place recently in the well-known stone and wood-block types of paving. Both continue to be used extensively in situations where traffic is very heavy. There are, however, three interesting types of surface which are becoming more common in certain circumstances.

Iron Paving.—Cast-iron paving blocks, laid on concrete, have been used of late in places where it is important to avoid the dislocation caused by closing the road for repairs. The most notable instance is the new Mersey Tunnel, three miles long: here the high cost of iron paving was considered to be justified by the fact that the carriageway should require no repair work whatever for many years. For similar reasons, some important and congested bus-stops in London are paved with iron blocks.

Rubber Paving.—Experimental stretches of rubber paving are to be found in several towns, but this type of surface cannot yet be said to have established itself firmly. From many points of view, rubber is an ideal material for a road surface: it is tough and resilient, wears well, and gives a very clean surface. It is, however, relatively

expensive, and the great difficulty of keying the rubber to the roadway does not yet seem to have been solved economically and satisfactorily. Various patent rubber pavings are, however, on the market; most of them consist of some two inches of rubber mounted on concrete blocks, which are laid in the same way as wood blocks.

Cement-bound Macadam.—This type of macadam is to be found mainly on steep hills carrying a good deal of traffic. Its rigidity prevents the tendency to creep into waves which is found with ordinary tar macadam or asphalt, and when properly laid it provides a very non-skid surface. It is well worth consideration in situations where suitable tar or bituminous binders are not easily obtained, or do not give a sufficiently durable surface.

Conclusion.

It seems likely that the next few years will see a revival of road work, both new construction and improvements, in Great Britain. At the same time, there are signs of a widespread desire to ensure greater uniformity of practice throughout the country, and it has been suggested that we should follow the system in force in most Continental countries and centralize the administration of our main roads under the Ministry of Transport, rather than decentralize it under the various local authorities as is the case at present. Whether this is desirable or not is an open question.

The Ministry of Transport's circulars on the technical details of road work already make for uniformity, and the annual reports of the Road Research Board* ensure that the best and latest information is available to all road engineers. Nevertheless, somewhat confusing differences in practice still exist: it is hoped that this survey may help to make the present position clear to those who may have to deal with permanent road work.

* This Board is in charge of all experimental and research work on roads. It directs the various experimental stretches laid on roads in different parts of the country, and possesses a well-equipped Research Station at Harmondsworth, where laboratory tests are carried out.

ELECTRIC ARC WELDING.

By LIEUTENANT H. H. C. WITHERS, R.E.

OWING to the rapidly increasing application of the electric arc welding process in industry, some knowledge of its problems, applications and limitations will soon be a necessity for every R.E. officer.

The subject is a large one, while a great deal of research and practical work is being carried out at present, so that this article can only touch upon a few of the principal aspects.

Briefly, arc welding consists in joining two pieces of metal (termed the work) by means of a third, or filler, which, in the electric arc process, is called the electrode.

The junction is formed by fusing the edges of the work, which have been suitably prepared, and filling the space with the metal of the electrode, to form a nearly homogeneous joint. The heat required is supplied by electricity, the work being connected to one terminal of a generator (usually the positive) and the electrode to the other, in a special insulated holder to allow of its manipulation by the operator.

Nearly all the problems connected with welding arise from the fact that intense heat has to be applied to the work. The main problems are :—

(*a*) The effect of the heat on the physical properties of the work.
(*b*) The effect of the atmosphere on the vaporized and molten metal of the weld.
(*c*) The distortion caused by the intense local heating.

Taking these in turn :—

(*a*) Fig. 1 shows a normal butt joint between two plates.

Fig. 1.

The edges are bevelled to form a V which is filled by the weld metal. The molten metal will be in the neighbourhood of 1500°C. It is obvious, therefore, that on each side of the V there will be zones ranging from 1500°C. down to the temperature of the plate as a whole. Now the critical temperature for steel lies between

700–900°C., depending on the carbon content. Steel heated above this temperature completely changes its structure, and by varying the rate of cooling, different structures can be "fixed." Rapid cooling produces a hard brittle material, while with very slow cooling, the steel will return to its original state.

The zone heated above the critical temperature is known as the "disturbed area" (shown shaded) and extends from ·02 to ·15 in. on each side of the weld.

Since the volume of the plate is usually very large compared to that of the weld, very rapid cooling takes place, so that the structure of the weld metal and disturbed areas is coarse-grained and brittle, very closely resembling that of a steel casting. That this is borne out in practice can be ascertained by the examination of the structure of a joint made with one run, using a piece of ordinary M.S. wire as the electrode. Most joints, however, are made with several runs, and the effect of each succeeding run is to anneal the runs below it, giving the weld a finer grain structure and improving the physical properties. Sections of welds examined under the microscope clearly prove that practice bears out the theory. The solution of this problem lies in minimizing the heat and in the production of suitable electrodes.

(*b*) The next problem is that of the effect of the atmosphere on the joint.

The metal of the filler is vaporized in its passage across the arc and is at a very high temperature, somewhere in the neighbourhood of 3000°C. In this state it is very susceptible to attack by both the oxygen and nitrogen of the surrounding air.

The first forms metallic oxides which are disseminated irregularly throughout the weld metal as very fine particles, which have the effect of considerably weakening the structure in consequence of the irregularities set up.

The latter has much the same effect as carbon in steel, only much more pronounced, so that if even a minute quantity of nitrogen is taken up, a small increase in the tensile strength will result, which will be more than offset by a very considerable reduction in ductility.

Hence a weld made with a piece of bare mild steel wire will have a low tensile strength and be very brittle, *i.e.*, the yield point and final breaking point will be very close together, say 18 and 20 tons/sq. in. instead of 16 and 28 tons/sq. in., as in the original M.S. This is of the very first importance in structural work. A porous weld is also very likely to result. This is of particular importance for switchgear and transformer tanks which will contain oil.

The remedy for these harmful effects appears to be in the use of a covered electrode, in which this country is the pioneer. The electrode is covered with a coating of flux, which is fused and flows outside the

vaporized metal into the weld, where it forms a slag, floating on top of the molten metal. It thus forms a protective covering for the steel, both during its passage across the arc, and also as it cools in the weld, where it materially slows down the rate of cooling, thus helping to form a finer grained and more ductile structure.

The slag has to be completely removed after each run before another can be put down, by means of a chipping hammer and stiff wire brush.

There are various fluxes, but the main property of all is that of a reducing agent. The thickness of the coating varies for different classes of work, from those which, with a very light coat formed by simply dipping them in a bath of liquid flux (known as " dipped " electrodes), are suitable only for use where a strength joint is not required, to heavily-coated electrodes, formed either by extruding the flux on to the rod, or by wrapping the flux round it like a puttee, which are used for structural and other work, where the properties of the joint must approach as nearly as possible to those of the parent metal.

Nevertheless, it must be remembered that a very large amount of structural welding has been carried out both in America and on the Continent, using bare wire, the necessary strength being obtained by the deposition of more metal, this method being claimed to be more economical due to the lower cost of the electrodes, and the saving in time in removing slag.

However, covered electrodes are very rapidly coming into general use, and are actually proving more economical owing to their very much better physical and mechanical properties.

From the army point of view, it is of considerable value to know that, should no covered electrodes be available, sound jobs can be made by using the nearest length of steel wire, provided its limitations are borne in mind.

There is a danger in using a too heavily coated electrode, in that it may allow of too long an arc being drawn.

A long arc is very strongly to be condemned for various reasons, the most important being :—

(i) That there is increased liability to attack by the air.
(ii) That it is very much more unstable than a short arc, and hence makes welding much more difficult.
(iii) A higher arc voltage is required, resulting in a greatly increased power consumption, which also means that more heat is put into the weld.

The size of the electrode used also has a considerable bearing on the amount of heat generated. Electrodes are sold according to their wire gauge size. The arc voltage (not to be confused with the striking voltage which is 60–80 volts) varies between 18 and 30 volts,

while the current varies from 25–40 amps. for the smallest (No. 14) gauge to 180–220 amps. for the largest (No. 4) gauge. The use of too heavy an electrode on very thin plates will simply result in the burning away of the edges of the plates due to excessive heat. The modern tendency, however, on plates $\frac{3}{8}$-in. thick and upwards, is to use heavier and heavier electrodes, up to rods like pokers, of $\frac{1}{2}$-in. diameter, relying on the speed with which the electrode is moved along the work to avoid overheating. This procedure is not to be recommended as yet, however, unless the welder is very skilled and has had some experience of this type of work.

(c) The last of the main problems arising out of the heat necessarily generated is that of the distortion caused in the work itself by the intense local heating.

There is no golden rule for overcoming this difficulty.

Experience is the main guide, together with careful thought being given to every joint. The following maxims should help to minimize this difficulty :—

(i) Long continuous welds should never be used. A short run should be put down in one place, then another somewhere else, preferably where it will counteract any tendency to distortion in the first run ; then back again to continue the first run and so on.

(ii) The work must be adequately clamped. "Tack" welds should be used and must be strong enough to hold the work in the desired position.

(iii) Weld metal contracts as it cools, tending to pull the sides of the V together, so that two plates which were lying flat to start with, will have their outer edges lifted up unless some precautions are taken to prevent it, such as clamping or turning the work over after the first run in the V, and putting a run down on the underside along the apex of the V.

This is especially important in tensile or bend test pieces, which, if not perfectly straight, impose a severe initial load on the weld in the preliminary straightening which will occur in the testing machine, so that a low and false maximum tensile strength for the weld will be obtained.

Power Supply.

This may be either A.C. or D.C. Equally good work can be done with either, but A.C. is a little more difficult, particularly if the supply is of 25 cycles, and overhead welding is almost impossible with it.

On the other hand, it is the cheapest to install on a first-cost basis, while the overall efficiency in running is far higher than D.C.

The supply must give an open circuit (or striking) voltage of at least 60 volts. Some makes have it as high as 100.

It then must give a load or working voltage from 16–35 volts, and it must be able to stand a dead short circuit (as when the electrode gets stuck to the work, a very common occurrence with beginners).

Quick regulation is desirable, to follow the arc fluctuations, as welding with a sluggish machine can be very difficult. From a consideration of the above, it will be seen that a lightly-compounded machine (about 5 per cent. over-compounded is best) with an open circuit voltage of 60–80 volts answers the purpose. A series resistance must be used to regulate the current to suit the size of electrode and type of work. This entails a big heat loss in the resistance.

A differentially-compounded machine, such that the load voltage drops to about 25 volts, does away with the series resistance, but is sluggish.

Other methods of avoiding this resistance loss are :—

(*a*) Drooping characteristic machines obtained by special design of the field and magnetic circuits (instead of by differential compounding) as supplied by Murex and Quasi Arc.

(*b*) The use of separate exciters, as in English Electric, Metro-Vickers and B.T.H. machines.

(*c*) Special machines, superimposing an A.C. striking voltage on a level compound D.C. 25-volt generator, as made by Mawdsy.

(*d*) Valve rectification of an A.C. supply, as made by Phillipps. This gives a very smooth welding current, as there are no heavy magnetic circuits to cause irregularity, while the efficiency is that of an A.C. set. They are made very robust and little fear of damage need be entertained.

For A.C. welding, all that is required is a transformer to give the required striking voltage. For ease of striking this should not be less than 80.

The usual type is a three-phase delta wound primary with an interconnected star secondary in order to balance the load, should only one phase be in use, and to cause as little interference between operators as possible due to the large variations in current during welding. The work is connected between line and neutral, which should be earthed.

Table 1 gives the various types and their efficiencies.

STRENGTH OF WELDED JOINTS.

In this country welding design is rather behind that in America and on the Continent, due to the extremely conservative attitude adopted by the main structural authorities, but perhaps it is better

to proceed cautiously and so avoid damaging the prestige of a new method of construction by some costly failure.

Welded construction is, however, now sufficiently advanced for it to have been recognized by the British Engineering Standards Association, who have very recently issued British Standard Specifications on the subject. These are B.S.S. No. 499, *Nomenclature and Symbols*, and B.S.S. No. 538, *Metallic Arc Welding as Applied to Steel Structures*, while it is expected shortly to produce specifications for "Standard Welding Tests" and "Welding Electrodes."

These can be obtained from "The British Standards Institution, 28, Victoria Street, London," and should be carefully read by anyone who has a welding job of any magnitude to carry out; a study of them will be well repaid.

Briefly, there are two types of joint in structural welding:—*Butt welds* and *fillet welds*.

Butt Weld.

The term is self-explanatory, and in theory it is an ideal method of joining to plates because:—

(1) It gives an even distribution of stress, with no eccentricity, as in a fillet weld.

(2) It saves the weight of overlaps: but in practice it is expensive because:—

(i) The edges must always be prepared (except in the case of sheets under $\frac{1}{4}$-in. thick) and the pieces cut to close limits for length.

(ii) The difficulty of holding the plates.

The preparation of butt welds is important. As has been explained, the weakest point in a weld lies in the bond in the disturbed area. The preparation of the work consists in bevelling the edge so as to form either a single or double V (depending on the thickness of the plate). The angle of the V should be such that the resolved components of the main stress will not cause failure in the bond. The best angle can be shown to be 78°. In practice the V formed by the bond will always be greater than that formed by the abutting bevels, especially if more than one run is used, so that the optimum angle for the apex of the V is usually taken as 70°.

The point of greatest weakness in a single V joint obviously lies at the junction of the two bonds, and should bending occur with the apex of the V outwards, the maximum fibre stress will be at the point of greatest weakness.

Bad bonding is also most likely to occur here, especially if too large an electrode is used in the first run, giving poor penetration. Hence

ensured by allowing a generous overlap. The B.S.S. lays down that the minimum overlap should equal four times the thickness of the thinnest plate.

Shear.

A 20 per cent. reduction in the permissible stress should be made for a welded joint subjected to pure shear. This can only occur in members in torsion.

Fillets Stressed Parallel to their Length.

If the components of the joint were not ductile, the weld would shear along the minimum dimension, the throat. Due to plasticity, however, distortion takes place roughly as shown in Fig. 3.

Under stress D tends to move to d, etc.

Fig. 3.

The stresses are very complex. In calculations for the length of fillet required, the following rules should be observed :—

(*a*) The minimum length of fillet weld to be taken as carrying stress is eight times the throat thickness.

(*b*) No strength should be allowed for the first and last $\frac{1}{2}$-in. owing to poor penetration, craters, etc., usually unavoidable at the start and finish of a run.

The B.S.I. specification lays down that the size of a fillet weld shall be specified by its shorter leg, and that the throat thickness shall be not less than ·707 times this length.

Working Stress.

For such a fillet, the maximum load (calculated on the throat thickness) allowed by the B.S.I. is :—

For an end fillet	6 tons/sq. in.
For side fillet	5 tons/sq. in.

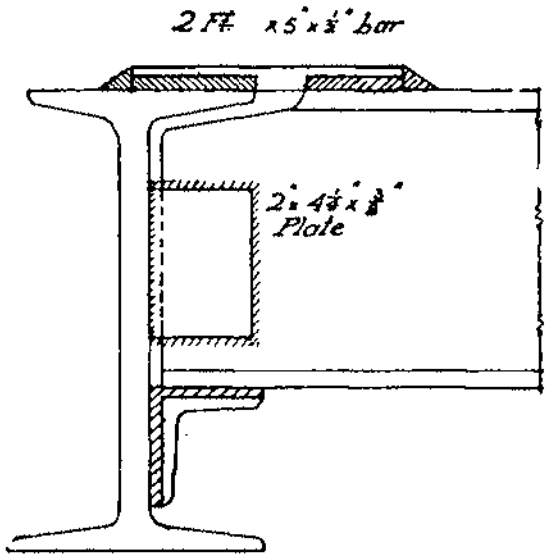
Combinations of end and side fillets should be used in preference to either alone, and in such a combination, the former should be calculated to carry the maximum load possible with the length of plate available, the latter then being proportional to absorb the remainder of the stress.

Intermittent Fillets.

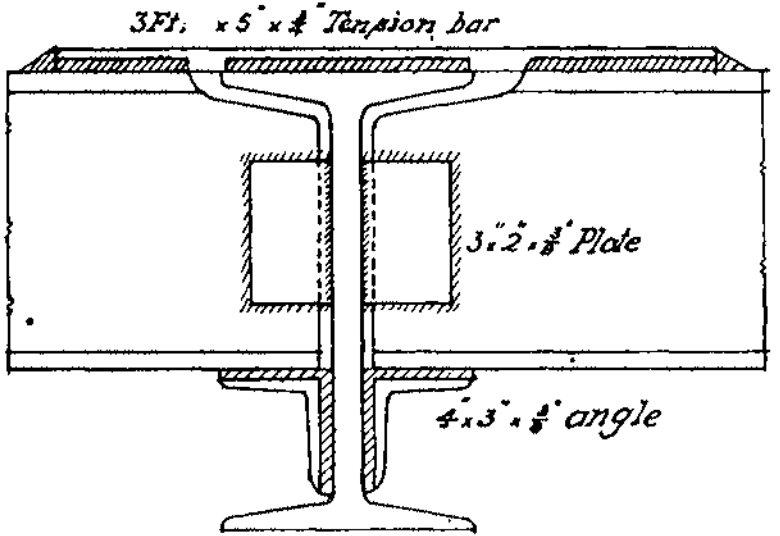
In many cases there is room to put down a much greater length of run than is actually required. In such cases short runs four or

FIXED BEAM END CONNECTIONS.

Fig. 4



Simply Supported Beam.



Continuous Beam.

a run termed a " sealing run " should always be applied on the under or reverse side of the V to ensure proper fusion at the apex.

Strength.

The B.S.I. specification lays down that the maximum permissible working stress in a butt weld in tension shall not exceed 85 per cent. of that of the parent metal, while that in compression it may be taken to develop the full strength.

All butt welds should be reinforced by making them 10 per cent. thicker than the plate on the open side of the V. This extra thickness may subsequently be machined off if desired, as in the view of some experts it leads to undesirable stress concentrations at the edges, but it serves the purpose of annealing the run below it and for that reason should never be omitted.

If no sealing run can be applied to a single V weld, then 30–50 per cent. should be deducted from the strength of the weld.

Fillet Welds.

Lap Joints.

This is the most commonly used weld and employs what is known as a " fillet " to join the two members (see Fig. 2).

Fig. 2.

The fillet can be stressed in two ways :—

Transversely to its length (End fillets).
Parallel to its length (Side fillets).

Considering the former first, the throat AB is the critical section, and the formula for the stress intensity most usually accepted is

$$S = 1{\cdot}62\ P/t \times l.$$

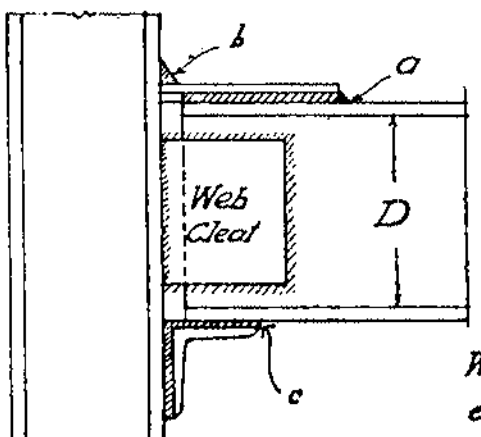
where S is the stress intensity on AB.
P is the load transmitted by the weld.
t is the length of the leg AD (or AC).
l is the length of fillet.

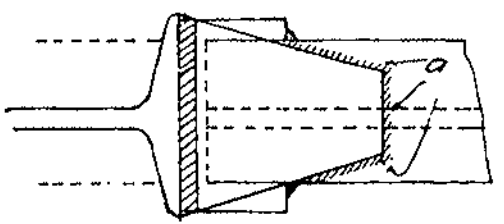
In arriving at this or any other formula for fillets it is assumed that :—

(*a*) The stresses are evenly distributed.
(*b*) The plates cannot bend to accommodate themselves to the couple produced by the load.

The former assumption is only approximately true due to stress concentrations at toe and root of the fillet, but the latter can be

Fig. 5





Web cleat designed for fixing moment of end of Beam = M. Then F = M/D.
Net length of Weld "a" to resist tension F.
" " " "c" " " F.
" " " " b not to be less than "a"

Beam to Stanchion Flange.

more inches long may be put down at any convenient spacing as required, but where a weld is exposed to weather, a continuous run should be used rather than such intermittent fillets.

DESIGN.

Success in welded construction depends largely on the initiative of the designer and his ability to break away from practice that has been developed for riveting.

Welded connections should be considered as completely rigid, and bending moments should be modified accordingly.

This leads directly to the assumption of continuous beams and a saving in weight can immediately be made consequent on the reduction of sections.

End connections require great care to ensure conditions of true fixation: when this is secured, the beam sections can be reduced but the column sections may have to be increased.

See Figs. 4 and 5.

There are two types of design :—

(*a*) That in which the designer regards the joints simply as connections to be joined by welding.

(*b*) That in which the designer regards the structure as monolithic, similar in many respects to that adopted for reinforced concrete.

The former leads to designs similar to riveted structures, with a multiplicity of gussets and eccentric bending stresses at the joints, but it also allows of fairly wide tolerances in cutting to length and hence of a minimum of preparation.

The latter necessitates narrower tolerances and more accurate preparation, but the extra cost is more than counter-balanced by the cheaper welding and reduced steel costs.

The accompanying photographs show a welded structure of the former type erected in the N.W.F.P. in India, carrying a bullet-proof water tank of 120,000 gallons capacity, while Figs. 6 and 7 show how a similar construction might have been carried out of the latter type.

Photograph A shows the reservoir in question.

Photograph B shows a joint in the structure, while

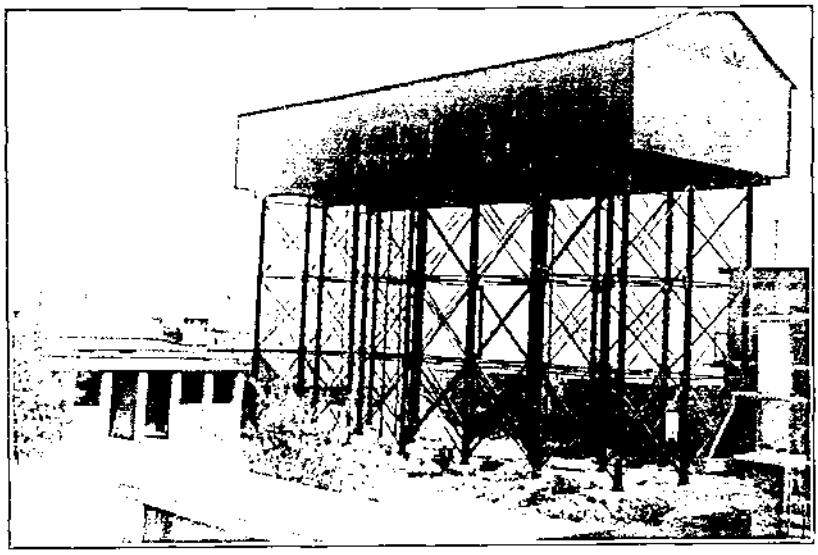
Photograph C shows a joint in the main girder.

This joint would have been a butt joint if the designer had considered the structure as monolithic.

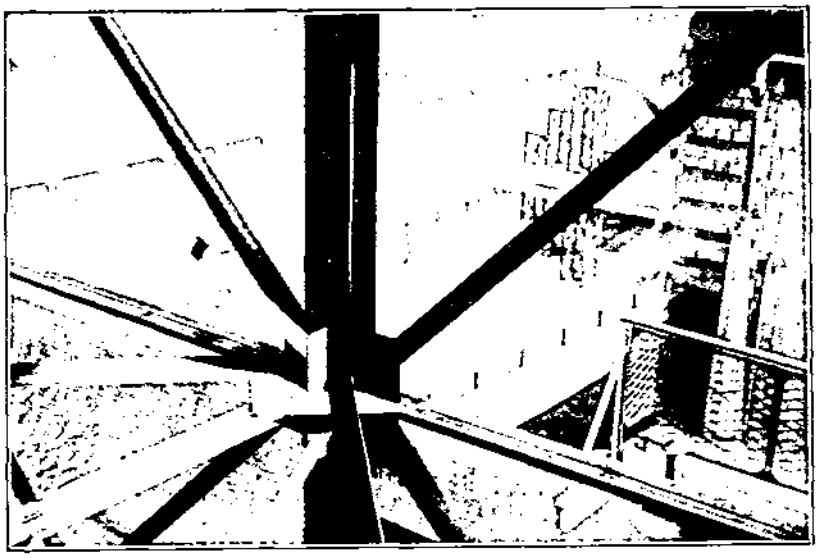
Photograph D shows the foot of a stanchion.

A comparison of the photographs and diagrams shows the far greater simplicity of the latter type of design.

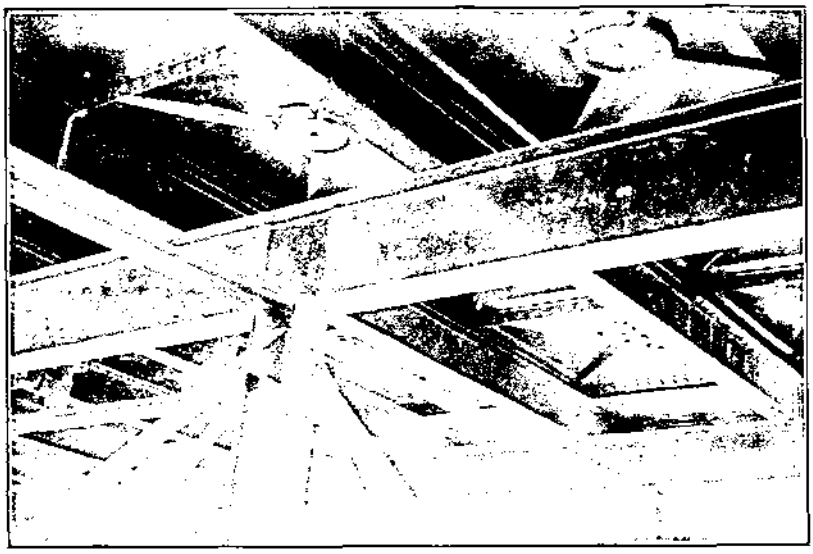
ELECTRIC ARC WELDING.



A.



B

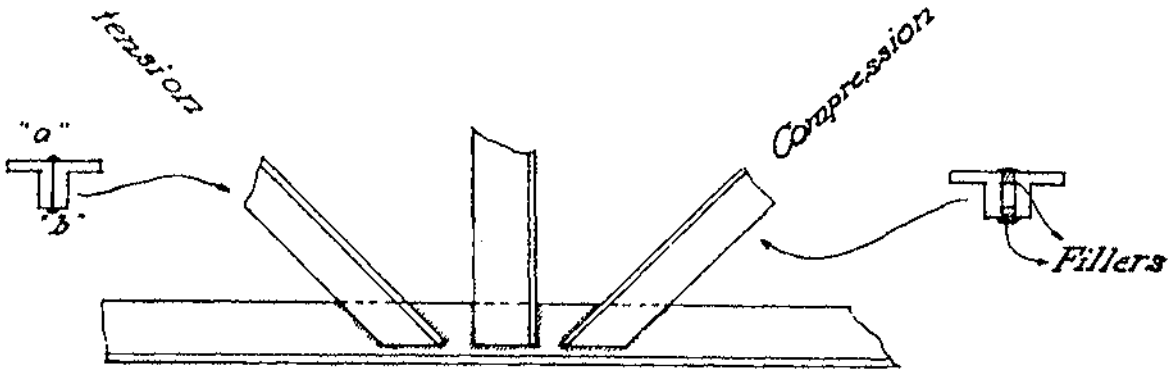


C.

D.

WELDED CONSTRUCTION DETAILS.

Fig. 6

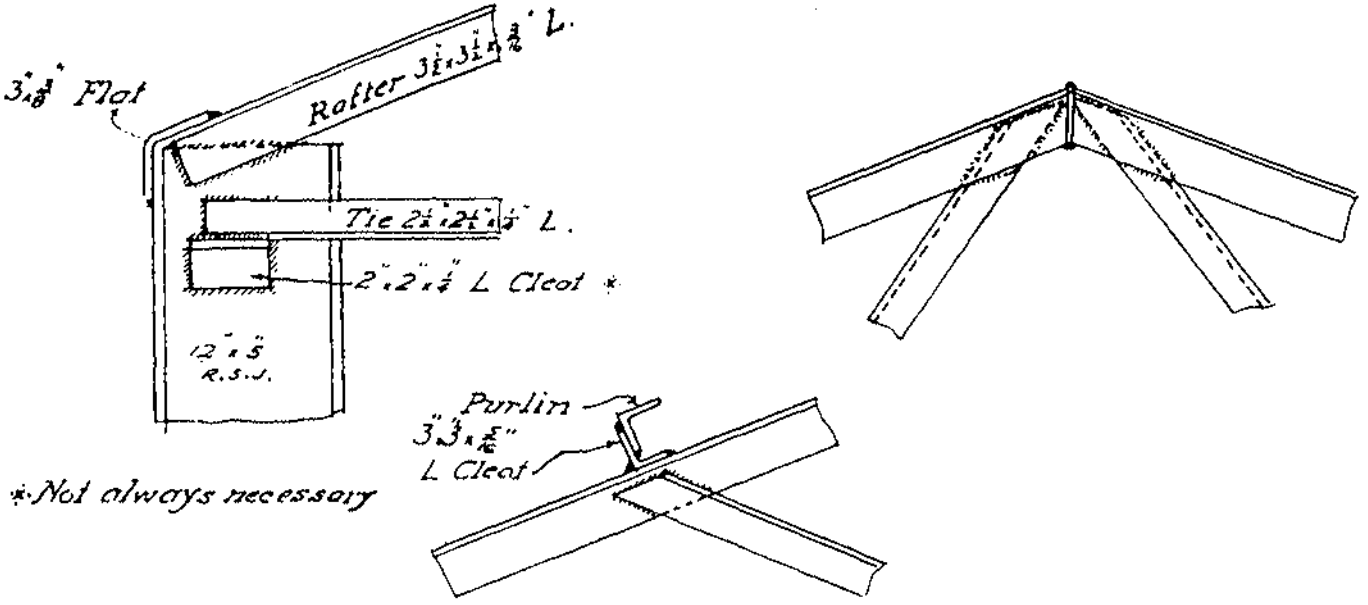


Length of welds "a" & "b" inversely proportional to distance from N.A. of member.

"Fillers" must be used in compression members.

MISCELLANEOUS DETAILS

Fig. 7



Simple Truss Details.

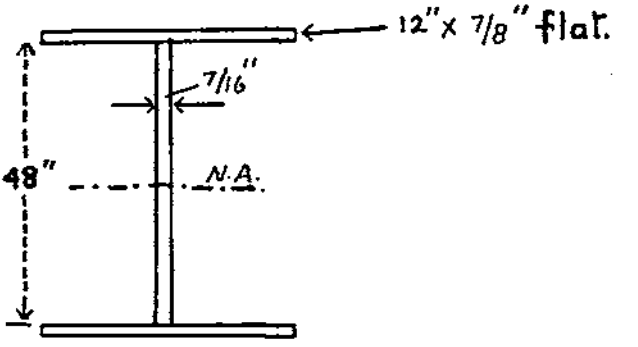
Plate Girders.

Welding offers a very easy method of building up plate girders from the cheapest of rolled sections-flats.

Weight can be saved by using the full area of the metal due to the absence of rivet holes.

It is permissible to use butt welds both in flange and web plates. Where a thicker plate is being butt welded to a thinner it should be chamfered at a slope not greater than 1 in 6 down to the thickness of the thinner plate. Tapered cover plates should be used for all such connections.

The following example for a simple plate girder may be of interest :—



If the span = 20 ft. and the load is 160 tons evenly distributed, then

vertical shear at end supports = 80 tons = V,

static moment of flange about N.A. = 256·6 in.^{2} = Q,

$\therefore$ horizontal shear between web and flange = VQ/I

= 1·24 tons/in.

= 14·85 tons/ft. run.

The permissible load on a $\frac{3}{8}$-in. side fillet

= $5 \times 3/8 \times 1/2$ tons/ linear inch

= 1·325 „ „ „

Hence a $\frac{3}{8}$-in. weld on each side of the web joining it to the flange will carry altogether 2·65 tons/linear inch.

$\therefore$ length of welding required $= \frac{14{\cdot}85 \text{ inches}}{2{\cdot}65}$

= 5·6 inches on each side.

Hence a $\frac{3}{8}$-in. weld, 3 in. long at 6-in. centres on each side, meets the case.

Similarly it will be found that 2 ft. from the support 2-in. welds, at 6-in. centres, may be used, or the size of the fillet may be reduced to give longer runs.

In fact a $\frac{1}{4}$-in. continuous fillet would be ample.

This result may seem rather amazing at first sight, but that it is borne out in practice is shown by the fact that the only large all-welded steel bridge in Great Britain at the moment was constructed with flats on the above lines, and has no welds of more than one run and larger than 5/16-in. except butt welds in plates.

This bridge is the approach bridge, carrying the main road over the railway to the new Tees bridge at Middlesborough, and consists of two 28-ft. spans, two 48-ft. spans and one 64-ft. span.

It was built by Dorman Long and Co. in 1932.

BRIDGE STRENGTHENING AND REPAIR.

This is an aspect of electric welding which seems to open a wide field of interest both for the civil and military engineer.

A riveted-cum-welded structure may not be looked upon with particular favour, but experience has proved that old riveted bridges repaired and strengthened by welding have been almost 100 per cent. satisfactory.

The success of such structures depends very largely on the ductility of the deposited weld metal.

Normally weld metal is not as ductile as rivets, but usually the rivets will have " slipped " in order to take the full load, so that the weld metal will not be called on to deal with this preliminary extension.

It is usually quite easy to put down sufficient weld metal to take the full load and so entirely to relieve the rivets. Also high-class electrodes are now being produced which will give a deposit very nearly as ductile as M.S. rolled sections.

A good deal of strengthening of railway bridges has been carried out in Australia, while in England the L.N.E.R. have also used electric welding extensively in this connection, thereby saving very large sums of money on bridges which otherwise would have had to be replaced. The saving thus effected varies from 4/5 to 1/2 of the cost of replacement by a stronger bridge.

The following notes give the lines on which such work is usually carried out :—

A certain amount of overhead welding is usually unavoidable, but it should be avoided as far as possible.

Plate Girders and Flanges.—These can usually be strengthened by :—

(*a*) Welding the flange angle to the web and flange plate by means of fillets. Sufficient weld metal can usually be put down entirely to relieve the rivet of the horizontal shear between the angles and plates.

(*b*) By adding new plates to give the additional area required. For the bottom flange, the new plate should be wider than the old, and for the top flange, narrower, to avoid overhead welding.

The new plates can either have holes drilled in them to miss the rivet head or they may be fitted in between the lines of rivets, or a packing strip can be inserted. In the latter case, the outer edges only of the strips, if they are to be covered by another plate and are not intended to take any stress, need continuous welds.

A channel section inverted on the flange is simple and quick, involving far less welding than other methods.

Butt welds may be used to connect new plates, or new plates to old plates.

Care should be taken that the end connections do transmit the flange stresses and that the new plates are carried well beyond the points at which the extra area of steel is required.

Webs.—Usually strengthened by fitting additional plates in the panels and welding all round the edges to the flange angles and stiffeners. There is no need to rivet or bolt the centre of the new plate to the old.

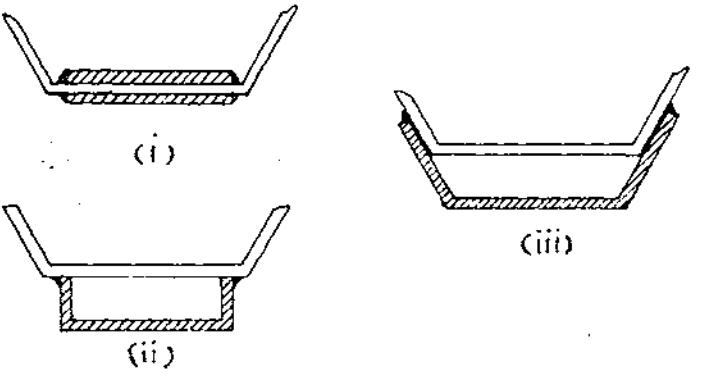
Additional web plates may be welded to the flanges outside the flange angles, thus forming a box-girder.

In both methods care must be taken to ensure a close fit at the edges before welding.

Troughing.—The flanges may be strengthened by additional strips and the webs by plates. Fig. 8 shows various methods. That depicted in (iii) is probably the simplest. It gives down-hand welding and the sections can be bent from flats.

Bridge Strengthening.

Fig. 8



Strengthening Troughing.

Trusses.—The strengthening of trusses is usually carried out by the addition of small gussets to strengthen the connections. The addition of new members requires very careful consideration and design.

Corrosion.—Many old steel bridges suffer very severely from corrosion. Usually the worst places are at the junction of the web and flange plates and also in the stiffeners at the same point. Large sections of the flanges may also be affected. The writer has seen some railway bridges in which for stretches of three or four feet there was no connection between the bottom flange and web of a main girder, or in which half a dozen stiffeners were corroded right through at the point of junction with the flange angle, while in nearly all, large holes had appeared in the flange plates, sometimes two or three square feet in area.

This type of damage is very easily and quickly repaired by welding, at a very low cost.

Where the " pitting " or " flaking " is not too far gone the metal may be built up by welding to its original section, after all the bad metal has been chipped out. Where corrosion is too far advanced, the corroded parts may have to be cut right out and new plates cut to shape, fitted and welded in.

In the case of stiffeners, new stiffeners in the form of flats welded in between the old ones is usually the simplest and quickest repair.

WELDING PROCEDURE.

To obtain the best results in welding, some sort of standard practice must be laid down and adhered to.

In doing this, the following points should be a guide :—

(1) No welder should be allowed to decide on what electrode and current to use for the job. The size of fillet and electrode together with the current to be used should be specified by the designer on the drawing.

To carry this out in practice, a man must be obtained who is reasonably skilled in depositing metal, and he should then be trained to deposit a certain length of run for each gauge of electrode to obtain a fillet of a given size.

Thus a standard size of run should be used for each gauge of electrode. By this means the welder will find his work very much simplified and its reliability will be correspondingly increased.

The following table is suggested as a basis :—

Gauge of electrode.	*Length of run.*	*Approx. size of fillet.*
10	8 in.	3/16 in.
8	10 ,,	7/32 ,,
6	12 ,,	1/4 ,,
4	15 ,,	9/32 ,,

For larger fillets, several runs should be used, working always from the bottom up.

Such a procedure greatly simplifies estimating, as the time and number of electrodes per foot run of welding becomes standard for each gauge, while the requisite cross section and hence strength is also ensured.

By having a voltmeter and ammeter in each welder's circuit, complete control is assured, and a high standard of welding should result.

A very useful table appeared in this connection in the April, 1934, edition of *The Welder*, published by Murex Welding Processes Ltd., Forest Road, London, E.17.

(2) Very close inspection of the work should be carried out. Every run put down should be inspected before it is covered by another. This does not entail a very great deal of labour. One inspector can easily look after six to eight welders. He should run a piece of distinctive coloured chalk down the weld. This, besides marking the run as passed, ensures his eye travelling over the whole run.

Points to look for are :—

(*a*) *Bad penetration.* Usually caused by too low a current.

(*b*) *Undercutting.* Usually caused by too high a current, or by the electrode being "weaved" too slowly. Incompetent welders nearly always undercut.

(*c*) *Craters.* Caused by faulty manipulation of the electrode, allowing slag inclusions to occur.

(*d*) *Correct setting up of the work.* In this connection it must be remembered that down-hand welding is easiest and should therefore be used whenever possible, while overhead welding, being the most difficult, should be avoided.

(3) *Testing.*—It is seldom possible to test the actual welds in a job, but as the strength of welds, given first-class modern equipment and electrodes, depends very largely on the ability of the welder, it is very important that the latter should be regularly tested.

This can be quite easily carried out by the means of test specimens. Careful records should be kept of all such tests.

If a tensile testing machine is available, a plain butt weld joining two pieces 3 in. wide, 6 in. long and $\frac{3}{8}$-in. thick, will serve. The section at the weld should be reduced by grinding to a little below that of the plate, to ensure the test piece breaking in the weld.

In the field, where such machines are not available, the following simple tests can be applied :—

(*a*) Two plates 6 in. x 8 in. x $\frac{1}{2}$-in. should be clamped together with their 6-in. edges offset by $\frac{1}{2}$-in., and a fillet run down one of the 6-in. edges.

After cooling they are broken apart by wedging at the free end opposite the fillet (see Fig. 9).

Fig. 9.

Good welds should break through the throat section. The points to note are :—

(i) Good fusion at the root.
(ii) Adequate penetration in the vertical and horizontal plate edges.
(iii) Absence of undercutting.
(iv) Uniformity, slag inclusions, general soundness.

(*b*) By welding a flat on to the web of an I-section R.S.J. so that it projects at right angles. After cooling it should be hammered over till it lies parallel with the web. The weld should show no signs of fracture.

Non-destructive testing is a difficult problem, and has not yet been satisfactorily solved. There are various methods :—

X-ray and Gamma-ray Testing.—Presents great possibilities, but entails very heavy expense, and is not applicable to many types of welding. X-rays are sometimes used on welded boiler seams.

Iron-Filings Test.—By magnetizing the work, the positions taken up by iron filings sprinkled over the joint will show discontinuities in the welding.

The method is cheap and fairly sensitive, but it is not applicable to many important types of welding.

Reluctance Test.—A more advanced version of the iron-filing test is to measure the reluctance of a joint.

Quite cheap testing sets are available and they might be found very useful, though they give no quantitative results, only indicating the position of faults.

A refinement of this method is an acoustic apparatus in which differences in the magnetic reluctance of a joint cause differences of tone in a buzzer connected to a pair of earphones.

Testing by Milling.—In this method, known as the "Schmuchler Test," a small hole is milled in the seam, by means of a specially designed portable milling machine.

The sides may then be etched with copper ammonium chloride, and the defects or otherwise of the weld easily seen.

It has been proved that the small holes so made have a negligible effect on the strength of the weld.

Where a large amount of important welding is being carried out, the milling test, used in conjunction with one of the magnetic tests for locating faults, gives a fairly effective guarantee of sound welds, while it serves also to keep the operator always up to the mark.

Some Applications of Arc Welding.

Of the many uses to which electric arc welding can usefully be applied, one which seems very well worth study, while the results of the disastrous earthquakes in India are still fresh in the mind, is earthquake-proof construction.

An earthquake gives a structure above ground a lateral movement, causing it to act as a cantilever fixed at the foundations. This movement must be resisted.

A steel frame building meets this requirement to a certain extent, but the special connections required are very cumbersome if rivets are used, so that the application of welding in this sphere opens very wide possibilities.

Another field in which welding offers opportunities is the repair and maintenance of machinery. In this connection a word on the welding of cast-iron may not be amiss. The welding of cast-iron is extremely difficult, owing to the brittleness caused by the intense heat. Instructions are issued in all the best welding concerns' handbooks, and if these are closely followed, a successful repair may possibly result. Cracked cast-iron cylinder heads are frequently met with, and present a very difficult job. A very skilled welder is required, and even then it is quite impossible to guarantee that the old crack is sound, or that another has not developed. Even should a sound job have resulted, it is not likely to last for any great length of time in service, due to the unequal temperatures and stresses produced under working conditions proving too much for any weld on cast-iron.

Non-ferrous metals.—The electric welding of non-ferrous metals is still in the early stages of development, but a certain amount of work is being done in bronze and other alloys.

In conclusion, it remains only to hope that this article may arouse interest in this new and rapidly advancing subject. For those who are interested there are very few books on the subject and the author

can only refer them to the instruction books issued by the foremost makers of welding equipment, such as Murex Welding Processes Ltd., Ferry Lane Works, Forest Road, London, E.17, and the Quasi-Arc Co., Ltd., 15 Grosvenor Gardens, London, S.W.

Both the above also issue monthly periodicals free, which are well worth reading.

Other authoritative publications, besides the B.S. Specifications already mentioned, are *The Practical Design of Welded Steel Structures* (from *The Journal of the American Welding Society*, August, 1933), and *Designing for Arc Welding*, published by the Lincoln Electrical Co., Cleveland, Ohio.

A copy of the latter is now in the R.E. Library and consists of prize-winning papers on various aspects of welding by experts from all over the world.

TABLE 1.

Type of Generator.	Voltage.	Method of Stabilizing.	Input per Arc Kw.	P.F.	Overall Efficiency. %
D.C.					
Level Compound ...	60	Series resistance	17·2	—	29
,, ,, ...	100	,, ,,	27	—	18·5
Drooping Voltage ...	60/25	Inherent	8	—	62·5
Multiple Operator 5% over Comp.	40	Series resistance and reactance	12	—	42·5
A.C. Transformer ...	100	Choke	6·3	·25	80
,, ,, ...	100	Resistance	22·5	·95	24
,, ,, ...	80	Choke	4·8	·25	90·2

The above figures are actual figures from machines, and are taken for the full load of the machine per operator (*i.e.*, a welding current from 240–300 amps. with an arc voltage of approx. 18 volts).

The power factor may be improved to about ·50 if a well-designed choke is used. Further improvement can be made in the usual way by condensers.

Brigadier-General Herbert Colborne Nanton, C.B., C.I.E.

MEMOIR.

BRIGADIER-GENERAL H. C. NANTON, C.B., C.I.E.

HERBERT COLBORNE NANTON was born in Cobourg in 1863. He received his school education at Upper Canada College, Toronto, entered the Royal Military College, Kingston, in 1879, and graduated as a Serjeant in 1883.

He was keen on sailing and canoeing and was the best man in handling an ice-boat, yacht, or Rice Lake canoe, during his career at the R.M.C. He thoroughly enjoyed Rugby football and played in the senior team for his last three years at college.

He graduated with a first-class diploma, but not high enough in his class to obtain the R.E. commission. In those days only one R.E. commission was given to each class, and that usually went to the first or second man of the year.

Nanton therefore decided to take up civil engineering as his profession and, as the Canadian Pacific Railway was then under construction, he and Percy Girouard were appointed assistant engineers on the Rocky Mountain section.

On the outbreak of the Riel rebellion in 1885 he threw up his railway job and joined the Canadian Militia, serving throughout the operations in the north-west. He received the medal and clasp for this campaign. During 1885 and 1886, graduates of the R.M.C., Canada, who held first-class diplomas and were under a certain age, were offered commissions in the R.E. by the Imperial Government. Nanton immediately sent in his name and was accepted. He joined at Chatham without delay and appeared with his medal and clasp. It is probably right to say that he was the first Y.O. to join at Chatham at the age of 22 with war service.

After spending some fifteen months at Chatham he was ordered to India. On arrival there he was posted to the Bombay Sappers and Miners and after some months transferred to the Military Works Department.

He served in the Lushai Expedition in 1888-89 and as Field Engineer with the Chitral Relief Force in 1895, for which he was awarded the medal and clasp.

He married Margaretta Joly-de-Lotbinière in 1891.

Sir Percy Girouard invited him to join his staff on the outbreak of the South African War, and on arrival in South Africa he was

appointed Deputy Assistant-Director of Railways and Assistant-Director of Railways in 1902. He was gazetted Brevet-Major (29th November, 1900) and Brevet Lieut.-Colonel (22nd August, 1902) for service in South Africa, where for some time he was in command of the armoured trains. He was mentioned three times in dispatches and awarded the Queen's Medal with three clasps and the King's Medal with two clasps.

On his return to India after the South African War, he was again posted to the Military Works Department as C.R.E. Bangalore District, and in August, 1903, he was appointed D.A.Q.M.G. at Army Headquarters (1903 to 1907). From 1907 to 1910 he was A.A.G., R.E. and Deputy Director-General Military Works from 1910 to 1914. He obtained his Brevet-Colonelcy in 1907.

When it was decided to send an Indian Army Corps to France, Nanton was appointed Chief Engineer and remained with the Corps to the end of 1915, when it left France. He was then transferred to the XV. Corps as Chief Engineer till 1917 and to the XVII. Corps for the remainder of the war.

It was under Nanton that the mining operations at Vimy Ridge were carried out. In 1915 he was given a C.B. and in 1919 a C.I.E.; he was also twice mentioned in dispatches.

After the Great War he returned to India and was appointed Chief Engineer, Southern Army, retiring on an Indian pension on 21st July, 1921.

All his friends in the Corps, and he had many, will remember him as a hard-working, conscientious, and keen soldier, whose one idea was to get on active service on every opportunity.

He had a great fund of good stories and was a charming and cheerful companion.

His death was deeply felt by many of his old friends in Canada and the Corps.

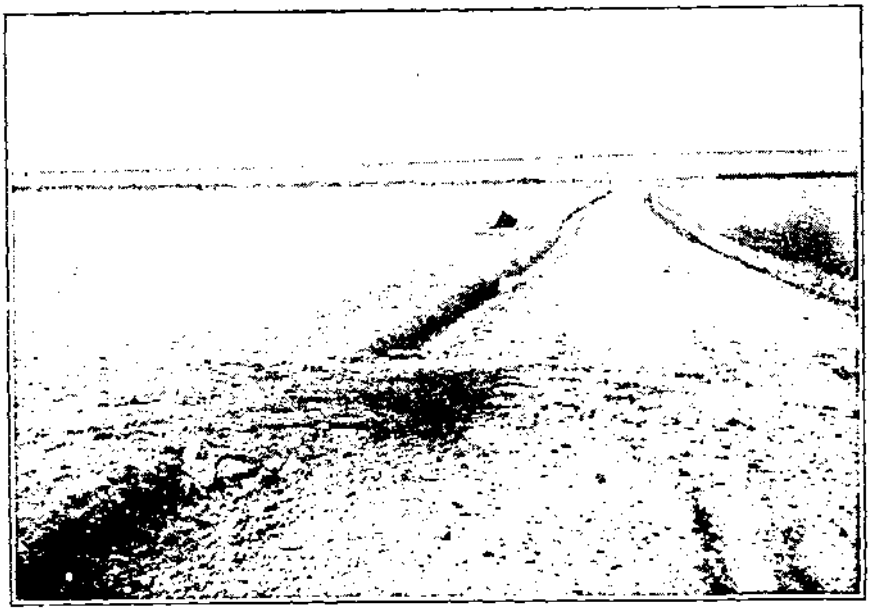
Throughout his service his ambition was to uphold the credit of the R.E. of which he was so proud of being a member.

He died in Victoria, B.C., on the 2nd May, 1935.

A. C. J.-DE-L.

A "MIX-IN-PLACE" ROAD.

The Terolas surface after 1 year.



The Terolas surface after 1 year showing untreated side entrance.

CORRESPONDENCE.

Colas House,
Buckingham Gate,
London, S.W.1.
21st June, 1935.

A "MIX-IN-PLACE" ROAD.

To the Editor, *The R.E. Journal.*
Institution of Royal Engineers, Chatham.

DEAR SIR,

In the March issue of *The Royal Engineers Journal* you published a very interesting illustrated article by Major F. E. Orange-Bromehead regarding a mix-in-place road surfacing trial on Salisbury Plain. The article described the shaping and preparation of the earth surface, the application and mixing of dilute Terolas bitumen emulsion with the existing surface soil and the final sealing of the surface with a double application of Colas and chippings.

Since this work was completed, the road has been exposed to a considerable volume of miscellaneous military traffic and a moderately severe winter. A recent inspection, however, shows that, apart from a few spots where the seal coat has become detached, the surface is in perfect condition.

On page 70 of the article in question, a subsidiary experiment was described in which the existing earth surface was merely brought to shape, consolidated and given a double surface-dressing of Colas and chippings. This surface has been exposed to the same traffic and climatic conditions as the main experiment, but it suffered severe damage during the winter and is now in bad condition. This subsidiary trial has demonstrated clearly that untreated earth which receives a double surface-dressing of emulsion and chippings is very much more liable to damage from traffic and the infiltration of moisture than a wearing carpet which has been impregnated with a small proportion of bitumen applied in the form of Terolas.

The publication of the enclosed photographs, which show the Terolas surface one year after completion, will, I think, be of interest to those who have read the original article.

Yours faithfully,

E. G. WACE, *Brig.-Gen.*

All Reviews of Books on military subjects are included in the provisions of K.R. 522c.

BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

March, 1918. Volume I.

THROUGH GERMAN SPECTACLES.

(From the *Frankfurter Zeitung* of the 19th May, 1935.)

"This work (*France and Belgium*, 1918. *The German March Offensive and its Preliminaries*, compiled by Sir James E. Edmonds. Macmillan & Company, London) will always hold a high rank in military historical literature. It describes the events in a style which has drawn its clarity and perspicuity, terseness and unemotional power, from the best soldierly traditions. It relates them with great restraint in the criticism of persons, but at the same time a very attractive frankness, which reveals a great deal to the thoughtful reader."

HISTORY OF THE GREAT WAR.

MILITARY OPERATIONS, MACEDONIA, VOLUME II, FROM THE SPRING OF 1917 TO THE END OF THE WAR.

BY CAPT. CYRIL FALLS.

(H.M. Stationery Office. Price: Text 12s. 6d., Maps 5s. 6d.)

Captain Cyril Falls continues his history of the political events from the dethronement of King Constantine in June, 1917, and his replacement by his son, King Alexander, with Mons. Venizelos as Prime Minister, and Greece now entering as an active belligerent. The history of the military operations is taken on from the failure of the Allied offensive in May, 1917, up to the Armistice with Germany, but he does not break off abruptly on the 11th November, 1918. He briefly winds up the story of the war in the Near East after the Armistice with Germany, by giving some information of the subsequent movements and activities of the troops, and adds a short Appendix I concerning the Army of the Black Sea from December, 1918, to May, 1919. By the way, the term "Army of the Sea," reminds one of the navy being told to capture a peninsula.

Other Appendices give in full some instructions from the British and French Governments and from the Supreme War Council to the C.-in-C. at Salonika and to General Sir G. Milne, also important operation orders and the order of battle of all the Allied Forces.

Major A. F. Becke and Mr. H. Burge have as usual provided excellent maps designed to give the clearest illustration of the story. Contrary to one's

experience of the maps of some unofficial war books, it is possible to find every name mentioned in the text, but the clearness of the maps is not confused by unnecessary names and information.

Allied Forces composed of many nationalities.

The forces of the Allies in Macedonia were composed of many nationalities. The order of battle for the final offensive (App. 2) shows the following divisions. British 4, French (including Algerians, Zouaves, Indo-Chinese) 8, Serbians 6, Greek 10, Italians 1. There was also an Albanian unit. Cavalry units were British, French (including Moroccans) and Serbian. The Serbian divisions had received a very valuable reinforcement of 16,000 Yugoslavs, captured by the Russians from the Austrian armies and sent as very willing and efficient volunteers, partly *via* Archangel, and partly *via* Vladivostock, to Salonika.

There had been a Russian division in Macedonia, but the revolution in Russia had eliminated that formation.

The story of the Allied Forces as a whole and of the British in particular.

The importance of the British force and of their action was as usual not represented by the proportion of their strength to that of the whole force, but it is obvious that, with only 4 divisions in a total strength of 29 divisions, if the historian had confined himself to recording only the actions of the British troops he would have given a very inadequate account of the operations in which they took part, and would have been unable to indicate the important effect of their efforts upon the operations as a whole. Captain Falls has, therefore, told the story of the whole Allied Army in Macedonia, but in dealing with British operations he has gone into greater detail. He is to be congratulated upon the proportion he has maintained between the story as a whole and the British portion of it in particular, which fully satisfies the desire for information about every British unit, while at the same time giving a remarkably complete and lucid account of a campaign, which is particularly complicated by political events, by the numerous nations concerned and by the large area of difficult and peculiar country in which operations took place.

The effect of vacillating policy and strategy.

Captain Falls brings out very clearly the strangling effect upon the actions of the French C.-in-C. and particularly of General Sir G. Milne, and of his troops, caused by the vacillating policy and strategy of the British and French Governments.

In the autumn of 1915, after the question had been often debated, notably in November, 1914, and in January, 1915, the British were dragged by the French unwillingly to the Balkans in a forlorn hope to save Serbia. The British Government agreed to send troops contrary to the advice of their General Staff, and thought they could limit their liability to some restricted and temporary operations from which withdrawal could soon be effected. Failure to save Serbia was followed by the decision to defend the port of Salonika only. "In the first half of 1916, there was a continuous struggle between the British and French General Staffs, the latter advocating an offensive, the former refusing to take part in one."

In August, 1916, the entry of Rumania into the war caused an offensive to be hastily ordered and the partial success at Monastir resulted. Again in the spring of 1917 the War Cabinet with the consent of Sir W. Robertson made a sudden and temporary reversal of their strategy. Till that moment they had resolutely set their face against an offensive, but when the Turks began moving two Divisions from Macedonia to oppose the Cabinet's cherished offensive in Palestine, then they urged the French to attack promptly in Macedonia to hold the Turks there. Capt. Falls criticizes severely General Sarrail's conduct of this offensive in the Spring of 1917.

"The British Government, unfavourably impressed by the conduct of this offensive "and influenced by the shortage of shipping, then washed their hands of the affair "and turned to Palestine, leaving the French to settle the Greek question. They "withdrew two infantry divisions, the bulk of the cavalry and a large proportion

" of the heavy artillery. *They cut down the pack transport establishment which had* " *only just been reached.* They set their minds resolutely against the idea of any " further active operations in Macedonia."

This attitude of the British Government was maintained till the 4th September, 1918, when it was completely reversed by the War Cabinet agreeing to their forces in Macedonia co-operating in the great offensive which was to start ten days later. The French Government and staff, and their C.-in-C. in Macedonia, on the other hand, continually kept in view the possibility of an ultimate offensive on a large scale. Governments can and do alter their policy and strategy in the twinkling of an eye, but the administrative machine of every government department concerned requires some months to give effect to that change of policy, when it is a case of reinforcing an army in the Balkans with all the personnel and munitions and equipment and transport which it requires for a major offensive, to be followed by a long pursuit through some of the most difficult country in the world.

Government departments must give effect to government policy, and when over a period of years the desire of the government has been to withdraw its troops from the Balkans, when it has grudgingly permitted them to remain there but strictly on the defensive at a limited distance from their base, and has constantly ordered preparations of schemes for withdrawal, it is obvious that the administrative machine of the departments concerned must refuse demands from the local commander for personnel, heavy artillery, ammunition, transport, mechanical and pack, engineer and labour units, and plant and equipment for repair of railways and roads, if such demands are based upon the requirements of a major offensive and long pursuit in the Balkans. There is never enough of everything for everybody. The question of priority of importance always arises, and a theatre of war which is strictly limited to the defensive and liable to be evacuated shortly will not receive much of the warlike resources available.

Captain Falls and the author of this review have dwelt upon this aspect of the effect of vacillating Government policy and strategy because, unless it is clearly realised, the student of the campaign will find it impossible to understand the causes of many difficulties and breakdowns, and will fail to comprehend the magnitude of the effort imposed upon the troops and their commanders in carrying through a successful offensive and pursuit in the Balkans without that careful preparation and organization and equipment which is so necessary for such difficult operations. There are special reasons, which will be explained, why in this case disaster did not ensue, but the price paid by the troops and their commanders in their loyal efforts to carry on under such circumstances was a high one. If we are required to operate again in such a country, it would not do to gamble upon this precedent for the lack of adequate preparation in the peculiar circumstances of the campaign we are considering.

The defensive period.

At the end of the Kerensky offensive in July, 1917, and the vigorous German reaction to it, it was obvious that revolutionary Russia was out of the war. In December, 1917, Rumania signed the truce of Focsani.

With these Allies out of the war the *raison d'être* of the Macedonian force had largely disappeared, but in the meantime we had acquired a new liability for the defence of our last joined Ally, Greece. The disappearance of our Eastern Allies, however, caused a very threatening situation for us in Macedonia. There was no doubt that it would now be comparatively easy for the Central Powers to secure a spectacular success in that theatre. Fortunately, such strategy on their part would have been thoroughly unsound. Time was valuable. The American Army had begun to assemble in France. The Central Powers must either negotiate for peace or seek a final decision in the west in the limited period available, before America made such a decision impossible.

But for Macedonia the threat existed, so that from August, 1917, up to the opening of the German offensive in France, in March, 1918, defensive measures were the preoccupation of the Allied Forces in Macedonia. General Guillaumat succeeded General Sarrail as C.-in-C. in December, 1917. Captain Falls does justice to General Sarrail in appreciating the peculiar difficulties of his task and considerable accomplishment in spite of those difficulties, but General Sarrail undoubtedly suffers by comparison with the two extremely able commanders who followed him in succession, Guillaumat and Franchet D'Esperèy.

General Guillaumat's able co-ordination of schemes of defence and the energy infused into them are fully described. Also his sound reorganization of the forces and the happy relations he established with the troops of all nations represented, and notably the British. Here, indeed, there was a contrast to the Sarrail régime. It is astonishing how even the most junior officer, and the rank and file also, can feel the effect of the hand of an able commander upon the reins. Some idea of the British share of the defensive task and the engineer work involved can be given if we mention that they were responsible for the security of about two thousand square miles of Balkan country of hills that were almost mountains, rivers, valleys, lakes and swamp; their four divisions held a front of about 85 miles measured direct; three main L. of C. radiating in three directions totalled 115 miles, measured direct, and probably 150 miles by the routes followed, and there were several hundred miles of lateral communications.

In three sectors the British were at grips with the enemy, at the mouth of the Struma, at the head of the Struma valley near the Rupel Pass, and again between Lake Doiran and the Vardar. On the front between those sectors there was a no-man's-land of several miles in width and both sides had occasional defensive areas within it or on its borders.

An active defence caused the usual type of raids in the three sectors where we were at grips, but in the intervening spaces raids grew into minor operations which are well described by Captain Falls. Almost invariably these minor operations were skilfully and gallantly executed and a distinct ascendancy gained over the Bulgars.

The forward positions occupied were well to the east and north of Salonika from the Gulf of Orfano on the right to Lake Ochrid in Albania, where we joined with independent Italian forces that carried on the line to the Adriatic. Had the Central Powers driven us back from these positions, then General Guillaumat's instructions were that his primary task was the defence of Greece, into which the Allies would retire, with, it may be said, a very much disillusioned Greek army. There was a considerable argument as to whether under such circumstances Salonika itself would or even could be evacuated. Round the harbour of Salonika itself as a final retrenchment there was a defensive system covering a very large area.

Reductions in strength of the force.

It was during this defensive period, actually between June and September, 1917, that the British force was reduced from 6 divisions to 4 divisions by the departure of 60th and 10th Divisions to Palestine; also 2 brigades of Yeomanry and some valuable heavy artillery.

After the German attack in March 1918, twelve infantry battalions were sent to France by reducing the infantry in divisions from 12 to 9 battalions.

Malaria.

Further considerable reductions in strength were made continuously by malaria and later in September, 1918, by influenza. Captain Falls says that where the British Army was concerned, malaria was the predominant factor in all operations. They had the misfortune to be in occupation of the most malarial districts within the Allied lines. An advance northward of a very few miles, if it had been possible, would have carried the whole Allied Army into healthy country. Men who had seen malaria in many tropical parts of the world were surprised at the virulence and

malignity of the Macedonian malaria, resulting in many deaths and serious incapacity and relapses among those who managed to return to duty. In December, 1917, there were 15,000 chronic malaria cases who could never rejoin their units and spent their time in hospital or convalescent camp and back to hospital.

Drafts.

The sick were gradually sent home but drafts to replace them were not sent out.

The French Army also was not maintained by drafts. The very serious shipping situation while the submarine campaign was at its height in 1917, and the general policy of no offensive in Macedonia, caused great difficulty in maintaining the Allied forces, not only in men, but in ammunition, and even in food; in fact on one occasion reserves of food were down to one day's ration.

Very little leave could be arranged. The Serbian Army was also much reduced by casualties and sickness, but was partly made good by the welcome reinforcement of 16,000 Yugoslavs already referred to.

Morale.

It might be supposed that, under such circumstances, the morale and discipline of troops would suffer and yet, miraculous to relate, it was just in these qualities that a very high standard was maintained by the British troops, a standard which attracted the notice of occasional visitors from the War Office or the supreme War Council. It was particularly referred to by General Guillaumat when he took over. The historian, when praising the troops for their endurance and constancy in resisting deterioration of morale, does not fail to give credit to General Milne and his senior commanders, who knew what measures to take to get this response from their troops.

Among the French troops there were echoes, in 1917, of the mutinies and disturbances that occurred in France after the failure of the Nivelle offensive. These were handled by the French command with a skill equal to that displayed in France.

The Serbians had their periods of dejection, and who can wonder, after what they had gone through, and when they saw their hopes of re-entering their country in 1916 and 1917 vanishing? There were also political reasons for some dissension amongst them, but the Yugoslav reinforcement and a period of rest acted like a tonic, and, as we shall see, when the final offensive was launched their morale was superb.

The Russian division, as already stated, dissolved in 1917 after the revolution.

The Greek Army had suffered in organization, administration, and cohesion by the long uncertainty as to which side they would join, and in the hopeless endeavour to maintain neutrality. The revolution which was caused by this state of affairs split the army into Royalists and Venizelists and there had been no opportunity to seriously prepare and equip the army for a modern war. This task was now undertaken by a French mission. As we shall see, the Greek Army supplied very valuable and gallant infantry, but were very deficient in other arms and in administration and rearward services. Heavy artillery was almost non-existent, field artillery very limited. They had a small quantity of pack artillery which was useful in exploitation and pursuit, but almost valueless in the break-in.

These deficiencies had to be made good by the French and British, who supplied the Greeks with artillery support in action and administered their rearward services. It was for these reasons that the Greek Army was split up by allotment of their divisions to the commanders of various sectors along the front, including General Milne, but in the Struma Valley a Greek corps was ultimately under the independent command of the Greek C.-in-C. The Greek Government, and command, and their troops, made it quite plain that they had entered the war not for the purpose of releasing British or any other troops to go elsewhere, as the British Government proposed, nor to remain indefinitely on the defensive. If 1918 had passed without a serious offensive, it is doubtful whether the Greek troops could have been retained in the field. They proved to be very gallant and valuable in the offensive but their temperament is not suited to a long war.

Strength of formations and units.

The reader must beware of gaining wrong impressions from the accounts of the actions of Armies, or corps, or divisions, or brigades, or even battalions, since these terms bring to the mind powerful formations and units, whereas in most cases, it was only their skeletons or even their ghosts who were functioning.

The order of battle shows, and the historian talks of, two Serbian armies, but in reality, these were two corps, each of 3 divisions and the divisions much below strength. They too required support from French artillery and French administration of their rearward services.

British and French divisions were much below establishment for the reasons already explained. British battalions went into action about 450 strong and many less than that. They suffered severe casualties in the Battle of Doiran and the exertions they made brought on relapses of malaria. Consequently, in the pursuit some units ceased to exist and were incorporated with other weak units, but the historian, to pursue the thread of his story, is bound to refer to them still by the numbers of their divisions and brigades. It was, however, a very skeleton force that was still in touch with the Bulgar at the Armistice.

The Italian division alone was always maintained at full strength, and the Greek infantry units started the offensive at a satisfactory strength.

Comparative strength of the two sides.

After taking into consideration all that has been said about effectives, the historian shows that the Allies were practically the same strength in combatants and guns as the Bulgar-German Army in September, 1918, over 300,000 combatants and over 1,500 guns. The Germans had withdrawn in December, 1917 two German divisions from this front. The Germans left, however, the Commander, Von Scholtz, and his staff of an army group consisting of 11th Army and Bulgar 1st Army, the Commander, Von Steuben and staff of 11th Army, the commanders and staffs of the LXI and LXII Corps of that army, and a divisional commander and staff for the army reserve, also some Jaeger battalions, a few Landwehr units, M.G., cyclists, batteries of artillery and signal units. All these German units exerted a powerful influence in delaying defeat, although we shall see that it is arguable that General Von Scholtz prevented the Bulgar C.-in-C., General Todoroff from retrieving the situation.

The withdrawal of two German divisions in December, 1917, to go to the Western Front, was a vital factor in the course of events. Captain Falls says that they could not decide the situation in the West and, with the scales so evenly weighted as they were in Macedonia when the issue of the battle hung for some days in the balance, it is almost certain that these two German divisions would have tipped the scale and averted defeat, or even turned the tables on the attackers.

Air Forces.

In 1917, the British R.A.F. were strongly reinforced and gained the mastery in the air. The French Air Force was also in the ascendant. The R.A.F. in the pursuit after the break through demonstrated, as in Palestine, the power and effect of Air Forces, especially where long columns of troops and transport, traversing defiles and mountain passes, offer a target to the bombers, which results in panic and dispersion and blocking of the routes. The German Air Force during the pursuit packed up and returned to other fronts leaving the Bulgars to their fate.

General Franchet D'Esperèy becomes C.-in-C.

In June, 1918, General Guillaumat left Salonika after being recalled to France to become commander of the Paris garrison.

The political situation in France was critical, the Germans were still advancing on Paris, and the French Government felt they required the support of a strong commander in Paris of unimpeachable republican sympathies. All commanders and troops in Macedonia had acquired complete confidence in General Guillaumat and were really sorry to hear of his departure.

The French Government had however, sent a remarkably able C.-in-C. in his

place. General Franchet D'Esperèy arrived on 17th June, 1918, and soon established the same degree of confidence amongst his force of many nationalities as his predecessor had obtained. It will be seen that he succeeded *in* finding the solution to a most difficult military problem and proved himself a commander of the very first rank.

The final offensive.

The historian's lucid account of the final offensive definitely disposes of the idea, sedulously propagated by the German O.H.L. to excuse themselves, that the Bulgars were demoralized and defeated before the offensive began, and that they had no fight in them. The last thing in the world that either the Bulgars or O.H.L. expected was a defeat in the field in Macedonia, and the Bulgars had no intention of leaving the war in that fashion. It is true that from June or July, 1918, they had read correctly the trend of events in France, and the Malinoff Government came into power in Sofia to find some way of extricating Bulgaria from the war. This, of course, had an effect on the Bulgar Army, but they realized the necessity of maintaining the front to give the statesmen a chance to play their cards. They knew, of course, that a defeat in the field would be an exceedingly unpleasant experience for them, and there was no reason why they should contemplate such an eventuality. Were they not equal in numbers and in guns to their enemy? How could equal numbers turn them out of positions which were by nature immensely strong and which over a period of years had been improved by every modern artifice, by diligent hewing out of the rock and by reinforced concrete? They had the advantage of high ground and observation and a country behind them which was easy to defend step by step. Their enemy had tremendous natural and artificial difficulties in front of him.

We have only to follow the bare record of facts recorded by the historian to realize that the Bulgars fought like men who thought they would win. For four days, 14th September to 17th September inclusive, on the Serbian front the break *in* hung in the balance, and on the same front it took 8 days of hard fighting, from 14th to 21st September inclusive, for the break *through* to be accomplished. On the British front, for the reasons that will be explained, the Bulgars repulsed all attacks and the Bulgar C.-in-C. was only just restrained by General Von Scholtz from passing to the offensive on a grand scale with two of his armies.

But when the break through on a front of 70 miles and a depth of 30 miles was definitely established, and further exploitation on a large scale and pursuit was vigorously pressed, then the Bulgar Army collapsed, as General Milne had many times advised his Government they would if once their front was really smashed.

The Genesis of the offensive.

On the 22nd June, Franchet D'Esperèy received a telegram from his government saying that a messenger was bringing him a "directive" and that he was to work on an offensive plan on the lines of General Guillaumat's projects. At this time the strategy of the Supreme War Council was still that which was last confirmed at their meeting on 21st January, 1918, *i.e.*, the defensive in Macedonia, but Foch and Clemenceau, treating the S.W.C. like some countries treat the League of Nations, signed a "directive" on the 23rd June which was handed to Franchet D'Esperèy on 2nd July, instructing him to prepare for an offensive which would break down the Bulgarian defences and open access for the Serbian and Greek Armies to re-occupy their countries. With a view to regularizing their action, Clemenceau and Foch arranged during the meeting of the S.W.C. from 2nd to 4th July that the military representatives should be called upon to report upon the possibility of an offensive in the Balkans. General Guillaumat took part in this investigation and strongly pressed for an offensive.

The report of the military representatives was not rendered till 3rd August, but it was then unanimous in recommending that preparations for an offensive in Macedonia should be pushed on, and that the C.-in-C. should be given a free hand as to the date of launching it. This resolution, although heartily backed by the French Govern-

ment, did not receive the consent of the British Government, and their approval for the co-operation of their forces, until the 4th September, when at an Allied Conference in London Guillaumat succeeded in persuading Mr. Lloyd George to give the consent of the British War Cabinet. From London, Guillaumat went to Rome and secured the consent of the Italian Government, so that on 10th September, Franchet D'Esperèy received a telegram from Clemenceau giving him a free hand to begin the offensive at a date of his own selection.

The organization of a Supreme War Council does not permit it to keep pace with events in war, any more than a League of Nations can keep pace with world events in peace. Had General Franchet D'Esperèy waited for the reversal of their strategy and the formal approval of the S.W.C. on 10th September before mounting his offensive he would not have launched it before the winter season made it impossible. But Franchet D'Esperèy started to work on his preparation when he received the telegram from Foch and Clemenceau on the 22nd June. For some time he kept his own counsel and it was not until the 25th July that he directed General Milne to prepare for an offensive and told him the part he proposed to allot to him.

General Milne had been consulted by the S.W.C. during their investigation and he had replied, "in my opinion an offensive here at the psychological moment may "have more than local effect and should be prepared for."

When General Milne on 25th July received instructions from the C.-in-C. to prepare for an offensive he realized how much he would require in drafts of personnel, additional artillery, ammunition, transport, mechanical and pack, and many other items if his attenuated force was to play its part, and he telegraphed urgently for these many wants to be made good. Sir Henry Wilson who was now C.I.G.S. replied by telegram that an offensive was undesirable and that reinforcements, munitions, etc., demanded were not available. The War Office and government departments concerned were bound to take this attitude until they had the approval of the Cabinet to reverse the strategy which had been in force since May, 1917. As already stated this approval was not given by the British Cabinet until the 4th September and General Franchet D'Esperèy launched his offensive 10 days later.

General Milne was in a position of great difficulty. With hardly any of his demands met for the reinforcement and equipment of his force, he knew they were totally unprepared and inadequate to undertake the rôle allotted to him of attacking the very strongest sector of the Bulgarian defences. It amounted to a forlorn hope. He was equally unprepared for extending his L. of C. through difficult Balkan country in a long pursuit. The historian, and let us hope the reviewer too, has made it plain how unprepared and inadequate the British force was for this task.

Under the circumstances no one would have been surprised if General Milne had told the C.-in-C. that his force was not in a condition to co-operate. Fortunately he took a wider view of the situation. He realized that the psychological moment had arrived to strike the Bulgar and thoroughly believed in the brilliant plan prepared by General Franchet D'Esperèy. He knew that he could rely on his troops to attack vigorously and gallantly any position they were ordered to assault. If he had little hope of success in such an attack, he realized that it would pin down the Bulgar reserves on his front, and that would enable the break through to be carried out on the sector which had been selected for that purpose. It was an unpleasant situation for a commander to be asked to order troops who were not sufficiently supported by artillery and ammunition, and were seriously deficient in numbers, to attack one of the strongest positions that can be conceived, with little hope of carrying it, but to perform the essential task of preventing the enemy from transferring his reserves to the sector where the break through was intended. Had General Milne not given the order he could have justified himself with ease, but one of the most important and brilliant victories of the war would not have been won. A victory which definitely shortened the duration of the war, and thereby saved thousands of lives.

The distribution of the Bulgarian forces is shown on map 4 and may be summarized by saying that the German 11th Army (now German only in name and in the higher command and staffs and special units already referred to) consisting of LXI and LXII Corps was on the right, where it met Austro-Hungarian forces west of Lake Och rid in Albania; next to the eastward came the Bulgarian 1st Army in the same army group under General Von Scholtz. This army was astride the Vardar and its left rested near the crest of the lofty Balasica Plassina over 5,000 feet high N.E. of Lake Doiran. From here the 2nd Bulgarian Army carried on along the Balasica Range across the Rupel Pass and down the Struma Valley. Pinned down to the sea coast from the mouth of the Struma to Dede Agach was the 4th Army of one Bulgarian division and some other formations. The order of battle and the text give full details of the composition and distribution of these formations. Here it must suffice to repeat that numbers of men and of guns were practically equal on the two sides.

General Franchet D'Esperèy's plan.

The selection of the sector for the break through was due to the suggestion of the Voivode Misic, the brilliant chief-of-staff to the Crown Prince of Serbia. He conceived the idea and won the assent of the C.-in-C., who, however, then proceeded to work out with the greatest care and skill the method to be adopted and to group and organize the forces suitably to their task along the whole front. The break through was to be effected firstly on the front of the 2nd Serbian Army between the Vetrenik and the Sokol (6-miles). After the capture of the latter feature the 1st Serbian Army was to advance on the left of the 2nd. The advantage of this choice was, firstly, that it provided that most essential factor—surprise, since it appeared to the enemy to be naturally so strong and forbidding with its precipitous drop from a high crest, that his defences on the summit were less formidable and less in depth than elsewhere. In fact the enemy was not expecting serious attack on this sector, but, secondly, we had in our possession heights from which our artillery could bring overwhelming fire to bear upon it. Thirdly, our communications and supply arrangements were favourable for mounting the attack on this sector. Fourthly, the main enemy communications down the Vardar Valley did not run back at right angles to his front but at an angle of 45° north-westwards, consequently a break through on this sector was only 35 miles direct from the nodal point of several communications converging between Krivolak and Gradsko on the Vardar. Seizure of these places would strangle the supply of the Bulgarian 1st Army and compel them to swing back eastwards on to the Servo-Bulgar Frontier and away from the German 11th Army to the west, who must try to retire northwards. From the first objective, Krivolak-Gradsko, we might hope to race the 11th Army for the strategic nodal point of Uskub (Skolpje) where the railways from Nish and from Mitrovica meet the Vardar.

Consequently, a real break through on the selected sector offered plentiful strategic fruits and the element of surprise to secure the tactical success without which no strategic fruits can be gathered.

The historian does full justice to many original features in General Franchet D'Esperèy's plan and, what is equally important, the methods by which it could and must be executed. They are full of valuable instruction for the student of the military art. Sound principles for the break through and rapid and complete exploitation are to be found in the description, principles which were duly followed in execution and completely crowned with success.

Distribution and organization of the Allies.

It has been stated that the forces on either side were equal in men and guns. How then could the C.-in-C. hope to break a fortified front of such unusual strength defended by men who fought as stoutly as the Bulgars did. His answer to that question was to concentrate three times the enemy's strength in men and guns on the sector selected for the break through, and to time his attacks on other sectors

not simultaneously, but so as to give the maximum assistance to the break through and its exploitation.

The spearhead of his attack six miles broad was the second Serbian Army, which he reinforced with two picked French divisions which were to be in the front line to effect the rupture. The success of this group would make it possible for the 1st Serbian Army on their left to advance. Their success would make it possible for the *Armée Française d'orient* (including an Italian division) on the left of the Serbian Army to widen the breach. This would cause the enemy to throw in all the reserves of the 11th Army and to call upon the 1st Army for their reserves, but at that moment the Anglo-Greek forces under General Milne would attack the 1st Army on both sides of Lake Doiran, where an attack threatened an advance up the enemy's main line of communications, concerning which he was so sensitive that he had made his defences here stronger than on any other part of his front, and stationed his army group reserve behind it.

Connecting General Milne's forces with the Serbian break through was the 1st Group of Franco-Greek divisions under General Anselme, whose attack was to be suitably timed to widen the breach.

On the right of the Allied Line a Greek corps of 3 divisions would demonstrate in the Struma Valley to pin down the 2nd Bulgarian Army. Concentration of overwhelming guns and men on a sector about 10 miles wide selected for its tactical and strategic advantages, and for the probability of surprise, rapid exploitation by reserves close at hand and launched without delay, widening of the breach by suitably timed attacks of formations on either side of the break in, pinning down of enemy reserves on other fronts, seizure of a nodal point on the enemy's main communications, which in this mountainous country would mean a mortal blow, these were the main features of General Franchet D'Esperèy's plan to break a fortified front of great strength with forces no stronger than the enemy's.

The execution of the plan.

From the 15th August the British began to draw the enemies' attention on both sides of the Vardar by bombardment and liveliness. On the 25th a larger operation was staged by the 27th Division west of the Vardar, which resulted in the skilful and gallant capture on the 27th August of the Roche Noir, an important portion of the Bulgar position. This caused violent counter-attacks which were beaten off.

The Battle of Dobropolje.

At dawn on the 14th September, the Voivode Misic, who had been entrusted by the C.-in-C. with the command of all the Franco-Serbian troops concentrated for the break through, ordered the commencement of the bombardment which heralded the battle of Dobropolje. The bombardment lasted all day and at 5.30 a.m. on 15th the infantry advanced. The two French divisions accomplished their mission of the initial break in and the Serbians followed up rapidly, but all the day of the 15th the issue hung in the balance as counter-attack by the Bulgars succeeded counter-attack. The first Serbian Army on the left, advancing before the Sokol had been captured, were repulsed, but as the Sokol fell in the evening they renewed their attack with success. By nightfall the enemy's whole front system on the sector attacked was in French and Serbian hands. Without a pause the Serbians pressed on through the night and at dawn were in touch with the enemy's second line three miles farther north, of which the Kozyak was the centre. Again the fighting swayed backward and forward all the day of the 16th, but on the morning of the 17th the enemy had withdrawn to their third line, from which the premature retirement of a division obliged them to withdraw behind the Crna and the Balasnica rivers, formidable obstacles.

General Franchet D'Esperèy directed the *Armée Française d'orient* on the left and General Anselme's group of divisions on the right of the break through to send their inner formations into the "pocket" on the 16th to help the Serbians batter against the sides of the pocket east and west to widen it, so that as the bottom of the

pocket extended northwards its sides also were driven out and filled with troops flowing in from adjacent sectors.

The reserves of the enemy's 11th Army had all been drawn in by the afternoon of the 15th. By the morning of the 17th, the Bulgarian troops holding the north and eastern side of the pocket were urgently in need of reinforcement, especially the 3rd Bulgarian Division which had borne the brunt of the assault and was about to reach the limit of its endurance, but on the 16th September, the British artillery had begun wire-cutting west of Lake Doiran and General Von Scholtz did not dare move his army group reserve from that front.

THE BATTLE OF DOIRAN.

The Plan.

The historian deals very fully and clearly with the offensive of the Anglo-Greek troops north and west of Lake Doiran under the command of General Milne. It is a story which reveals the sturdy fighting qualities of British, Greek and Bulgar, and is well worth reading. Here one can only summarize it by saying that the XII Corps was to attack on the 18th September, west of Lake Doiran, to secure the "P" ridge. On the right of this attack the Greek Seres Division less one regiment was to carry a forward position running down a spur to Doiran village and then advance on the main position behind. On the left the 22nd Division with two British brigades and one Greek Regiment of the Seres division were to direct their attack "successively against the three lines of defence and the further defences of the "'P' ridge in rear of them." The 26th and 27th Divisions were dangerously denuded of artillery to concentrate every available gun upon the front of attack. 231 guns of all kinds were assembled. "In order not to alarm the enemy unduly, previous "artillery activity was to be limited to a period as short as possible."

Wire-cutting proceeded on 16th and 17th September, and on night of 17th/18th came a "bombardment of certain areas and neutralizing fire with chemical shell against "the enemy's battery positions." The assault on the morning of 18th September was to be covered by a creeping barrage of 18-pdrs. while the 4·5 and 6 hows. fired on carefully-chosen positions in rear. The 26th and 27th Divisions, less a great deal of artillery, were holding the line east and west of the Vardar.

Simultaneously at dawn on the 18th September the XVI Corps (28th Division, 228th Brigade and Greek Crete Division) were to attack the enemy's position north of Lake Doiran on the Blaga Plannina spur. This involved an advance of 4½ miles across No-Man's Land into a plain with little cover on it, completely dominated by the enemy's observation and guns on the Belasica Plannina, rising to 5,000 feet and the lower spurs running down to Lake Doiran. A front of nine miles had also to be held. There were, therefore, available for the attack of the XVI Corps three Greek infantry regiments of the Crete division and two brigades of the 28th Division and 89 guns of all kinds. The attack was to be carried out by the Crete division with the 84th British Brigade protecting its right. The 85th Brigade were in corps reserve.

The execution of the plan.

At 5.8 a.m. on the 18th September, on the right of the XII Corps, the Seres Division advanced, captured the enemy's forward position including Doiran Village and, pushing on, broke well into the enemy's main line, capturing 783 prisoners, but the Bulgars counter-attacked heavily with their reserves and gradually forced the Greeks back, without, however, recovering their forward position and Doiran village, which the Greeks retained.

On the left of the Greeks, the 22nd Division, less one brigade and plus one Greek regiment, advanced to the task already described. One must read Captain Falls' narrative to realize what a terrible task they had. Wire cutting had been satisfactory but the hostile m.g. had mostly escaped the artillery preparation. The utmost gallantry was displayed by British and Greeks. They made wonderful progress, capturing several objectives, but their losses were appalling, some units losing 70%

of their strength. There were not enough left to reach the final ridge. The Bulgars counter-attacked vigorously and the remnants of the attackers had to retire to their starting line.

The attack of the XII Corps had failed and could not be renewed on the 18th. The XVI Corps troops allotted to the attack had to advance into the open plain by night and obtain such concealment for their artillery as was possible. The enemy outposts had to be captured by night before the field artillery could take up their positions for wire-cutting. Artillery bombardment opened between 6.48 a.m. and 8 a.m. The first Greek attack began between 7.30 and 8 a.m. before the artillery preparation was complete; the attack failed. Another attempt was made between 2.30 and 3 p.m. after a fresh bombardment. With the wire not properly cut it is doubtful whether the attack could have succeeded, but a misfortune made it quite impossible, the long grass containing the 9th Greek Regt. caught fire which spread swiftly and drove the regiment back. The 29th Greek Regt. nevertheless penetrated the enemy's trenches and made some progress up the hill but was caught in a cross-fire and driven out.

All the Anglo-Greek attacks on the 18th September had therefore failed. Insufficient power of artillery, lack of numbers in the infantry and the terrific strength, natural and artificial, of the position which is so fully described by the historian are the causes which made the task really a hopeless one.

General Franchet D'Esperèy sent a message to General Milne that every effort must be made to profit by the break through on the Serbian front, and he placed the 14th Greek Division at General Milne's disposal. It was still the duty of General Milne to prevent the Bulgarian Army group reserves leaving his front to restore the situation opposite the Serbians, and this he accomplished for another day.

Anglo-Greek attacks on 19th September.

General Milne re-grouped his forces for another attack on the XII Corps front west of Lake Doiran to take place at dawn on 19th September, but did not contemplate another attack by XVI Corps. The two regiments of the Seres Division were still strong enough to repeat on the 19th their performance of the 18th, but the 3rd Greek Regt. and the 22nd Division were only remnants and were assigned to holding the line. For the attack on the left, the 65th Brigade of 22nd Division was called up from an isolation camp to which it had been relegated on account of an outbreak of influenza, the 26th Division handed over the 77th Brigade to G.O.C. 22nd Division, and the 2nd bis regiment of Zouaves was also placed at his disposal. General Duncan, commanding 22nd Division, had the same ultimate objectives to secure but he altered his instructions for the method of attack.

On the 19th September the Seres Division (two regiments) on the right again penetrated into the main position, even farther than on the day before, but were again driven back. The Franco-British attack on the left was completely dislocated, by the Zouaves receiving some artillery fire on their way to their starting line which so disorganized them that they never took any part in the attack at all. The Divisional Commander, when he received the news of this mishap, made desperate efforts to reorganize the preparations for the attack. Captain Falls gives the full story of messages delayed or not delivered, or issued under misapprehension of the actual circumstances, and the dilemmas of commanders who knew the actual circumstances but received orders based on misapprehension. The nett result was that the British brigades on right and left of the attack went forward, but the Zouaves who were to link up their efforts never started. When the Greeks were driven back on the right, then the further the right-hand British brigade advanced the more isolated it became, till eventually the remnants had to retire to escape being encircled. The British brigade on the left also made gallant progress, but such a hostile position was not to be captured by the isolated attack of a weak brigade.

Again, therefore, the Anglo-Greek attacks had failed on the 19th September, but they had achieved their purpose, since it was not until late on the 19th that the

66th Bulgarian Regt. in army group reserve started to march from opposite the British front to try and retrieve the situation opposite the Serbians. It was too late. The 3rd Bulgarian Division had broken on the 19th. The 66th Regt. could only take up a position in rear on which to delay, but not to stop, the enemy.

Casualties in the battle of Doiran were for the XII Corps: British, 3,489, Greek, 2,751. Bearing in mind the weak strength of units before going into action these casualties are very severe. In the XVI Corps losses were: British 86, Greek 777. Enemy casualties were about 3,000.

Captain Falls records some criticisms which have been made that raise interesting points for discussion about the battle of Doiran.

Plans of the Enemy's Higher Command.—On the afternoon of the 19th September, the Commander of the 1st Bulgarian Army being well pleased with the repulse of the Anglo-Greek attacks considered the moment favourable for a counter-offensive on a large scale. He proposed to the Bulgar C.-in-C., General Todoroff, who agreed with his view, that the 1st and 2nd Bulgarian Armies should make a grand offensive by concentric advances on Salonika. It is just possible that, with the Allies now as weak as they were east of the Vardar, this bold measure might have succeeded. It is certain that no other plan could now save the Bulgar Army. General Todoroff proceeded to confer with General Von Scholtz, with whom apparently he shared the command; at any rate, there was no complete unity of command. Fortunately for us, General Von Scholtz was too closely concerned with the position of the 11th Army to be able to take a broad view of the whole situation. He dissuaded General Todoroff from his daring proposal, and it was agreed to try and close up the "pocket" in the 11th Army and then to press in the sides. But Von Scholtz had not the means to do this. On the contrary, the Allies were daily enlarging the pocket northward, westward and eastward.

Exploitation and Pursuit.—On the 20th the French and Serbians were across the Crna, and the Serbian 2nd Army was still gaining ground northwards. General Von Scholtz, at 4 p.m. on the 20th, issued orders for a further withdrawal, which necessitated the first army giving up their magnificent position across the Vardar to Lake Doiran that had defied the Anglo-Greek attacks. They had to swing back their army north-eastwards behind the Vardar up to Gradsko. On the 21st the Serbian 2nd Army reached the valley of the Vardar between Demir Kapya and the confluence of Crna and Vardar, the first strategic objective. General Anselme was wheeling on his right to conform. General Milne was re-grouping his forces to keep in touch with the retreating Bulgarians by advancing on the 22nd. General Franchet D'Esperèy now began to direct the Serbians and the *Armée Francaise d'orient* on their left towards the strategic area Veles–Uskub (Skolpje) in the Vardar Valley, which was to be crossed along the whole length up to Uskub. That place was a nodal point in communications, where the Vardar railway turned north to Nish and the railway from Mitrovica came in and the road to Kustendil in Bulgaria started, just as Gradsko was the starting point from the Vardar Valley for the road to Bulgaria *via* Stip and the Bregnelnica valley. There was now a race for Uskub between the Serbians and the LXII Corps of the 11th Army who would be cut off if they lost the race. General Von Scholtz reluctantly and too late had given the order at 4 p.m. on 22nd for the withdrawal of the LXII Corps on his extreme right from the position which it had occupied from the beginning. The LXI Corps was to retire to Veles. In this race for Uskub a French cavalry brigade under General Jouinot-Gambetta played a very important part. Coming up on the left of the 1st Serbian Army, which was fighting for the Vardar Valley with French troops from the *A.F.O.* following in support, General Gambetta, leaving all vehicles, struck north from Prilep with his cavalry on a direct line over the hills without even bridlepaths and dashed for Uskub. That place had a garrison of depot troops. He surprised and captured it at 4 a.m. on the 29th September, while Bulgar forces were between him and the Serbians in the Vardar Valley lower down, and the LXII Corps was about to descend

by the Tetovo road on Uskub. He had wedged his cavalry into the strategic point and proposed to defend it against all-comers. He was reinforced by Tranié's detachment of French coming up the Vardar Valley before he could be overwhelmed by the attack of LXII Corps, but the Armistice saved him on the 1st October from the issue of a fight which might or might not have gone in his favour. It was a remarkable example of the bold and successful use of cavalry in mountain warfare, which had a great effect on events.

Exploitation had by the 22nd become pursuit. The Bulgar Army was pivoting on the summit of the Balasica range above Lake Doiran and swinging back by the Kosturino Pass into the Strumica valley, by Stip and the Bregalnica valley, and by the Kustendil road, to gain a north and south line from which they could retire up the Struma valley into Bulgaria. The 2nd Army was holding on along the Balasica range and across the Rupel Pass to give time for the armies on its right to do this. The LXI and LXII Corps were trying to retire northwards to Nish. Everywhere the enemy was destroying road bridges and very thoroughly demolishing the railway.

The Serbians were like hounds running with a breast-high scent. They hustled the enemy along, the 2nd Serbian Army following up eastwards towards the Bulgarian frontier, the 1st Serbian Army pressing up to Uskub and thence northwards towards Nish. All the Allies were doing their best to keep up with the Serbians. The allied line was pivoting on Lake Doiran and wheeling to the east with the outer wing going north to Nish. The British were on the inside of the wheel. General Milne had brought the Cretan Division and 28th Division from east to west of Lake Doiran and given them the spur up to the Belasica to conquer, the Cretan Division on the right and the 28th Division on the left. The small remnant of the 22nd Division was between them. On the left were the Greek 14th Division and the 26th Division making for the Strumica valley by the Kosturino Pass. In rear, on the left, was the 27th Division which had to cross from the west to the east bank of Vardar. On the 24th September mutiny began to appear in some Bulgar units and particularly among deserters rushing headlong to seize railway trains by which to escape.

The R.A.F. were creating havoc in defiles and passes by bombing columns, particularly transport.

Down came the rain to add to the difficulties of pursuer and pursued, turning roads into glue.

When the British reached the Strumica valley beyond the Kosturino Pass supply arrangements broke down. The causes of this breakdown were twofold. It has already been explained that up till the 10th September the policy of the British Government had been to prepare for evacuation of the British and not for a long advance into the Balkans, and that all demands for everything required for such an operation had been refused. Pack transport had been cut down and the troops operating in the hills were now badly in need of this. But the second cause of the breakdown was that we had never supplied the right type of mechanical transport for the Balkans. Our M.T. was mainly composed of lorries carrying three tons but with a gross weight of seven tons, whereas Italians, French and Bulgars used lorries carrying about 1½ tons with a gross weight of under three tons. Our lorries could not travel on improvised roads. When they reached the enemy's roads, which had supplied the enemy and now carried him away, our heavy lorries broke them up and soon made them impassable. There had been plenty of warning of the unsuitability of our heavy lorries. For three years on the defensive we had with great labour made first-class roads that could carry these heavy lorries within the area we defended, but such roads cannot be improvised in a pursuit.

We had started the offensive with units much below strength. Heavy casualties in action had reduced our forces. Malaria and influenza had removed many more than those lost in battle. Now even the remainder could not all be supplied. There were, therefore, very slender British units connecting the Cretan Division with the 14th

Greek Division and extending on their left. We were really only keeping in touch with the Bulgar who was retiring at his own pace and holding on to his pivot on the Balasica. Some difficult fighting occurred on the spur up the Balasica range and in the Strumica valley at Yenikoi, but this fighting was stopped by the Armistice, which the Bulgars signed on the 30th September, and *hostilities with the Bulgar ceased on 1st October.*

The Armistice with Bulgaria.

The Bulgarians signed the terms dictated to them by General Franchet D'Esperèy, which included the condition that the LXII Corps, cut off at Uskub, should lay down their arms and become prisoners of war, thus raising the total captures to 77,000 prisoners and over 200 guns. Another condition gave the use of Bulgarian railways, roads, telegraphs, etc., to the Allies.

The Reaction of German O.H.L. and the Reconquest of Serbia.

When the first appeals from General Von Scholtz reached O.H.L. they were treated with indifference and a single brigade was promised. It appeared to be only a matter of the Bulgarians falling back and losing a little ground which seemed to be immaterial. It never occurred to O.H.L. that the Bulgarians would suffer a complete defeat and then collapse. When the real significance of events began to dawn on them they arranged to reinforce with three German and five Austrian divisions and one cavalry division directed on Nish, but it was too late. No one on either side reckoned on the wonderful pace at which the Serbians would move over mountain and valley. They did not ask for a supply organization, they only demanded ammunition, and they were even economical in the use of that, since their rapid enveloping movements over mountains manœuvred the enemy out of his positions. They were returning to their own country and they lived on the country and on supplies captured from the enemy. Their forces grew as they advanced. Nothing could stop them.

Von Scholtz was so impressed with the vital strategic importance of Nish that he was tempted to try and concentrate the reinforcements coming to him too far forward. He deployed two divisions south of Nish to cover the detrainment of the others at that place, but the Serbian 1st Army overwhelmed his covering force and drove them headlong back. Two more divisions were caught barely detrained and not fully deployed, and likewise broken up and driven back. The reinforcements of the Central Powers were being defeated in detail. Nish was captured on the 10th October. North of Nish the 1st Serbian Army halted for four days to be reinforced. General Franchet D'Esperèy recalled the 2nd Serbian Army from the eastern Serbian frontier, passed it behind the first and deployed it on their left. At the same time he sent such French troops as he could supply, which was not many, to support the 1st Serbian Army and also into Bulgaria and on to the Danube. This was a complicated criss-cross movement, the necessity for which is explained by Captain Falls.

But the Central Powers now decided to evacuate Serbia and they re-crossed the Danube in good order between 25th October and 1st November. On the latter date the 1st Serbian Army entered Belgrade in triumph.

The effect on O.H.L., and on General Ludendorff in particular, of this collapse in the Balkans can only be described by the German word *kolossal*. On the 4th October F.M. von Hindenburg, in writing to the Imperial Chancellor to tell him the time had come to end the war, and in stating his various reasons for that decision, placed first " as a result of the collapse of the Macedonian front."

The Bulgarians could not have been defeated unless the Central Powers had been fully occupied elsewhere. The great victories and advances in France were the primary cause of the Bulgars being left to their own resources and also the primary cause that *after* defeat they realized the game was up, but it is wrong to suppose that the situation in France caused the Bulgars to give way without fighting. The bald facts of Captain Falls' narrative show that the Bulgars fought doggedly for many days, expecting victory, and had no intention of accepting defeat. They were beaten fair and square in a hard-fought fight. This great victory had a great effect on

Austrian morale. It prepared them for the knock-out blow at the battle of Vittoria in Italy on the 24th October. The Macedonian victory undoubtedly shortened the war.

What Next?

The Bulgars were out of the war on the 1st October, but the war was not yet won. There were still Turks, Austro-Hungarians and Germans to be fought.

General Franchet D'Esperèy's main idea was to cross the Danube from Serbia and from Bulgaria, raise the Rumanians again, who were being held down by Mackensen's army group, and then advance on Budapest. He also had his gaze directed towards Dresden. He chafed at being what he called "a prisoner of his communications," which were demolished in Serbia, a condition which even with the use of Bulgarian communications reduced the strength that he could assemble on the Danube. The next moves, however, could only be settled by consultation between the British and French Governments. After victory, Allies began to cast jealous eyes at the spoils. There were some very delicate negotiations about advancing on Constantinople and opening the Straits, and the nationality of the chief commanders of navy and army in these operations. Captain Falls tells the story with all its pitfalls. Suffice it here to say that the army that advanced on Constantinople, composed of British, French, Greeks, Italians and a few Serbs, was mainly British and commanded by General Milne, while Admiral Calthorpe commanded the Allied fleets. But the Turks had no more fight in them. Their outlying province of Syria had been completely conquered. Allenby was at Aleppo, and now the Bulgar guard of their front door had decamped. They only had four weak divisions in the Straits and practically nothing between Constantinople and the Maritsa. They negotiated an Armistice with Admiral Calthorpe. Hostilities with Turkey ceased at noon on 31st October. At that hour, General Milne's force in its advance on Constantinople was in the following positions: 22nd Division at Dede Agach, with a battalion at Ipsala, Cavalry Brigade just north of Dede Agach. French 122nd Division at Gumuldyina with advanced troops at Demotika on the right bank of the Maritsa. 26th Division at Mustapha Pasha opposite Adrianople. Greek I Corps echeloned between Kavalla and Drama.

In the subsequent advance to the Danube the advanced troops of the 26th Division reached Rustchuk, from which a battalion proceeded to Bukharest to represent the British when the King of Rumania re-entered his capital.

On the 12th November, after the coasts of the Dardanelles and the Bosphorus had been manned by British and French, the Allied fleets steamed through to Constantinople, which was now occupied under the command of Lieut.-General Sir Henry Wilson.

Casualties:—Appendix 21 gives a note of the casualties of the British, including the small contingent of Indian troops throughout the whole campaign. It can be summarized in the total figures:—

Battle casualties:

Killed, 4,096; wounded, missing, prisoner, 19,676.

Non-battle casualties:

Died of disease or injury, 3,744; sick or injured, 477,518.

Casualties from malaria alone:

Admitted to hospital, 162,517; deaths, 787.

Evacuated to U.K., 1917/18, 34,762.

Conclusions.

In his concluding chapter the historian roams quickly over the whole three years of the campaign. He deals with questions which go to the roots of the strategy of the whole war. He does not take enough space to go really fully into these interesting questions, but he may be said to give one some headings under which to consider

them. The reviewer certainly has not the space in which to attempt to follow Captain Falls into this controversial ground, but there is one matter on which he feels that he must join issue with the historian.

Mountain warfare and the Balkans.

Although the small British force of 4 divisions was definitely ordered by its government not to prepare for a major offensive and a long advance into the Balkans, in fact was continually instructed to remain on the defensive and be ready to evacuate the country; although it happened to be allotted to the defence of the most malarial portion of this theatre of war, *i.e.*, the lower portion of the valleys of the Vardar and Struma, north of which most of the Balkan country is very healthy; although it was not maintained by drafts; although deprived of pack transport and given lorries weighing 7 tons gross, which caused it to be hamstrung in the pursuit; yet Captain Falls seems to suggest that we can base upon operations carried on under such tremendous handicaps the conclusion that British troops are not very suitable for warfare in the Balkans or in mountain warfare anywhere.

One seems to remember that the British Army acquired a world-wide reputation for its military operations in the mountains of Portugal and Spain, a reputation which it has maintained in other mountainous countries. It may be granted that foresight is particularly necessary to prepare the right transport and equipment for British troops operating in the Balkans to get the best out of them, but given reasonable consideration in these matters and a little training, then they are as formidable in mountain warfare as in any other type of war. In the Balkans in the last war, the moral effect of those four skeleton divisions of British in holding the Allies together was out of all proportion to their numbers.

The corollary is also true that when one is fighting in the Balkans it is essential to secure Balkan troops as Allies. They are formidable fighting men in that theatre of war, whether they be Serbians, Greeks, Bulgars or Turks; and I would add Rumanians, because that nation must not be judged by their first performance after entering the war. Their own strategy, and the lack of proper support from their Allies, at first gave the Rumanian troops little chance to show how they can fight. Later, they gave full proof of their fighting capacity.

The natural aptitude of these nationalities for fighting in the Balkans is multiplied when their deficiencies are made good by a great power, whether that power be British, French, or German.

Transport these Balkan troops to other theatres of war in Europe, and compare them with, and pit them against, modern European armies, then perhaps their willingness and capacity to fight might decrease considerably, but in the Balkans they can exert a great influence on any war, which cannot be estimated by the routine procedure of counting their munitions and equipment and noting the lack of administrative organizations common to the armies of the Great Powers.

In the last war there were about 1½ million Balkan soldiers or perhaps nearer 2 million, whose governments, with the exception of the Serbian, who were committed, wished to join the winning side if only they could guess which side that was. They were not to be won by diplomacy, but the first great power or group that would stake a well-organized and equipped force of 200,000 of their own men to support these Balkan nations was likely to win them all to its side, and ensure the Balkans being held for their advantage.

Value of studying the Macedonian Campaign.

For our army which may be required to fight through and far beyond the Indian frontier and in many parts of the world, over mountains and along valleys, and then on intervening plains, there is much valuable information to be obtained from Captain Falls' history of the Balkan fighting.

In the valleys and plains, light mechanical vehicles with a good cross-country capacity are required, but in the mountains every advance up a valley must have forces roaming wide on the surrounding hills with pack transport and pack artillery,

and on the lower features, mechanized field and heavy artillery; Engineers working alternatively with mechanical and pack transport.

The army requires to train to use both mechanical and pack transport. It has been recognized that the horse-drawn vehicle is obsolete.

The value of an air force in giving information and in bombing columns in defiles and passes is obvious. Conversely, when traversing defiles the necessity for an escort above in the air and the picketing of hills with anti-aircraft weapons.

If cavalry are prepared to risk their horses' legs and their riders' necks by scrambling over rocky hills without bridle paths, as General Jouinot-Gambetta did, then there are fine opportunities for them.

In the mountains the infantry with pack transport will be the arbiters of the battle, unless and until the fighting crystallizes into elaborately constructed defences without flanks as occurred for three long years in Macedonia, in the last war.

These are some of the deductions from the Macedonian Campaign which suggest themselves for our use in the future.

The Campaign also illustrates the maxim that success in war comes down from the top! H.L.P.

IN THE WAKE OF THE TANK.

By Lieut.-Col. G. Le Q. Martel, D.S.O., M.C., R.E.

(Sifton, Praed & Co., Ltd. 2nd Edition. Price 12s. 6d.)

In the Wake of the Tank, is an account of the first eighteen years of mechanization in the British Army. This is a second edition of the book. It retains, practically unaltered, the original first fifteen chapters which deal with the historical development of tanks and mechanization. The other three chapters are now expanded into five and have been completely rewritten. They are concerned with progress to date and present policy.

Lieut-Colonel Martel is a tank enthusiast. He is also an authority on most matters connected with tanks, on their handling in war as well as on the details of their design. His book is as well informed as one would expect from a writer with such qualifications.

In the first of the new chapters the various classes and types of mechanical vehicle are reviewed and the present position as regards design and capabilities is described. Starting with the super-heavy tank, an experimental design, the writer discusses in turn the medium tank which is at present our main armoured fighting vehicle, the light tank that scouts for it, the armoured car and finally unarmoured vehicles. The armoured car he considers to be of declining importance by reason of the ease with which roads can be blocked against it. A limited number may be required for medium and long-distance reconnaissance where a high road speed is necessary, but for closer work, entailing more fighting, light tanks can be used. It is possible that for medium distance reconnaissance there is a future for the use of some light and cheap car such as the Austin Seven, lightly armoured perhaps. Essential qualifications for work of this nature are lightness so that the crew can get the vehicle over obstacles, inconspicuousness and high speed over roads and tracks. The employment of unarmoured vehicles for tactical purposes will not necessarily be confined to scouting by small machines. The larger ones may be used for convoy and patrol work.

From descriptions of vehicles the writer passes to their employment and to a study of the tactical reasons that led to the demands for the various types. He is concerned in Chapter XVII primarily with the tank brigades as the means of re-creating the mobile arm that since earliest times has formed a part, sometimes the predominant part, of armies but whose functions cannot to-day be fulfilled by cavalry alone. The cavalry can no longer cover long distances sufficiently rapidly to escape detection nor are they able by themselves to attack anything except a very weak opposition. In the tank brigades there is the means for restoring the situation

Once again the commander will be able to divide his army into mobile and combat troops. He will be able to use the former to push ahead for reconnaissances and to control the enemy movements and the latter to hit him when he has been manœuvred into the desired position while the mobile troops attack the flanks and then pursue. Such operations by mobile troops have proved vital in the past and may well do so again. It is idle to suppose however, that there will not be cases in future great wars where the enemy has had time to prepare a defensive position and where such a position rests on secure flanks. This is a very different picture. The attackers have to penetrate the defensive position but a tank attack with this object could scarcely fail to be prohibitively expensive in tank casualties. How then can mechanical vehicles assist the combat troops in the main assault? Three possible solutions are discussed—super-heavy tanks capable of withstanding the fire of anti-tank weapons, infantry tanks which are heavily armoured but only sufficiently to withstand the lighter types of anti-tank weapons and lastly, a former proposal of the author's, small tanks used in fairly large numbers. Each has its own advantages and its disadvantages. The argument for the heavy tanks rests to a great extent upon their good obstacle-crossing capacity. But no obstacle-crossing capacity that we can at present give a tank will enable it to cross a line of anti-tank mines. This being so, the only advantage of the heavy tanks over the small tanks will lie in the immunity given by the former's armour, and it is open to question whether the small tanks cannot achieve the same degree of protection by numbers and the consequent dispersion of the enemy anti-tank fire. Lieut.-Col. Martel suggests that perhaps the solution lies in a combination of the methods, in having some fairly heavy tanks to support the main attack and at the same time providing smaller machines which would belong to the infantry battalions.

There is a chapter on the use of unarmoured vehicles with some interesting figures to show that the fear of a long road space which is sometimes used as an argument against the mechanical enthusiasts is largely illusory. The estimate from the traffic at Piccadilly Circus, that thirteen completely mechanized divisions moving north and south could be crossed during the same twenty-four hours by a similar number moving east and west, certainly tends to dispel the bogey. It would, of course, be quite impossible for this number of normal divisions to cross each other in this way. Clearly we need have no fear of congestion so long as we completely eliminate the man marching on his feet. But this may be looking rather far ahead. It is a prospect that is not yet in sight.

The whole trend of modern military progress is towards the development of fire-power and mobility, to the creation of small but hard-hitting and rapidly moving forces. Mechanization provides the means to the end. But *In the Wake of the Tank* is far from being a mere propagandist treatise on mechanization. The factors that prevent a more rapid mechanization than we are actually carrying out, as well as the effects of anti-tank weapons and obstacles, are stated very clearly. The reader will realize that the tank attack will have many difficulties to overcome. He will see too that for much of its effective action the tank is dependent upon the man who can fight on foot. Who else can assault across a river and so make possible the passage of that obstacle by tanks? Who, when raiding tanks have reached their objective, can carry out the demolition that was the purpose of the venture? Only men who can leave the vehicles.

For engineers, many new problems are being created by the tank. Much of the work of getting our mechanized forces over obstacles and of making obstacles to oppose the enemy tanks, as well as of providing the destructive element for our tank raiding forces, will fall to the sappers. The tasks will call for work at speed and often probably with a minimum of personnel. A very high standard of training and intimate knowledge of tank requirements will be essential therefore. Engineer co-operation with mechanized forces is in many ways a new subject and one that requires careful study. Lieut.-Col. Martel's book forms an excellent starting point.

H.P.W.H.

proper, but also with distribution, instruments, testing, fault finding, illumination, batteries and bells, dynamos and motors.

To the student, the large number of numerical examples with worked solutions, which are a feature of the book, will prove very valuable. The diagrams are clear and designed to bring into prominence the points which are of chief importance.

Both the student and the engineer will be grateful for the various references to the Regulations of the Institution of Electrical Engineers for the Electrical Equipment of Buildings. These references and the comments made upon them refer to the latest edition of the Regulations. As this edition has only so recently been published, it is no mean achievement on the part of the author to have brought his book so rapidly into line with them. The book is well worth the 6s. at which it is published.

G.T.H.C.

FIVE-PLACE TABLE OF NATURAL TRIGONOMETRIC FUNCTIONS TO HUNDREDTHS OF A DEGREE.

Compiled by AMELIA DE LELLA.

(Chapman & Hall. London. 1934.)

This table has been compiled, as the preface states, "in response to a frequently "expressed desire on the part of engineers for a five-place table of natural trigono- "metric functions of angles expressed in degrees and hundredths of a degree." It has apparently been produced under the auspices of the General Electric Company of New York.

It is difficult and would indeed be unfair to criticize a production which appears to fill "a frequently expressed desire" in New York, but which does not seem to have any defined sphere of usefulness in this country.

In England we are so accustomed to the division of the degree into minutes and seconds that its decimalization into hundredths can have little interest.

In the main the table has been compiled from the monumental undertaking of Henry Briggs, Professor of Geometry at Oxford some three hundred years ago, who calculated natural sines to fifteen places and natural tangents to ten places.

Three copyist errors were discovered by the compiler, a fact that shows that the publication under review is no mere rounding-off of Briggs' figures, but implies a careful scrutiny of the original. The table is clearly and sensibly arranged and the figuring well printed and spaced.

Side tables of interpolation are not included. J.C.T.W.

MAGAZINES.

REVUE MILITAIRE SUISSE.

(*April*, 1935.)—1. *Histoire militaire de la Grèce* (1890–1933).

General Negroponte, the writer of this article, held important commands in the Greek Army from 1914 to 1918.

In 1897 Greece became involved in war with Turkey. She had no allies, no strategic plan, she was unprepared and had no competent commanders. The war was over in a few weeks. There was only one battle worthy of the name, that of Domokos, where the Greeks missed their chance of a victory. On the other hand, the Turks were unaccountably slow, especially after the capture of Pharsala. The Greeks did not pay heavily for their defeat, but their military prestige abroad fell and their morale was lowered.

In 1912 the three Balkan States formed a league against Turkey, in spite of the efforts of the Great Powers to prevent the war. After a campaign lasting 40 days, Turkey was defeated. If it had not been for bad staff work in the Greek Army, the Turkish Army might have been destroyed during its retirement on Salonica.

During the summer of 1913 Bulgaria, without a declaration of war, attacked her former allies, the Serbs and the Greeks. The campaign lasted a month, and ended in the complete defeat of the Bulgar Army. King Constantine led the Greek Army with skill, but in this campaign, too, the Greeks made serious blunders.

The attitude of Greece during the Great War is well known. At the beginning of the war, nearly all Greeks favoured the Entente. When the question arose of taking part in the Dardanelles enterprise, two separate parties were formed. King Constantine and the Gounaris cabinet favoured a continuation of neutrality; the Venizelist party was for immediate support of the Entente. Venizelos was still in power when arrangements were made for landing British and French troops at Salonica in October, 1915, but he fell soon afterwards.

Both in Great Britain and France the Balkan front was regarded as of secondary importance, and insufficient troops were sent to Salonica to make the expedition a success. General Sarrail, the commander-in-chief of the allied forces, was sent there because he was not wanted in France. The writer considers that Sarrail was to blame for having caused a prolongation of the war. Instead of attempting to unite the whole Greek nation, he played off one party against the other. It was not until General Franchet d'Espérey took over the supreme command that real progress was made.

In 1916–17 a provisional government was set up at Salonica, which declared war on the Central Powers, and Greece had two governments, the royal government at Athens remaining neutral. After the final defeat of Bulgaria in 1918, the World War came to an end almost everywhere, but Greece became involved in another war with Turkey in Asia Minor. This war has been classed as an act of folly, but the disasters that befell the Greek Army were due, not only to the half-hearted way in which the war was carried on, but to lack of support on the part of the Entente.

2. *Exercices et manœuvres.* By Colonel Léderrey.

A *précis* of the main points on which manœuvres should be based.

3. *Portraits de grands chefs. Foch, Joffre.* By Lieut. Magnat.

A brief study of the characters of Marshals Foch and Joffre, in which the writer dwells upon the relationship of their handwriting with their character.

(*May*, 1935.)—1. *L'avenir de l'aéro-chimie, d'après le général Douhet.* By Lieut.-Colonel Mayer.

This is a criticism of a book entitled *La doctrine de guerre du général Douhet*, by Colonel Vauthier, in which the latter explains the well-known views of the late Italian general on the war of the future.

General Douhet's doctrine is that a future war will be decided entirely in the air, and that armies and navies will only play secondary parts. The truth or fallacy of this doctrine cannot be proved from the events of the World War. Conditions have changed greatly since then. General Douhet explains that his doctrine holds good for the present day only. Circumstances may change, and an effectual means of protection against aero-chemical warfare may be discovered.

War is brutal, and it is of no use attempting to limit it to civilized methods. No convention made in peace-time for such a purpose will be respected when a country is fighting for its existence. If, from motives of humanity, the initiative of using poison gas or other abominations is left to the enemy, a nation must be ready to use effective reprisals.

The object of aero-chemical warfare will be to terrorize the population, civil as well as military, by attacking the interior of the country, as well as the front. To show how nations are becoming alive to this fact, Colonel Vauthier quotes from the White Paper signed by Mr. Ramsay Macdonald on the 1st March, 1935, and points out that

the increase in expenditure on the British air force is only the first stage on the road to its rapid extension.

The first object in aerial warfare will be to obtain the command of the air. Opinions differ as to the methods by which this should be done. The weaker force will not seek an encounter battle, but will avoid it, and it cannot be compelled to fight. It will prefer to concentrate its attention on ground targets, such as aerial bases and important munition works.

General Douhet's main principle was to attack with all available strength; there was to be no economy of aerial force, especially at the beginning of hostilities. Signor Mussolini has modified these views to some extent; he admits the possibility of an aerial duel, and intends to provide a powerful aerial artillery. Were Douhet still alive—he died in 1930—he would probably have protested against this idea, as being analogous to General Moltke's interference with, and spoiling of, the Schlieffen plan. Only the future can show how far Douhet's bold conception has proved to be right.

2. *Le combat de localités.*

In this first article Captain Piguet describes, with sketches, three village combats, to be followed, in the next number, by the conclusions drawn from the fighting.

At Bazeilles, on the 1st September, 1870, the Marine Division (12th Corps) of MacMahon's army made a gallant defence against a corps and a half of Germans. Owing to the fog that prevailed, the German artillery was unable to support the attack. It was not until the 12th Saxon Corps outflanked the French that the issue of the fight was decided.

On the 21st August, 1914, portions of the 2nd German Army attacked the French position at Arsimont on the Sambre. They did not attempt a frontal attack, but made a successful flank attack from the west. Counter-attacks were made, respectively, by one battalion of the 70th Regiment, the whole of the 71st Regiment, and the whole of the 19th Division. Eventually the French retired.

The third battle described is the attack on Dixmude in October, 1914. A brigade of Belgian marines, retiring from Antwerp, had been ordered to retire on Dixmude and hold the latter for four days against the advancing 4th German Army. They actually held out for 26 days, until, finally overwhelmed by superior numbers, they were compelled to fall back to a prepared position west of the Yser. The Germans had no alternative to a frontal attack, and their losses were heavy.

3. *Transformations apportées au matériel mitrailleur et procédés de tir.*

Captain Daniel describes the latest improvements in the Swiss machine-gun. The gun has been furnished with a device for concealing the flash, the leaf of the sight has been modified to facilitate fire on aeroplanes, canvas cartridge-belts have been replaced by metal ones, etc. The main improvements are in the gun-carriage, and the writer explains how they affect the use of the gun in the field.

(*June*, 1935.)—1. *Evocations! Les souvenirs de commandement du Général de Langle de Cary.* By General Clément-Grandcourt.

General de Langle saw service as a subaltern in the war of 1870–71 on General Ducrot's staff in Paris. He was severely wounded in the battle of Buzenval. His subsequent military service was spent in active commands; in 1914 he had reached the top of the tree, and was member of the supreme war council.

Having reached the age limit of 65 on the 4th July, 1914, he was placed on the retired list, but was recalled on the 25th July and was given command of the 4th Army. This army, intended at first to be a reserve army, numbered 260,000 men, and held a frontage of 80 km. in the battle of the frontiers.

General de Langle showed his skill in leadership in the retirement and in the battle of the Marne. He directed the offensive in Champagne in the winter of 1915. In spite of the want of success of subsequent offensives he was given command of the group of armies round Verdun, and he commanded at Verdun during the most critical days of 1916. Here he was blamed for withdrawing from the Woëvre salient (an

action of which Marshal Franchet d'Espérey approved later on) and, along with many others, was relieved of his command. He died in 1928.

General Clément-Grandcourt recommends the account of General de Langle's life as well worth study.

2. *L'organisation des batteries et des états-majors de l'artillerie de campagne.*

In this article Lieut.-Colonel de Montmollin traces the changes that have taken place in the employment of field artillery since 1914, and compares its organization in the Swiss Army with that in the French, German and Italian armies.—(*To be continued.*)

3. *Le combat de localités.*

In his previous article Captain Piguet described the attack and defence of three localities: Bazeilles, Arsimont and Dixmude. Here he draws some general conclusions, only a few of which can be mentioned for lack of space.

Villages offer good concealment from aeroplanes. The line of defence should either be well outside or well inside a village; the outer edge invariably draws the enemy's fire. Powerful flanking fire should be provided outside; and there should be a local and a general reserve.

A village draws on an attacker like a magnet. A frontal attack should never be made. If a village is strongly held, a frontal attack will involve heavy losses; if weakly held, the village will be captured more easily by an enveloping movement. Tanks are useful for opening the way for the infantry. There is no object in using gas if it is intended to occupy the village soon afterwards.

Of all phases of modern warfare, village fighting is, perhaps, the most difficult to practice in peace-time, but it is a form of fighting that would probably have to be resorted to if Switzerland were ever invaded.

4. *Le fusil-mitrailleur sur affût.*

Captain Daniel describes, with the aid of five photographs, two tripod mountings for a light machine-gun. The ordinary tripod weighs, alone, 11 kg., and with the gun, 19 kg. It can be carried on a man's back. For this purpose it is fixed to a *cacolet*, which brings the total weight up to 23 kg. The tripod can be adjusted for use against aircraft, and, in this position, the gun has an all-round fire up to any angle of elevation.

It is proposed to introduce a similar tripod mounting for the ordinary machine-gun. A.S.H.

RIVISTA DI ARTIGLIERIA E GENIO.

(*March*, 1935.)—1. *Il problema delle munizioni nella guerra mondiale e le sue difficoltà in una guerra futura.* By General Bollati.

The problem of munitions affected the progress of the World War throughout the greater part of its course. With the commencement of position warfare on the Western Front it became a serious matter. Russia began the war well equipped with munitions, but was extravagant in their use, and her arrangements for keeping up a supply were inadequate. In the struggle between Austria and Serbia, both sides suffered from shortage of munitions, and only the timely arrival of a train-load of French ammunition *via* Salonica saved Serbia from collapsing a year sooner than she actually did.

The writer takes us through each year of the war on the various fronts: Gallipoli in 1915, and Mesopotamia in 1916 failed largely through lack of munitions. The expenditure of ammunition on the Austro-Italian front is examined in considerable detail.

With regard to the future, if another war were to break out, the numbers engaged at the start are not likely to be less than those employed in August, 1914. But calculations made in peace-time should be based on the state of affairs that prevailed in November, 1918, rather than on that of August, 1914. Italy *is*, however, far

better prepared than she was in 1915. Her resources have been developed, her roads and railways have been improved, she is well provided with mechanical transport, and her air force is very efficient.

2. *Le inondazioni nel campo tattico.* By Captain Giampietro.

Inundations have often been made use of in warfare, as obstacles to the advance of an enemy. A few instances occurred during the World War. After the Caporetto disaster, Venice was isolated by cutting the dykes. The Belgians successfully held up the German advance by flooding the district round the Yser. At Tannenberg, Hindenburg was able to take advantage of swamps, without having to resort to constructional work.

In dealing with artificial inundations, the usual case will be that of a water course running parallel to and in front of the line to be defended. A dam built across the stream will cause the water to pond up until a lake is formed, which will delay the enemy's advance, if not hold it up altogether. The French regulations class inundations as deep if they exceed 1·80 m. (6 ft.) in depth, and as shallow, if they are not more than 0·50 m. deep.

The site of a dam requires careful selection. If a bridge is handy, its piers will afford support to the fascines or brushwood mattresses used in the construction of the dam. One or more overflow channels must, of course, be provided.

The writer has worked out a typical example of an artificial inundation, with sketches and calculations.

3. *Il calcolo pratico della penetrazione dei proietti e degli effetti di scoppio.* By Captains Cavicchioli and Ravelli.

Tables and calculations showing the penetration of projectiles into different kinds of materials.

4. *Considerazioni sul ripristino dei ponti metallici per ferrovia.* By Captain Paoli.

In northern Italy alone the length of railway bridges that exceed 10 m. in span total up to a length of 50 km. In view of the strategic importance of these bridges, it is important that the engineers should be able, rapidly, to repair any damage done to them. A new method of repairing steelwork that is being extensively used nowadays is electric arc welding, which dispenses with the heavy riveting used in the past.

When iron bridges were first built in Italy there were no official regulations regarding the calculations for their strength, and they were built far stronger than was necessary for the loads they had to carry, so much so that they have continued in use under much heavier modern traffic.

Steel came into use for bridge girders in 1891, and the regulations allowed far heavier working stresses than had been permitted before. Many of these newer bridges are structurally weak.

The use of steel in bridge-building allows of a very economical form of construction, that of a girder continuous over two or more spans. The continuous girder has many advantages. Should a pier be damaged or washed away in a flood, the girder will remain intact, and the bridge can be repaired by building a temporary support.

In time of war, however, it is far more likely that damage will be caused (by aeroplane bombs) to the girders than to the piers. Damage to a continuous girder will cause a change in the stresses throughout its whole length, and its repair becomes a very awkward business. The writer is emphatic in denouncing the use of such girders anywhere near the frontier, where there is a large number of bridges of considerable span.

5. *I carburanti. La benzina e la sua conservazione.*

Captain Tatti explains how petrol deteriorates by keeping, and how this deterioration can be reduced. Some of the methods recommended are the following :—

Drums for storing petrol should not contain copper or rust. They should be filled

so as to provide a minimum surface of petrol in contact with the air, and as little air as possible inside the drum. The stopper should be air-tight, and the drums should be stored in a cool, ventilated spot.

6. *L'artiglieria di Adua.*

Lieut.-Colonel Ravenni gives an account of the gallant conduct of the Italian artillery in the disastrous battle of Adua against the Abyssinians of the 1st March, 1896.

General Baratieri, believing that the Shoan army was about to disperse, made his dispositions for an attack. He did not consider it likely that the enemy would be in occupation of the hills north-east of Adua: the artillery consequently marched near the head of each column during the fatal night march.

The Albertone brigade of native troops, which was leading, was attacked at day-break by overwhelming numbers, and the gunners (two Italian, one native battery) were practically annihilated after firing away all their ammunition.

The Arimondi column, ordered up to support the Albertone brigade, was attacked furiously in front and in flank. Its one battery, a mountain battery, came into action early, but all its mules were killed and, after a gallant effort to carry away the guns by hand, the guns had to be abandoned. Two quick-firing batteries, sent up in support by the reserve brigade, were almost wiped out.

The three batteries of the Dabormida brigade were engaged all day and, finally, helped to cover the retirement of the column. Having fired away their whole supply of 1,600 rounds, the survivors withdrew.

The writer concludes with a few general comments on the battle and has a high word of praise for the infantry escorts, who were sacrificed along with the gunners. The article is of special interest in view of the present strained situation in Abyssinia.

(*April–May*, 1935.)—1. *L'artiglieria in guerra di movimento.*

General de Pignier, Inspector of Artillery, describes at some length the employment of artillery in mobile warfare, with special reference to the rules approved by the new official regulations for the employment of higher units. The greater part of the article is devoted to artillery in attack, as it is in the attack that its employment differs most from that in stabilized warfare.

2. *I bombardieri nella guerra del* 1915–18.

General Maltese describes the introduction of trench mortars when the belligerents settled down to stabilized warfare on the Western Front. It was not long before these weapons were employed on the Italian front.

One of the first experimental Italian models was the "Maggiora" mortar, which was fired by the explosion of a mixture of air and acetylene gas—a unique type of its kind. In 1915 the French brought out the Dumézil-Batignolle model, and supplied a few to the Italian Army. Some of the subsequent Italian models were based on this pattern.

In November, 1915, a trench-mortar school was started at Susegana on the Piave. The writer describes the training at this school and the different types of mortar used; we are told how the different groups were sent out to join the units at the front after completing their course of training. The Trentino offensive in July, 1916, necessitated a speeding up of the course. Hitherto gunners only had been trained, but now it was found necessary to take men from the infantry and cavalry.

In 1917 the training was intensified, and the demand increased for the larger types of trench-mortars, especially for the long 240-mm. pattern. A 400-mm. mortar was experimented with. The general retirement from the Julian front at the end of October, 1917, necessitated the immediate transfer of the school to the south of the Po, where training was again in full swing after an interval of a month.

In 1918 the trench-mortar corps was completely reorganized and did some very valuable work in the front line alongside the infantry, contributing largely to the final victory.

RIVERAIN SURVEY IN THE PUNJAB.

1901–1929.

By the Survey of India.

This short volume describes a classic instance of the confusion of thought that is, even to-day, sometimes in evidence, where the necessity, or otherwise, for survey is in question. The stages common to such instances are as follows:—

(i) The period when time or money is short, and everything is done to exclude a proper survey and to make use of makeshift methods.

(ii) The period when the makeshift methods have broken down, with subsequent confusion, and grudging recognition of the necessity for a survey, which is hampered and rather haphazard.

(iii) The period when the full value of a survey is realized, full support is given to it, and the problem tackled thoroughly.

The history of the Riverain Surveys in the Punjab goes through each of these phases and is admirably described in an introductory note by Brigadier Sir Edward Tandy, who, as Captain Tandy, R.E., was in charge of the Survey proper from its commencement in 1901 to 1909.

This Introduction and Chapter I deal with period (i) above, when maps were prepared by the Local Settlement Officers who, ignoring the first principle of survey, carried out their tasks by working up from the part to the whole. In addition their work was limited to an accuracy of about 1/150. With this accuracy, errors continuously cumulative and indeterminate, and the ground marks obliterated each flood season, it is not to be wondered at that the method finally crashed. It was all the more serious when errors of half a mile or more in their rough maps led to bloodshed to decide the ownership of ground, because there appeared to be no more equitable way of correcting the errors.

Chapters II and III deal with the work when transferred to the Survey of India, 1901–1929. Of this period, 1901–1904 may be said to represent period (ii) above, when, to quote from the book itself, "the Survey Section worked with no definite "programme, and with little idea of the magnitude and difficulty of the task," or again, "Work . . . was scattered all over the Punjab in a fragmentary and most unsatisfactory way."

From 1904–1929 the work entered into period (iii) above, with the benefit of full organization and efficient methods.

It must be realized, of course, that the events described took place, in some cases, over 35 years ago. To-day the value of survey is more fully realized. Its value, however, cannot, of necessity, be spectacular, so that there is still a tendency to begrudge time and money for this work.

The volume under review is primarily a record of the work carried out. If more details of the difficulties encountered on the work could have been included it would, perhaps, have had a more general interest.

W.H.S.

ELECTRIC WIRING.

By W. J. Ibbetson, B.Sc., A.M.I.E.E., M.I.Mar.E.

(E. & F. N. Spon, Ltd., 4th Edition. Price 6s.)

This is a new edition of a most useful handbook for wiremen, engineers and students. It is intended to cover all the important sections of the syllabus for the "B" Course in electrical installation work of the City and Guilds of London Institute and also to give considerable help to those who are taking the "C" Course.

The printing is good and the book contains, in the space of some 250 pages, a remarkable amount of information. There are in all sixteen chapters. The first four of them are devoted to general theory. The remainder deal not only with wiring

3. *Il contributo dell'arma del genio alle operazioni di forzamento di una grande linea fluviale.*

Major Cappuccini has worked out a scheme, in detail, in which he endeavours to show the part played by engineers in a river passage. The scheme is illustrated by means of two maps.

The general idea is that a blue force has met with a reverse and is falling back on Florence from the east, closely followed by a red force. In retiring, the blue force has destroyed all the bridges over the Arno. The 50th Division (red force) has received orders to force a passage across the Arno and make a turning movement on Florence from the south.

The site and nature of bridges to be constructed by the engineers, and the telephone and wireless connections to be established, are described in detail.

4. *Le nostre attuali cognizioni sul logoramento delle artiglierie.* By Lieut. Verduzio.

The wear and tear of big guns shows itself by certain definite symptoms, viz., the deformation of the bore, the pitting of the surface and wearing away of the rifling, and alterations in the structure of the metal. The consequences are: a loss of initial velocity and of range, inaccuracy of shooting and the danger of premature bursts.

The writer discusses the various theories of the causes of damage, *e.g.*, escape of gases, the "fluid vein," the action of high temperature and the chemical action of gases, and suggests that by working on these lines methods might be discovered of prolonging the life of guns.

5. *La rigenerazione dell'aria nei ricoveri antigas.*

Captain Giardino explains the theory of regenerating the air in gas-proof shelters by the use of oxygen cylinders, or capsules of sodic hydrate or peroxides. He works out six practical examples, showing the results he arrives at.

6. *Osservazioni sulla passerella n.* 1. By C. Corradi, engineer.

The writer has made a few notes on a standard floating bridge, whose construction he proposes to simplify by omitting the longitudinal cables. It is difficult to get an even tension on these, they may cause an excessive load on some of the boats, and they add to the time occupied in construction.

7. *Possibilità di tiro nell'impiego delle batterie controaerei autocampali.*

Captain Boffa has written a short article on the fire of anti-aircraft guns mounted on lorries.

A.S.H.

REVUE DU GÉNIE MILITAIRE.

(*March–April*, 1935.)—1. *Note sur les abatis.* By General Abadie.

Abatis are of two kinds, those consisting of large trees, which create a formidable obstacle, and those of smaller trees that form "accessory defences." In this article the writer deals with the latter class only.

The smaller type of *abatis* can be used instead of, or in conjunction with, a barbed wire entanglement. In thickly-wooded country the trees would be felled on the spot; in less densely-wooded, or in open country, the material might have to be carried some distance.

In north Syria, in 1920 and 1921, bands of Turks, sometimes supported by artillery, used frequently to attack isolated French posts. The posts that had the good fortune to possess even a thin line of thorn zariba held out successfully, while many of the others succumbed.

In European warfare, if the country is thickly wooded, it is advisable to leave the larger trees standing, and to fill the space between them with smaller trees and undergrowth. The actual position of the obstacle—whether on the edge of the wood, or farther back—will depend upon the facilities for flanking fire.

In more open country it is impossible to conceal an *abatis* from view from aircraft,

and surprise is out of the question. The construction of *abatis*, in such circumstances, will take a considerable time.

In the second part of the article General Abadie discusses the use of *abatis* in the defence of the wooded country on the eastern frontier of France. He has taken a concrete example from a map, showing a bit of the country south of the Oise, which for the sake of argument, he assumes to represent the frontier. The scheme is worked out in detail, showing the necessary working parties, and the time required for the works proposed.

2. *Étude sur les transmissions dans la division de cavalerie.*

Captain Marty has written a long article, carefully worked out, illustrating the problems that will confront the engineer captain in command of a signal unit employed with a cavalry division. The latter consists of one motorized and two mounted brigades. The technical troops available are :—one telegraph company (with 60 km. of field cable and 120 km. of light cable), one radio detachment (with 15 posts), one carrier-pigeon detachment, and a group of mounted signallers. The writer has worked out a series of schemes, with numerous sketch plans.

He arrives at the following conclusions :—Radio telegraphy is the basis of signalling in a modern cavalry division. Posts should have a long range, they should be easy to regulate and adaptable to changes of wave-length, they should be capable of following cavalry at all speeds.

The signals commander has a difficult task: he must be quick in thought and action: he must be aware of his divisional commander's intentions, and he may, with his technical knowledge, be required to influence tactical decisions. There must be thorough collaboration between the signals commander and the divisional staff.

3. *Où en est la radiesthésie.*

Here we have another article on water-divining. Lieut.-Colonel Correnson deals with the theory of the subject. Much of the knowledge that we possess nowadays is due to the studies of the Vicomte Henry de France, who has written *Le sourcier moderne* and *Les souvenirs d'un sourcier.*

The effects produced in water-divining are believed to be due to the emission of electro-magnetic waves. Dowsers use the following instruments :—(1) a compass, (2) a rod, (3) a pendulum, (4) a point. (2) and (3) are the most important.

The rod is a V-shaped implement of a material transparent to electro-magnetic waves, such as dry wood, but not necessarily hazel. It is held in both hands, palms uppermost, and the point rises or falls, according to circumstances, as it enters a field of force. M. de France prefers a rod consisting of two flat strips of whalebone, 20 to 25 cm. long and ½-cm. wide, fastened together at one end. The strips and the fastening should be black in colour.

The pendulum consists of a spherical or cylindrical mass of wood, glass, ivory or stone, suspended at the end of a thread 30 cm. long, which can be wound round a small rod about 10 cm. long and ½-cm. in diameter. Weight, cord, and rod must all be black. The pendulum has the advantage of being easy to work at the first attempt by a novice, the divining rod requires a certain amount of practice and skill.

The operator holds the rod to which the pendulum is attached between the thumb and forefinger of the right hand. The weight of the pendulum and the length of the cord must be regulated to suit the particular material (*e.g.*, water, oil, iron, etc.) that is being searched for. When it comes over such a material, the weight will rotate in a clockwise or counter-clockwise direction according to the polarity of the operator. (This will be opposite in right- and left-handed persons.)

The greater part of the article is devoted to electro-magnetic waves, to which both rod and pendulum re-act, and to the regulation of the pendulum. It is important that the length of both rod and pendulum should be exactly correct if satisfactory results are to be obtained.

A.S.H.

REVUE MILITAIRE FRANÇAISE.

(*April*, 1935.)—This number has a somewhat limited interest. The first article is *Une opération moderne en Afrique du Nord* (*Février–Mars*, 1934), by Colonel Arlabosse. This deals with a subject which has figured frequently of late in this *Revue*, but, unlike the previous contributions, the account of the operations in February and March last year is more precise, and is written as a military study pure and simple.

The French are obtaining a great deal of valuable experience in the rapid manœuvring of highly mobile forces in these Moroccan operations; and Colonel Arlabosse sketches the short campaign in the Anti-Atlas in exactly the manner which the military reader would like. He describes the general situation in southern Morocco as it was in January, 1934, and the particular portion of the country in which operations were to be carried out, namely, the Anti-Atlas region, outlined by the names Agadir—Taroudant—Tisint—Tizounin—Assa (an area roughly 250 kilometres by 100, north-east of the Spanish enclave of Ifni, see *Times Atlas*). He describes the orders received by General Giraud; the plan drawn up by the latter; the troops to be employed; the composition of the columns, and preparations to be made before any advance could take place. The General had only a month and a half for preparations, as the great heat and scarcity of water prohibited any operations later than the middle of May.

Rapidity of manœuvre was the essence of the French plans, and the operations were entirely successful. The combination of the motor vehicle, the aeroplane and radio-telegraphy makes short work of military expeditions in these African regions, wherever the going is firm; but in spite of the apparent ease with which success is obtained, much careful thought and preparation go to the making of it. Among the young Colonels commanding these desert columns there are no doubt the future Gallienis and Mangins of the French Army.

L'économie allemande dans les rapports avec la défense nationale pendant la guerre de 1914–1918, by Commandant Lelarge D'Ervau, deals with the economic factors of the German national effort during the Great War. This gives many details of interest, and goes to show how hard pressed the Germans were towards the end of the war. The starvation of a nation by blockade is a terrible weapon, but it is not so uncivilized as the bombing of civilian populations. In the case of the blockade, suffering can be ended by crying "Halt." With air bombardments the slaughter is final.

The last article in this number is the most interesting one, *Emploi militaire de l'avion léger*, by Commandant Eon. The author describes the predicament in which the German High Command found itself at the beginning of September, 1914, when it lost touch with its great armies and could think of nothing better than to send the head of its Intelligence Section in a motor-car to ascertain the situation and give the necessary orders. He contrasts this state of affairs with what might have been done if, instead of sending a single motor-car to make its way along the encumbered network of roads, von Moltke had sent officers in light aeroplanes to the army commanders. Even the undeveloped machines of those early days would have enabled this to be done, but the new weapon was still so unfamiliar that nobody thought of using it in this way.

The author describes vividly how the light aeroplanes of to-day—such as are now being used by civilian flying-clubs for pleasure and sport—could be used to keep the General of a division completely in touch with any situation. It would not be delayed, like the motor-car, by the congestion of roads; it could readily find suitable landing-grounds; it would take only a few minutes to do the work which it might take hours for a motor-car or motor-cycle to accomplish. It is, in fact, the ideal substitute for those galloping aides-de-camp which Napoleon employed so liberally on his fields of battle.

The advent of the auto-gyro machine should make this new way of reconnaissance even more adaptable to present-day purposes.

(*May*, 1935.)—General Fournier begins an article entitled *Les Armées Françaises dans les opérations offensizes de* 1918, which is an epitome of Foch's plans for the resumption of the Allied offensives in 1918 and an account of the successive reinforcements of the various armies to enable them to keep up the pressure. The sub-title of the article is *La Noria des Réserves*, an expression which the author explains was first adopted by Pétain at Verdun, and has become a fixture in French military parlance. A " noria " is a primitive Persian contrivance of buckets on an endless rope, used for irrigation purposes. Applied to military phraseology, it means the cycle of movements by which divisions or Corps were put into the line and taken out into rest before their exhaustion was complete. Pétain elaborated the system in his defence of Verdun, and the British Army first adopted it in the battle of the Somme.

As soon as Foch took over the supreme command in April, 1918, he set about planning the early resumption of the Allied offensive. Owing to the continued German attacks, extending into the middle of July, he was unable to launch his own attacks until then. It must have added very much to Foch's anxieties to find that he had continually to use up his reserves to oppose each fresh German attack. The huge scale on which the operations of 1918 were carried out makes it very difficult for the historian to present a clear and connected account.

Foch's counter-offensives were not haphazardly launched, and during all the heavy fighting from April to July, he was maturing his plans, and awaiting his opportunities. He was particularly anxious to drive the Germans away from the railway line St. Just—Breteuil—Amiens, and from the great Amiens railway centre, so that free lateral communication between the British and French fronts could be restored. This was in due time achieved by the British Fourth Army, in August. The creation of the deep Château-Thierry salient made its reduction another objective of primary importance.

The author describes the inception of these plans, and gives lists of the divisions in line, in rest, and in reserve for all the French Armies involved. The British divisions which took part in these French offensives are distinguishable by the letter W added to the numeral. Only the briefest description of the results are given.

Trois Débarquements en presence de l'ennemi, by Commandant de Périer, with a preface by Marshal Franchet d'Espèrey, describes three examples of military landings in force selected from the military history of the last 80 years; namely, the landing at Old Fort in the Crimea, the landing at Suvla Bay in 1915, and the Spanish landing at Alhucemas in 1926. The landing in 1854 is first described. It can hardly be said to have any but historical interest to-day, owing to the vast changes in mechanical means, but it was nevertheless an outstanding example not only of a combined naval and military operation, but of one carried through by different allied nations. The initial preparations had been made with the minutest care, and the landing may be termed a striking success; but the Russians were inactive, and the sea at first was calm, although a gale sprang up in the evening of the first day. There were the usual delays due to want of a unified command. The article gives full details of the arrangements, and of the troops taking part in the landing. There were 4 French and 5 British infantry divisions and 1 British cavalry division.

Captain Thoumin describes French Flanders in an article, *La Flandre Française. Essai de géographie militaire*, with 5 maps. The same author wrote on the subject of the value of intelligent appreciation of ground in the August and September numbers of the *Revue*. The article describes the characteristics of the Flanders plain, with its all-too-familiar properties.

This large tract of country has seen many military operations throughout the centuries; its chief interest to-day lies in the facility with which much of it can be inundated, and thus made impassable to mechanized forces.

(*June*, 1935.)—General Fournier continues his articles on *Les Armées Françaises dans le opérations offensives de* 1918. Foch's original plan was to begin his operations by liberating the Paris—Amiens railway and the mining areas, but the renewed German attacks at the end of May put a stop to the preparations. Then came the French successes of the 18th July, and Foch was able to revert to his former plan. The main attack was to be carried out by the British Fourth Army, supported by the French First Army on its right, and the action extended still farther to the right by the French Third and Tenth Armies. The French First Army (Debeney) was placed under Sir D. Haig's orders, and was to envelop Montdidier on the north and south. The French Third Army (Humbert) was to take part by attacking la Petite Suisse, south of Noyon: and the Tenth Army (Mangin) was to be prepared to gain the plateaux south of the Oise and the Ailette. Foch's plan thus aimed at a main objective, with a successive prolongation of blows extending to the right so that the Germans should have no respite, and be forced to use up reserves with no opportunity to rebuild them.

From April until July, the First Army had been active, and by a series of engagements had gradually forced the Germans to evacuate the left bank of the Avre, thus preparing the way for the large-scale operation projected in co-operation with the British attack. The prodigious scale on which the offensives of 1918 were carried out is made clear in this article, which summarizes in convenient tables the allotment and redistribution of the French divisions for each of the great Allied attacks. Attention has been so much focussed on the main battles that the astounding work involved in staging them has been rather overlooked. At that stage of the war, great feats of organization became commonplace, but nevertheless a study of those performances leaves one with a sense of profound admiration for the work of the Higher Commands. In the midst of the preparations for the combined Franco-British offensive, which was so successfully launched on August 8th, Foch was planning his further attacks, and on July 24th a vast programme was communicated to the Allied Commanders-in-Chief. Each offensive was to be successively extended right and left, and a check here or there was to be met by a fresh thrust elsewhere.

The article provides a useful summary of these great counter-strokes.

Trois Débarquements en presence de l'ennemi is continued, and an account given of the Suvla Bay landing, August 7th, 1915. The tragic story is by now well known to British students, and no fresh light is thrown on it by this short account; but the summary is clear and to the point. The author emphasizes the fact that all the preliminary preparations were exceedingly well done. He holds the Navy responsible for the initial mixing up of the first échelons, which were not put ashore at the prearranged places; he blames the military staff for the failure to bring portable water-supplies ashore in time to save the troops wandering about in search of it; and for their failure to send sufficient artillery ashore with the 10th and 11th Divisions. He is, of course, severe in his condemnation of the inaction of the Corps and Divisional Commanders at Suvla.

The concluding article in this number is headed *Analyse de l'Ouvrage du Général Autrichien von Eimannsberger. La Guerre des Chars*, by Capitaine X. The writer points out that most of the books hitherto published in Germany dealing with tank warfare have been limited to reviews of what has been happening abroad. General Eimannsberger—a retired Austrian officer—has published his personal ideas. His book contains three parts; in the first, he studies the part played by tanks in the Great War, and seeks deductions from it; in the second, he discusses anti-tank defence as conceived at the present time; and in the third, he forecasts the conditions under which large armoured formations may participate in a future war.

The General describes the tank operations in the Battle of Cambrai in November, 1917, the French tank actions on June 3rd, 1918, (when 3 Renault tanks manned by 6 men broke up the attack of a whole German division), and on July 18th; also, of course, the tank operations on August 8th, 1918. The same features marked all

these operations. There was always the initial surprise, then a check, and finally the petering out of the attack and its degeneration into local attacks which used up the Tanks. But at Cambrai, Soissons and Amiens, a break-through was obtained in each case before the Germans could bring up reserves to stop it. No such result could be obtained with the artillery bombardments, the very preparations for which forewarned the enemy in good time. Moreover, the tank attacks did not destroy the ground as the artillery did.

The author reminds us that although considerable masses of cavalry were at hand in each case of a break-through, no cavalry exploitation was realized. Horseflesh is too vulnerable. We must use this new Robot cavalry.

Another conclusion drawn from the Great War is that tanks must be employed in masses. Wherever they were employed in penny packets—*e.g.*, in the Ypres Salient in September, 1917—they were failures. On the other hand, the tanks then used were very heavy, cumbersome vehicles. There is to-day a greater variety of armoured vehicle, leading to much greater flexibility in tank tactics.

The Germans had little or no anti-tank defences in front of their infantry. We must not, therefore, conclude that all tank attacks will have similar chances.

General Eimannsberger next deals with the question of anti-tank defence. Foremost among the defensive measures he puts the anti-tank gun. He considers that this should be of a calibre not less than 47 mm. Its projectile ought to be capable of piercing 30 mm. of armour at 500 metres distance, at an angle of 60 degrees. The rate of fire should be of the order of 40 rounds a minute. Such a gun would weigh from 770 to 880 lb.

These guns should be given to the infantry, a company of 6 guns to each battalion, with an ammunition section and mine-laying supply. For a division, an anti-tank battalion of 3 similar companies is proposed. For general reserves, anti-tank regiments of 3 battalions are recommended.

The organization of the defence is next discussed. The usual German method allowed one regiment (3 battalions) to a divisional sub-sector of 2 kilometres frontage; one battalion in front furnished the outposts and the garrison of the principal line of resistance. A second battalion acted as screen to the artillery. The third battalion, in rest, was in divisional reserve. The enemy had first of all to overcome the advanced posts, then the main line of resistance; after which he had to be counter-attacked by the second line battalions, finally by the reserves. The anti-tank guns should be grouped in "centres of resistance," armed on all faces. Rifle units should be posted 300 metres in front of the anti-tank gun groups, to deal with the enemy's infantry which may be following his tanks. The guns must not be placed too near the front line, as they cannot be easily hidden. The enemy must not be allowed to register on them beforehand. If the tank attack breaks through the principal lines of resistance, the local counter-attacks by battalions in rear will not prove effective. The enemy must be delayed, to allow time for the reserves to intervene.

General Eimannsberger would arrange his anti-tank defence as follows:—The front battalion's 6 guns would allow 1 gun to 300 metres of frontage. These would be protected by land-mines. Two rifle companies of this battalion in front would constitute a strong line of infantry fire. Behind, at a distance of 1,000 or 1,500 metres, would be the company of anti-tank guns, covered by the third rifle company disposed 300 metres in front of them. The second-line battalions would organize a position at least 3 kilometres behind the front line, out of effective range of the enemy's artillery. Each battalion in this second line should be reinforced with a company of the divisional anti-tank guns. Two rifle companies would be posted, as before, about 300 metres in front of the second line, while the third company organized centres of resistance in rear. The third battalions, in reserve, should organize a third position in rear of the artillery. With the divisional anti-tank regiment, it would thus be possible, on a divisional front of 6 kilometres, to have 6 A.T. guns per

fire was heard. The 17th was a day of great calm, followed by torrential rain at night. Continuous distant gun-fire went on all day on the 18th, and all sorts of rumours prevailed. About 9 a.m. on the 19th a body of mounted men arrived, and the inhabitants were astounded to see the emperor at their head. The latter had only had twenty hours' rest in the previous four days, he had been thirty-seven hours in the saddle, without food for a whole day, and had made a night march of 60 km.

The writer gives us an account of Napoleon's doings on that day: his letters to his brother Joseph and to the Council of Ministers, and his instructions to Marshal Soult. Soon after 2 p.m. the emperor drove off on his way to Paris.—(*To be continued.*)

A.S.H.

MILITAERWISSENSCHAFTLICHE MITTEILUNGEN.

(*April*, 1935.)—*The latest Changes in Uniform of the Austrian Army from a Historical Point of View.* The late Minister for War, General Vaugoin, first abolished the People's Army, substituted it by a Federal Army, and then worked throughout a very long term of office to bind this small body to the old Imperial Army by means of traditions, and otherwise. In pursuance of this policy recent *Dress Regulations* have ordered various re-introductions. The latter include the officer's shako, which, having started in 1811 as a cavalry forage-cap, widened its sphere to become an officer's head-dress of all arms, and disappeared only in 1919; the yellow and black sash, of the colours of the coat-of-arms of the Holy Roman Emperor, which was discarded in 1914 as making its wearer too conspicuous for war; collar-badges of stars (one to three) marking the three grades of each category, from general to n.c.o.; and the cross-belt and cartridge-case for artillery and cavalry (the mark of being on duty). The habit of officers misappropriating this case for the carrying of cigarettes appears to have existed as far back as 1798. During all the changing distinctions of officers, from the first, which was the size, nature and decoration of the stick carried by all officers and n.c.o's, through the various kinds of partisan carried, to braid, at first mainly on the head-gear, to collar-patches, stripes and stars as rank-badges, the one infallible sign of an officer in the Austro-Hungarian army (and now in the Austrian army) remained, viz., the gold sword-knot, made of universal pattern in 1837; a distinction, however, which owes its effectiveness to the invariable wearing of the sword.

Problems of Naval Strategy in the Mediterranean. Lieutenant Sokol, late Austro-Hungarian Navy, analyses in turn the positions and requirements of the Mediterranean Powers, *i.e.*, those nations which border on that sea, and also those other nations whose interests lie thereon. For reasons given he presently reduces these Powers to three, viz., Great Britain, France and Italy, and of these he points out the widely differing nature and degrees of their dependence on the Mediterranean. "England's position resembles a series of fortified posts in a territory which is not unconditionally subject nor reliable, and yet the possession of which is necessary for the life of the mother-country." Nor are the ends of this "territory" secure, as the passage of the Straits of Gibraltar by German submarines, and the Turkish attack on the Suez Canal proved. Further, in these days of aviation and of submarines, even allowing for the fact that improved possibilities of observation will tend to cause the last-mentioned to transfer their activities from enclosed waters to the high seas, England's position in the Mediterranean has lost in value. "In order to play an active part in the Mediterranean England must have a close confederation with either France or Italy." The recent political rapprochement between France and Italy might, therefore, if honourably and logically furthered, bring about a new chapter in the history of the nations interested in the Mediterranean. "But hard facts cannot be got rid of by passing attempts at reconciliation. When matters

kilometre in the forward position, and 12 per kilometre in the second. The division itself would have 72 anti-tank guns, and the author also wants the divisional anti-aircraft guns to be capable of use as anti-tank as well.

The General envisages the employment of two types of divisions :—The motorized division, and the division of tanks. The former division might be composed as follows :—

3 infantry regiments of 3 battalions (each having 6 A.T. guns).
2 regiments of A.T. guns (each of 54 pieces).
1 regiment of artillery (anti-aircraft and anti-tank).
1 group of motor machine-guns.
1 battalion of engineers.
1 battalion of land-mine layers.
1 observer squadron.
Signals, etc.

The A Tank Division might consist of :—

2 brigades each of 3 battalions of medium tanks and 1 battalion of light tanks.
1 brigade of motorized infantry (3 battalions of Chasseurs and 1 regiment of A.T. guns).
1 regiment of artillery (A.A. and A.T.).
1 group of motor machine-guns.
1 battalion of engineers.
1 battalion of land-mine layers.
3 squadrons of chaser-planes (2-seaters).
Signals, etc.

The tank division would only be used for the offensive. These divisions would allow of extremely rapid operations, the action being first begun by the tank divisions, and the motorized divisions used for covering the flanks and occupying the ground. To support the attacks of ordinary infantry divisions, independent brigades of tanks are suggested.

The article concludes with a description by General von Eimannsberger of a modern tank battle as a concrete case, reproducing the situation as it was on August 8th, 1918, on the Western Front. The total force envisaged runs to a whole group of tank armies, employing 10,000 tanks and numerous motorized divisions.

The article contains much that is of interest, and points the way in which modern thought is tending. Such vast tank operations are, after all, not beyond the picture which the British programme for 1919 might well have realized. If the adversaries give each other time, the war outputs of the factories would be equal to the demands.

W.H.K.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(*May*, 1935.)—1. *Le combat de Beerst-Bloote.*

Lieut. Velge gives an account of incidents that occurred in a sector of the line held by the III/3rd. Chasseurs à pied, between the 10th and 28th May, 1915, during which time the Germans delivered four attacks.

2. *Le barrage de feux.*

Major-General de Krahe has compiled a long article on fire barrage, taken from text-books and official circulars. All infantry weapons, *i.e.*, machine-guns, rifles, grenades of different kinds, mortars and anti-tank guns, must each take their part in a defensive barrage. The effective range of each type of weapon is given ; the machine-gun, which is the backbone of the infantry fire system, has a grazing fire up to a range of 750 m. The decisive range for infantry weapons is between 200 and 400 m. A distinction is made between the duties of machine-guns allotted to individual battalions and the companies of the divisional machine-gun battalion.

The duties of artillery in defence are dealt with, and the writer concludes with general considerations on the subject of barrage.

3. *L'observation à l'artillerie de corps d'armée.* By Lieut.-Colonel Nonnon.
A criticism of an article by Captain Smesman that appeared in the March number.

4. *Les leçons de l'instructeur d'infanterie.*
In this article Lieut.-Colonel Bouha makes a brief *résumé* of a work by Commandant Laffargue on the training of N.C.O's and men. The infantry soldier is trained to use his rifle, machine-gun and entrenching tool, but his most valuable possession, his brain, is neglected. The tendency of his training is to convert him into an automaton and to suppress all his individuality. After a few weeks' training he will do nothing without an order; he has ceased to think for himself.

Commandant Laffargue's book shows the lines on which a soldier's training should be carried out. In the first part the author deals with the formation of the soldier: technical, tactical, and moral. The first is the knowledge and handling of arms: here the personal interest of the soldier should be aroused, and drill not looked upon merely as a method of killing time. In his tactical training the soldier should be made to realize that in battle he is both hunter and game. His inventiveness and initiative should be developed to the fullest extent. In his moral training the soldier's tenacity, combativeness and conscience should be developed. The spirit of the hunter should be encouraged, rather than that of the game. His leaders should be in the habit of using their intelligence rather than referring to regulations. In practice it will be found that all regulations are based on common sense.

The second part of the book deals with individual tactical instruction, and the third mainly with the elementary machine-gun unit.

(*June*, 1935.)—1. *Quelques souvenirs des débuts de l'aéronautique belge.* By Lieut.-General Wahis.

In May, 1913, Captain Mathieu, of the Belgian air force, was instructed to make experiments with a new machine-gun, presented by its inventor, Colonel Lewis, of the American Army. Reports on the gun were very favourable. Colonel Lewis endeavoured to get a Belgian firm and, subsequently, the B.S.A. Company in England, to take up the manufacture of his gun, but both firms declined to take it up on a small scale. Eventually a group of Belgian financiers took up the Lewis patents, and the manufacture of this American gun was commenced in England by a Belgian firm.

On the outbreak of the war in 1914, the manufacture in Great Britain of all arms not officially adopted was stopped. The Lewis gun had not been officially adopted, and it took time and pressure on the part of the aviators of the R.F.C. and the Navy to get the Lewis gun accepted as an official weapon.

In December, 1914, the writer was deputed to London to obtain a supply of Lewis or other machine-guns. Up till then Belgian aviators had been armed with a Winchester carbine or Browning pistol. His visit did not produce much result. The first Lewis guns were supplied to the Belgian air force in the summer of 1915, and they were designed to take British and not Belgian cartridges.

General Wahis relates how, in despair, he went to see a friendly British R.F.C. officer who, learning the state of affairs, filled the General's Renault car with boxes of ammunition, and did not even ask for a receipt.

2. *Les tirs d'arrêt.*
Major Sottiaux discusses the official regulations on artillery barrage fire, and draws attention to the importance of depth in the zone of fire, in preference to a linear barrage.

3. *La guerre des mines sur le front anglais.* By Captain Misson.
This article is mainly compiled from one entitled "British Military Mining, 1915–1917," by Major-General Harvey, published in *The Military Engineer* for November, 1931; but other authorities, both German and French, are also quoted.

become serious it is as little to be expected that France will give way without fighting as that Italy will give up her claims."

Bridges or Ferrying? This is a résumé of papers by three Hungarian officers which appeared in the *Magyar Katonai Szemle*: In the first of these papers Lieut.-Col. Pacor says that nowadays the hostile effect upon a river-crossing by means of a bridge is so powerful that it is necessary for the bridgehead to be pushed out to a distance of from 6 to 8 kilometres: a bridgehead of this size would take a whole division to hold: the time of ferrying can be shortened up to 80% by the use of motors instead of oars: the comparative times of crossing by a division are: For ferrying with oars: for bridge-crossing: for ferrying with motor-craft :: 50 : 20 : 13. Hence with means of ferrying fully motorized a division can dispense with a bridge altogether leaving that to the succeeding divisions to provide. The author thinks that in future the importance of military bridges will much decrease, and he advocates almost exclusively motorized ferrying.

Against this Major Molnar says that the foregoing figures must be considered from the point of view of the amount of equipment available. If there is a shortage of ferrying material a bridge may carry ten times as much as a ferry in the same time, and even if ferrying material is ample the bridge will transport four times as much. He admits that the importance of ferrying has increased, but not that the importance of bridges has decreased. The existence of bridges will always be of decisive importance in warfare. The answer to the question "Bridging or Ferrying?" is "Both."

Captain Loidin says that the carrying capacity of the material built into a bridge is sixteen times as great as the same quantity used for ferrying: motorized ferrying in no way will allow bridges to be dispensed with: the provision of a large number of ferrying-places is a question of the number of approaches and of cross-country vehicles available. The Austrian reviewer considers that all three writers have pre-supposed a crossing against a superior adversary. He says that it is well known that, with approximately equal strength of the opposing forces, increases in weapon-effect balance out, and hence it follows that under these conditions nothing is essentially altered in the question of bridging or ferrying as far as the tactical side of the crossing is concerned.

The 42nd Regiment consists of notes on the history of a fine fighting corps, whose motto was *Nunquam retrorsum*, and which from the 1809 campaign bore the title of "the Grenadiers of Aspern and Wagram," had the Duke of Wellington as its Colonel-in-Chief for over thirty years, and after him King George of Hanover. From the latter's successor in that position, his son, the Duke of Cumberland, the 42nd took the field in 1914 known as the "Cumberland Infantry." Though the regiment's home, Theresienstadt in Bohemia, passed with the peace into a Succession State, Czecho-Slovakia has permitted the old Austro-Hungarian army number "42" to be retained.

Bacteriological Warfare. The international law side of this question is not here considered. The author, S. Schildermann, of the Dutch Military Gas-school, thinks that, in case of need and if it could be done, there would be as little scruple about using bacteria as there was about using gas. Fortunately for all concerned his greatest authority, Professor Jürgens, after exhaustively considering all the possibilities of war by the use of bacteria, of infecting your enemy and not yourself, finds the difficulties and limitations too great to encourage any hopes in those (if any) who would like to add a new horror to war.

The remaining articles in this number include:—*Russia's Armament*, notes by General Schilhowsky on a pamphlet written by three Swedish officers and published by Voggenreiter's, Potsdam, price R.M. 1·80: the continuation of last month's Tactical Exercise: *Field-marshal Prince Windischgrätz*, a reply by the author of that work to the *critique* which appeared in the October number (*vide The R.E. Journal*, March, 1935, p. 153); and a review by Colonel Kiszling of von Rabenau's "Operative Decisions against a Number of Superior Opponents," Mittler and Son, Berlin, price R.M. 2·50, which brings out that in the author's opinion it was not the lack of a

single military command that brought about the defeat of the Central Powers in the Great War, but "the lack of a common political leadership." For one cannot—as the Chiefs of the General Staff did—at the same time set tasks and solve tasks, unless one is, like Napoleon or Frederick the Great, ruler, statesman and general combined. Consequently the Central Powers should have had a statesman of pre-eminent qualities to set the army commanders the necessary military tasks.

(*May*, 1935.)—*New Military Books.*—This number contains a supplement written by Major-General Schubert, which announces a vast increase of interest in military matters consequent upon Germany's throwing off the fetters of the Versailles Treaty as regards both armament and conscription. The flood of new military publications is very great, almost too great to keep in touch with. Among his many recommendations General Schubert includes *They Arm!* by H. R. Berndorff (6 schillings), Captain Liddell Hart's *Infantry of To-morrow*, Major-General Fuller's *Generals of To-morrow*, and especially *Austria's Popular Book of the Great War* (at 10 schillings), General Krausz's *The Causes of our Defeat* (reduced to 8 schillings), and a collection of Austrian war-maps of all theatres, except Rumania, consisting of four maps at 1/750,000 and 56 at 1/200,000, a real bargain, as it is now offered at 12 schillings instead of 120 l (J. Lenobel, 22 Seilerstätte, Vienna I). Mongolia and Abyssinia also figure in the list, the respective authors being Professor Lessing and Max Grühl, while a splendid picture of Japan is given in a handbook by Corazza, and Dr. Albrecht Wirth in a pamphlet called "Eastern Asia" has written a guide to the problems of the Far East.

Twenty Years ago; the War-plans of the Central Powers. This article deals with the conversations and correspondence in the spring of 1915 between Generals von Falkenhayn and Conrad von Hötzendorf, the Chiefs of the Staff at German G.H.Q. and at Austro-Hungarian G.H.Q. respectively, and rough sketches make clear the nature of proposal and counter-proposal. The plans mentioned are those which were connected with the combined offensive at that time in progress against the Russians in Galicia and now known as (Mackensen's) Gorlice Offensive, which was meeting with good success; with the attitude of the Central Powers towards Serbia, where the Austrians were for the defensive, while Falkenhayn wanted them to attack; and with what was to be done in the event of Italy declaring war, which she presently did. The two Chiefs seldom saw eye to eye, and if Conrad, in the opinion of his German colleague, insisted too much on the Italian danger, the cautiousness of Cadorna's advance, even if foreseen, could hardly be banked upon. The only safe assumption was that the Italians would use their great numerical superiority (8 to 1) in an energetic thrust on Vienna, a thrust which would have the advantage of bringing the Serbian army into co-operation with them on their right. General von Steinitz thinks it was lucky for Germany and Austria that the Entente had no Napoleon in command when Italy declared war, for the Central Powers would then have been brought to their knees in a few weeks.

A consideration of the sketch-map of Europe showing the four theatres of war with the comparative strengths of the opposing forces lends colour to this view. In France, in Poland and in the Balkans the numbers on each side were approximately equal: on the frontier of the Tyrol and Carinthia 100,500 men are shown as having faced up to 875,000.

The Re-armament of the Swiss Artillery, by Major-General Rieder. The Swiss have been comparatively slow in utilizing the experience of the Great War in bringing their artillery up to date. Their 75 mm. field-gun has had its range increased from 6,000 to 11,000 metres. Formerly a flat trajectory weapon its carriage has now been altered to allow of 45° elevation, and it has now been made to take to pieces for mountain-transport. There is an entirely new 75 mm. Bofors mountain-gun, by which the range has been increased from 9,200 to 10,800 metres, with nine loads instead of eight. The next step in re-armament will be the replacement of the 12 cm. (4·8") Heavy, M.82, which is over fifty years old, by a 105 mm. (4·2") Heavy.

Also the 4·8" Howitzer is going to be reduced by a new liner to 4·2". The 6" Howitzer on account of its precision and powerful effect will be retained, although its short range of 8 km. is regarded as a defect.

The remaining articles in this number are *Thoughts on Umpiring*, and the conclusion of Colonel Zellner's *Tactical Exercise*. There follow a number of reviews and notes :—*Big Bertha and the War*, an illustrated account by Lieut.-Colonel Justrow of the heaviest German siege-gun, the 42-cm. Howitzer, nicknamed by the German gunners themselves after Frau Berta Krupp of Essen. On the other side of the line the name was sometimes applied to the long-range gun (or guns) bombarding Paris. There were at the outbreak of war five of these monsters on rails (the Austrians, who were regarded as leading the way in siege artillery matters, considered this a mistake), and two on wheels. Under the title *Generals of To-morrow* General Kraus reviews the German translation of Major-General Fuller's book on Generalship, and cannot refrain from producing a formidable list of commanders who were highly successful in war "although they were over 45 years of age." He says that it is not a new type of general we have to form, but the old type of which Prince Eugene was the finest example.

The Way of the Cross of an Emperor (*Charles I of Austria*). Austria's last Emperor, who was not yet 30 when he succeeded to the throne, reigned through the last two troubled years of the Great War, was deposed when the Austrian Empire broke to pieces, and died in exile four years later. The author, Herbert Vivian, is thanked by Major-General Materna for his courteous and sympathetic treatment, the more appreciated as coming from a foreigner of an ex-enemy nation. Exception is taken to the statement "Pangermanism was Austria's undoing," which, thus boldly put, is misleading. What undid Austria was not her own but Prussian Pangermanism. The Austrians were unfortunately fighting for ideals other than their own. This is clearly brought out by Colonel Pohl, quoted in Baron Werkmann's "Germany as an Ally" (*vide The R.E. Journal*, September, 1932, p. 567).

The Trend of Organization in the British Army. Colonel Rendulic gives without comment an ample précis of Colonel Macready's lecture last November at the R.U.S. Institution (*vide R.U.S.I. Journal*, February, 1935).

Tannenberg, by General Ludendorff. A pamphlet of 45 pages with 5 sketches, in which the author opposes those writers who have apportioned a share in the victory to others than himself—to Hindenburg, Hoffmann, Prittwitz, François, etc. The word "lied" occurs rather frequently. All who are interested in Tannenberg must naturally read and study this account also, and are warned not to allow their attention to be unduly diverted by excursional polemics against "Rome, Judah and the Free-masons!"

F.A.I.

WEHRTECHNISCHE MONATSHEFTE.

(*April*, 1935.)—*Wehr und Waffen* makes its first appearance this month under a new name, and having changed also its editor, its cover, size of page, type (Roman for Gothic) and to a certain extent its character, the latter change being in accordance with a recent Government order that all periodicals, of whatsoever nature, were in future to be first and foremost national-socialistic, and might serve their special branches and subjects, art, literature, the drama, sport, religion, war, etc., only in the second place.

Lieut.-General Schwarte "lays down the editorial pen" after sixteen years as editor of *Heerestechnik*, and, since the amalgamation of that paper four years ago with the *Artilleristische Rundschau*, of the combined magazine under the title of *Wehr und Waffen*. Lieut.-General Schwarte is handsomely thanked in his first editorial by the new editor, Lieut.-Colonel Justrow. The latter, who is a gunner, has great experience on the constructional side, having been for many years ammuni-

tion expert on the Artillery Proof Committee, and as such having been concerned with the development of the German artillery both before and during the Great War. He is also an original and stimulating writer, and as the author of *The Commander and War-technics* (Stalling, Oldenburg; price R.M. 6·50), he criticizes Schlieffen's Plan, maintains that Verdun should have been tackled first, and attributes the German defeat to the over-rating of strategy and the neglect of technics.

A Valuation of the Weapon, by Admiral Hansen. In the old legends the weapon was honoured along with the hero, Durendal with Roland, Excalibur with Arthur, and even the weapon's maker, like Weland, had his meed of praise. History on the other hand, has always preferred to give credit to the conqueror, and not to the inventor; and very often there has been an equality of arms, so that no offset to the conqueror's prowess was needed. History can also furnish plenty of instances of the value of the weapon, from Mylae through the Spanish Armada to Coronel and the Falkland Islands. Off Mylae, the foundation of the Roman Empire, her supremacy in the Mediterranean was laid by the victory over the Carthaginians owing to the invention of the spiked drawbridge enabling the Roman ships to grapple and the Roman soldiers to storm. Similarly, the victory over the Spanish Armada was the first step in England's struggle for the mastery of the seas, and hence towards the building of its world-empire. Without detracting from the fame of the English admirals, who led their squadrons splendidly, or from the fame of the English sailors, whose skill even then stood notably high, it may be pointed out that the English guns were superior to those of the Spaniards, who had looked upon their artillery as a matter of secondary importance. As regards the two sea-fights of the Great War mentioned, each ended with the complete destruction of the side which was inferior in speed, armour and armament. The history of the world can hardly furnish more tragic examples than these two battles of the hopelessness of a heroic struggle against superior weapons.

We have now arrived at a new age, an age of technics, in which what has stood for centuries passes in a decade. In future the technical expert must be given in the leader's councils the place which he has not yet been granted. About leader and man we need have no anxiety: it is up to us to keep abreast of technical progress, at home and abroad, so that leader and man do not find in their need that the superior weapon is lacking.

On the Theory of the Movement of the Projectile in the Conical Barrel. A mathematical investigation by Professor Schmitz of the effect on the projectile of using a conical barrel, invented by Carl Puff in 1903 as a means of obtaining increased muzzle velocity, and later applied by Gerlich to his 7-mm. rifle. The formulæ arrived at by Professor Schmitz are then employed in a numerical example, viz., that of a 15-cm. gun bored out conically to 20 cm. so that the interior of the bore is a uniform continuous frustum of a cone diminishing in diameter to 15 cm. at the muzzle. The muzzle velocity of 1140 m/sec. thus arrived at checks fairly with 1160 m/sec. as the muzzle velocity given by the evaluation of the gas-pressure diagram by the usual method of Krupp. Although Gerlich in his trials doubtless obtained very high performances and also proved them, there is no doubt that the increase in performance by means of the conical barrel depends on pressure and expansion-room. Hence one should not compare the muzzle velocities obtained with cylindrical and conical barrels of the same length but of the same expansion-room, *i.e.*, the cylindrical barrel will have to be longer. In this case there is so little in favour of the conical barrel as not to repay the difficulties of manufacture of gun and of ammunition.

Modern Weapon-development and the Problem of Anti-tank Defence. Starting with the intimate connection between fire and movement, viz., that the object of fire is either to prevent the enemy's movement or to facilitate your own, Major Dänicker points out how the modern development of the flat-trajectory weapon has been all in favour of the defence, since the defender can get cover easier against it, and with his m.g's kept close to the ground can come quickly into action against an attack,

while the attacker's flat-trajectory fire must cease long before his infantry get near their objective. The m.g. shows thus a deficiency in offensive power, and the attacker has to rely more upon his artillery and trench-mortars. The relative power of the defence had gained so much in modern warfare that the tank was invented to overcome the difficulties of the attacker and to restore movement to the battlefield. Major Dänicker calls the invention of the tank an "ingenious act of despair." The limitations to the further development of the tank are both obvious and grave, while the possibilities of A.T. defence are by no means exhausted. The author genially suggests, for instance, that where A.T. weapons are not present in sufficient numbers (and it is not easy to see how the large number claimed as necessary, viz., 16 per battalion, can be provided), a small light weapon, quite incapable of piercing a tank's armour, might still fire at it a smoke-producing substance, which, adhering to its outside, would blind it for sufficient time for an A.T. weapon to arrive. Where A.T. defence can be organized, tanks, even with their improved speed and cross-country powers, should not be able to do more than get through singly, and not in mass. As for the battle between mechanized armies, this is only thinkable if both parties agreed to have none other than mechanized troops; it may be ruled out as long as the defensive power of modern weapons is able to forbid the movement of mechanized formations, even if only locally. The mechanized raid will be no more decisive than was the old-time cavalry raid.

Recent war experience with tanks in the Gran Chaco has gone to confirm that a few tanks can do nothing, as they are quickly put out of action one by one: while in China the Japanese aeroplanes accompanying the tanks proved mostly incapable of discovering the Chinese A.T. guns, which, concealed until the last moment, brought the tank attacks to a standstill.

The defeat of the tank is brought about best by a weapon of a defensive nature. How far a country will confine itself to fighting tanks defensively is not primarily a technical question. It is an organization question, decisively influenced by a more general strategic problem, which consists in finding a new way for land and air forces, consequent upon development having led, owing to their having different requirements, to a considerable cleavage between offensive and defensive weapons—a way which shall ensure the right combination of attack and defence necessary for the gaining of success in battle.

Economic Considerations regarding the Question of Capital Reserves in War. An article of interest to soldiers who happen to be shareholders, the gist of which is that in war-time reserves of capital are not only unnecessary but a source of danger, since their existence makes it more difficult to calculate prices correctly. Readers may rest assured that national-socialism will know how to make the necessary changes, in other words they are warned to expect confiscation.

The Blowing-up of the Summit of Mt. Cimone by the Austro-Hungarian Troops. The Austro-Hungarian offensive from the Tyrol in May, 1916, broke through the Italian position between Mt. Pasubio and Asiago as far as the edge of the Tonezza Plateau, overlooking Arsiero. Here it was held by the Italians gallantly recapturing Monte Cimone, which rises 230 metres above the rest of the plateau and is its furthest point. The Italians thus saved the Venetian plain, and the rear of their Isonzo armies, but it was touch and go. The summit of the mountain was quickly fortified, and defended by over twenty machine-guns. The Austrian line settled within 100 metres of the top with its sentries only 30 to 40 metres from the Italian wire. Their position was very uncomfortable, as the plateau was so narrow as to constitute a defile, and the prospect of capturing the summit was negligibly small. Here technics intervened, Lieut. Makler of the Sapper Battalion proposing to mine the mountain-top. Starting his galleries so close that working was interfered with even by hand-grenades, he drove three shafts, spoil being removed at night. The Italians at once got busy counter-mining. Fortunately for the miners' nerves both sides used pneumatic borers, so that as long as the noise of the enemy's boring continued the

miners felt safe. The work lasted weeks. At length, when the Austrians were ready to blow, a patrol brought in an Italian prisoner who had on him the date and time of the next battalion relief. Ten tons of ecrasite were built into the mine-chambers (while the automatic borers were kept studiously working elsewhere), and fired at 5.45 a.m. on the 23rd September, while the battalion relief was in progress. The whole position was wrecked. An Austrian officer and 100 selected men went forward and occupied the crater. At 8 a.m. the Italians opened drum-fire on the position, and 28 cm. air torpedoes could be watched coming up from the valley. The writer, a captain in a mountain battery, noticed that the barrage, which had at first been deadly accurate, fell off in efficiency as the sun got higher and the air hotter. The Italian shells then started passing over the position and bursting in the valleys on either side of the narrow spur. An Italian searchlight directed on the Monte Cimone all night served the Austrian working parties for putting the crater in a state of defence. The Austrians had two men killed; they took 600 prisoners, whom they had first to release from their blocked dug-outs, and calculated that they had killed 900 more. Their successful enterprise against this mountain-top was an appropriate answer to a similar Italian success on the Col di Lana the winter before.

The International Automobile and Motor-cycle Exhibition, Berlin, 1935 (continued). Lorries: These took up by far the greatest space in the exhibition, not only on account of their size, but by their numbers. This is mainly due to the new traffic regulations for the national roads, and hence also a number of new types up to 6½ tonners. The steady progress of the Diesel engine is noticeable. It has now got down as far as being put into 1½-ton lorries and small omnibuses. Besides the cheapness of its fuel the Diesel engine has the advantage that it can if necessary be run on petrol, requiring only 3 to 5% of lubricating oil to be added for the lubrication of the injector pump.

M.A.N., of Nüremberg, showed the winner of the Russian International Diesel race, from Moscow to Tiflis and back, 5,200 km. on Russian roads, which was successful from competitors from seven other countries, including Great Britain, and fourteen different firms.

Photographs and drawings show:—Daimler's cross-country 3-axled lorries, G 3a, LG 3000 and LG 4000. The smallest of these is a 1-tonner across country load, 65 H.P., with carburettor, and maximum speed of 60 km. per hour. In addition to the normal four-speed gear box it has an extra gear box so that the driver has at his command eight forward and two reverse. The two last-named types can have Diesel or magneto. All three can climb up to 40% with full load.

A 5-cylinder Büssing engine, probably modelled on the British Gardner, which, however generally builds up out of two and three-cylinder aggregates.

A 6-cylinder Henschel-Lanova Diesel engine, 95 H.P., type-S. The chassis of a light military cross-country lorry by Krupp, LH 43, which has stood severe trials at home and abroad, *e.g.*, in Turkey and in S. America.

The 3·5 litre Boxer engine of the same, which is specially built very low for army purposes.

A Vomag 8-cylinder Diesel engine designed to be built in underneath the chassis and yet accessible, although completely enclosed against dust and dirt. It weighs 1·84 tons and develops 185 H.P. at 1,500 revs.—(*To be continued.*)

Problems and Questions of Military Technics. Under this heading the editor proposes to publish from month to month questions and answers, examples and exercises, for the purpose of stimulating his readers and improving their judgment in military technical matters. He leads off with "the most famous gun of the Great War, beside *Big Bertha*," the Paris-gun, *i.e.*, the gun used for bombarding Paris in the spring of 1918 at a range of 125 kilometres, and mentions several points of interest, *e.g.*, that a copper driving-band would have been quite useless, and that the shell had to be provided with steel ribs instead, notwithstanding the consequent extra wear on the barrel: also that the weight of each charge had to be calculated carefully according to the state of wear of the bore after every round.

Assuming dispersion with the Paris gun to have been in length 1% of the range, and in breadth ·1% of the range, a number of examples are then set for readers to work out, the answer required being generally either the percentage of hits to be expected on a target of given length and breadth, or the number of rounds to be fired so as to get a certain number of hits, or the number of guns required, assuming a life of seventy rounds.

Army and School in Italy. A short account is given of the recent measures of the Government of Italy for the militarizing of the youth of that country (*cf. R.E. Journal*, March, 1935, p. 157). It is claimed that these measures prove how the victor-states not only arm " in the most monstrous and threatening manner, but also militarize the whole nation." " And what of Germany ? "

" The Dictate of Versailles has forbidden all military training of the German people."

" A nasty, vicious temper," remarked the Red Queen.

Military Technical Literature. In spite of Versailles, the League of Nations, etc., there is no sign of disarmament noticeable in people's mentalities. In all countries since the Great War the young have been inoculated with the thought of getting ready for war by means of literature, provided partly by Government funds. It was high time that Germany should follow suit.

Specially recommended are *Peace through becoming Prepared for War*, *The Military Sciences of To-day*, and *Military Political Pocket-book*, all published by the *German Society for Defence Politics and Sciences*; also *Mathematics in the Service of National Political Education* (a handbook for teachers), *Topographical Mathematics*, *Collection of Artillery Tasks for the Upper Classes of the Higher Schools* (published by Diesterweg, Frankfury a/M), and above all Schmitthenner's *Militarily Prepared and Free* (Julius Beltz, Langensalza), in which the view is selected for special approval that " the mutual high object of the army and of the sporting associations of the young must be the education to combatant."

(*May*, 1935.)—*Jubilee of the Firm of Polte.* Fifty years ago a working-man named Polte, in quite modest circumstances, took over in Magdeburg a small factory for making boiler and steam-engine fittings, and, having made the necessary research, and devised the necessary machinery, started making infantry and artillery cartridge-cases. After fifteen years his staff had grown from 23 to 1,000, and he was supplying not only the German Army, but nearly all foreign countries. Polte received many distinctions, and in the war rendered great services to his country with his supply of cartridge-cases, and also of telescope accessories, but his firm was almost completely done away with after the Treaty of Versailles. To-day it is in full activity again, and has an ever-increasing output. " In the interest of our fatherland " the editor wishes it every success.

Raw-material Economics in the Great War and Now, by Professor Wiedenfeld. To the political catchword, " A people without space," and to the thesis of statistical experts on population, " A people without youth," the material-economist must now add a third formula, " We Germans are a people without capital " ; capital being understood not in the sense of bank-balances, but of the national possession of raw materials, of everything which has through home-labour to be converted into objects for use or into means of production. Professor Wiedenfeld points out the similarities between the present economic state of Germany and the same during the Great War, and shows how the problems are now more difficult to solve. He sounds a note of warning that nobody can now be permitted, as individuals were permitted in the war, to make profits out of the national necessity. Prices must be regulated by the State, and must not cover more than the costs of materials and labour, interest on capital, and a depreciation quota, technically measured. There is no room for industrialists' profits, arising from a free market, when scarcity of raw materials causes the suspension of the free market. The writer forecasts, what the newspapers have since confirmed, a tax on home products for home consumption to be applied to lower the cost of exports, so as to enable the latter to compete in foreign markets.

Professor Wiedenfeld makes a sad picture of Germany's economics, but he winds up bravely with the motto, " Difficulties are there to be overcome."

A New Process for Making Concrete for Military Purposes. In mining it has long been the practice to close up cracks and make them watertight by the use of liquid cement. The same means has been used for repairing cracks in masonry. A further extension of the use of liquid cement is for making concrete without the usual preliminary mixing of materials. In this system the concrete must be of coarse metal, large stones, etc., and finely powdered cement; but no sand can be used. A wall is first built dry, and then liquid cement is forced into it from below. The latter in rising drives out all the air, and completely fills every hollow space. A concrete wall is thus formed which is absolutely watertight.

This system described here by a mining engineer, Director Schneider, was first made public in the *Bauingenieur* for September, 1932. It appears to be eminently suitable for military purposes, especially in permanent fortification, or for dugouts, magazines, etc., the making of which even below the natural water-level in the soil would thus present no difficulties. As there is no mixing, and no ramming, the transport and other questions are much simplified, especially in mountain country, where the stone is generally available on the spot from *nullahs* and *moraines*.

An example is given of 1,000 cublic metres of stone having been built into position. The spreading coefficient is 50%, so that 500 cubic metres of liquid cement will be necessary to fill the interstices. If the site of the work is higher than that of cement delivery the cement will be pumped into the material. If the site is lower the cement will be delivered by a pipe on which suction is maintained so that the air is sucked out of the metal, and the cement disappears into every crevice. The chief difficulty is the maintenance of an unbroken flow of cement so as to prevent air from being taken down with it. Using a 2 cm. diameter delivery pipe, 1,000 cubic metres of material, as in the example, can be cemented in less than one hour, a performance which means that by this method a job can be done in as many hours as it formerly took days. Naturally a very rapid setting cement is best, otherwise the setting and hardening, and hence water-tightness, may take the best part of a month to attain.

Problems and Questions of Military Technics contains the answers worked out to the seven artillery examples set in the April number.

Tradition and Technics. Taking as his text an utterance of Lieut.-Colonel de Gaulle in *France Militaire*, " Victory has ever belonged to him who has best understood the spirit of his age," the writer depicts tradition as the great opponent of technical progress. As an example of what can be achieved when an army is not hindered by " the conservative persistence of the general staffs of the capitalistic powers " he enumerates various points of superiority over other armies in technical matters which he claims as possessed by the Red Army of Soviet Russia.

The remaining articles include *Concerning the Ballistic Degree of Resistance*, by Professor Rothe; *Ranges of Modern Guns*; *The Modern Motor-cycle and Modern Accessories*, which deals with the exhibits of this nature at the last International Exhibition in Berlin; *Army Language*, a plea for eliminating all words of foreign origin; *The Temperature of Fired Projectiles*; a review of the present state of tank-development in all countries; and *Economic Mobilization*, which holds up as a pattern to other nations what the United States have done to this end.

(*June*, 1935.)—*125 Years of the Artillery Proof Committee*, by Lieut.-Colonel Justrow. This committee owes its origin to the great Scharnhorst, when as Chief of the Staff he was rebuilding the Prussian Army after Napoleon's defeat of Prussia. It came into being thus, like the *Tugendbund* as part of the national revival which led to the Wars of Liberation, to Elba and St. Helena.

Scharnhorst's ideas were to introduce order in development and design into what had up to then been a playground of individual fancy, and to combine theory and practice by allowing practical gunners of all ranks to have their say before the committee.

The author praises as the Committee's most priceless possession the free expression of opinion at committee meetings, which helped to build up a common knowledge and a common sense of responsibility in the whole matter of producing artillery material.

The Use of the Pendulum-gun and of the Ballistic Pendulum, by Dr. Hänert of the Naval School, Mürwik. The question of the distribution of the charge when fired cannot be determined purely theoretically, only experiments with exact measurements of recoil can lead to its complete elucidation. Cranz's improved recoil-measurer can be used for this, but its great sensitiveness leads Dr. Hänert to propose "some other very simple" arrangements for trials. They are based upon the gun being slung and fired against a cylindrical pendulum, upon the hardened end-surface of which the projectile breaks up.

Artillery Fundamental Principles. A former Heavy Artillery Group commander deals, very pleasantly to the layman, with all the factors which affect the accuracy of shooting. He points out that the tables containing corrections for weather and other influences should not have a value assigned to them which they cannot possess, and ought not to be used for percentile corrections. Waste of ammunition can be prevented only by adopting a procedure which will compel the B.C. to check constantly the accuracy of his tables. The utmost accuracy of measurement is necessary not only for "errors of the day," but also because at the very great ranges demanded by modern tactics small errors of measurement mean great differences at the target. We require every guarantee of hitting at the longest ranges, and that means the introduction for heavy and field artillery alike of the best instrument of measurement, viz., the theodolite.

Difficulties of Technical Origin in the Leadership of Mechanized Formations. Major Butkau, having taken great pains, has little difficulty in pointing out the weaknesses and limitations of mechanized formations in their conduct and warfare, and carries his tale as far as expense of provision, upkeep, "the unceasing river of oil," and replacement. He congratulates Germany on having been spared all participation in the years of experiment and trials.

The editor adds the necessary corrective. The warning against exaggerated claims on behalf of mechanization must not lead to its being neglected. Mechanized formations have arrived and will remain. The difficulties that beset mechanization, many of them nursery troubles, having once been recognized, the problem is to remove them so as to make of mechanized formations a capable weapon. As regards the tank he still holds to his opinion that the best answer is a well-prepared artillery.

The remaining articles in this number are *The History of Fire as a Weapon*, by Major Reddeman, who organized the German Flame-throwing Service in the war, and who points out in this first instalment that fire in attack and in defence was one of man's earliest weapons; and *Military Science and the School*, in which a Director of Studies runs over the titles of a number of books, which would not generally be recognized as school books, but which the recent Defence Law (16th March, 1935) would appear to bring into that category. Books on ballistics, aerodynamics, aeroplane-construction, topography, sound-ranging, the war game, etc., are here recommended for ensuring that Germany's youth acquires in its studies the necessary understanding of military science.

F.A.I.

VIERTELJAHRESHEFTE FÜR PIONIERE.

General von Beseler. The frontispiece is a photograph of this officer, who from 1904 to 1911 was Chief of the Engineer and Pioneer Corps, and Inspector-General of Fortifications, and "the conqueror of Antwerp and Novogeorgievsk." The latter refers to an important feature in the great Austro-German offensive against the Polish

salient in the summer of 1915, which effected what Conrad had pressed for in 1914, viz., the pinching out of Warsaw. Novogeorgievsk (since 1918 called Modlin) was the fortress at the junction of the Bug and the Vistula, covering Warsaw. It was surrounded by the Group of Armies commanded by von Beseler on 12.8.15, and surrendered eight days later.

The Orders of the "Alberich" Blocking Operation. Alberich was the code-name for the withdrawal in the winter of 1916-17 of Crown-prince Rupprecht of Bavaria's Group of Armies (6th, 1st, 2nd and 7th) to the Siegfried position, known by us as the Hindenburg line. This first instalment deals with the orders of the Group, and those, by both G.S. and G.O.C. Pioneers, of the 2nd Army, which had farthest to go, and an area to evacuate almost as large as that of the other three Armies put together.

These arrangements for a retirement have already been held up as a model for what our Fifth Army might have done early in 1918 (*vide R.E. Journal*, March, 1935, pp. 162, 163), but there is the very great difference that the Germans intended to retire without being attacked. The keynote to what the Germans did in their retirement was the passage in General Ludendorff's original instructions, which ran, "Our opponent must find in front of him an entirely exhausted country, in which his possibilities of movement have been rendered difficult to the utmost degree." One month was given for working out and sending in all proposals, and a further nine days for reconnaissance and providing the necessary explosives. If, as the writer says, the retirement in the thoroughness and care expended in its preparation and execution, and also in its effects, stands alone in the history of war, he feels bound to admit that the case was quite exceptional in that the retirement took place from position warfare, and with an expenditure of strength, means and time, which could never, even approximately, be at one's disposal, in ordinary warfare.—(*To be continued.*)

Co-operation or Subordination? The question refers to the relationship of the pioneer-arm with the infantry it serves; and this article is by way of answer to the article noticed in *The R.E. Journal*, March, 1935, p. 164. Roughly, we may say that the infantry prefer the latter, thinking that it ensures them better support, while the pioneers think that subordination may lead to their being used for tasks not strictly in accordance with the purposes of their own arm, in fact, that they might sometimes be better employed elsewhere. Although it is simpler to judge thus, the correct answer can be given only on more real grounds. Subordination of the engineers to the infantry leads, as it would in the parallel case of artillery being so subordinated, to a narrowing of the sphere of their utility. On the other hand the allotment of pioneers to a division does not allow of effective pioneer support being given everywhere. The pioneers, owing to the insufficiency of their numbers, must be concentrated at the most important points. What these points are, only the commander of the troops can decide; a decision which will naturally be made after consultation with the O.C. pioneers. Again, modern developments and especially the increased use of blocking have enormously increased the engineers' tasks. This may well lead to companies and sections being so widely distributed that their O.C's cannot get a clear enough picture of activities and requirements: here subordination would be best. At present the view—that of the writer of the last article—that subordination should be exceptional and co-operation the rule, is running ahead of facts. Circumstances must decide in each case which system is to be adopted, while the use of the pioneers under one commander remains the object to be striven for.

Signals for Pioneers (anglice, divisional engineers). The acceptance and passing of enemy intelligence, of orders and instructions, has at all times been one of the most important means by which the commander controls his troops. The tasks of a modern pioneer battalion are so varied in nature and so widely distributed that the addition to it of a signal section is essential. This signal section would be motorized, and its equipment should include: 2 small telephone wagons for laying cable, for

lineman's work, or for carrying supplies when cable is laid from man-pack; 2 light telephone wagons for line building, with 20 km. of heavy, and 3 km. of light cable, and 8 telephones; 2 light engineer vans, for reconnaissance, supervision, carriage of personnel, etc.; 4 small wireless sets; daylight signalling lamps, Very lights, flares and smoke-producing apparatus.

The article gives no proposed strength of personnel; but a plan of signal communications, such as might be provided by the engineers for themselves for use during the building of a bridge, and the signal orders for the necessary tasks. To defeat the enemy's listening-sets the orders lay down that all lines must be metallic within 3 km. of the front.

Training of the Pioneer Company. This instalment deals only with the orderly or runner, what is required of him, and how he should be trained. Requirements and training are, apart from his cycle, the same as those of a motor-cyclist dispatch rider.

Storm-pioneers in the 1918 Offensive Battle. This relates not to the over-running of the Fifth Army, but to the subsequent smaller push towards Hazebrouck. It narrates the doings of two pioneer sections acting as storm troops in the turning movement from the north against Kemmel on April 26th, first in the capture of the Bluff, and subsequently in the capture of Lankhof Château, S. of Bedford House on the Canal, where it is crossed by the Ypres-St. Eloi road. The latter was carried by *coup-de-main* at night, a brilliant bit of work. There is no doubt that their recent successes had increased the Germans' self-confidence just at a time when boldness is most paying.

Demolition by Explosives as a Measure of Civil Air-protection and to Prevent the Spreading of Conflagrations. This article with explanatory sketches deals with the subject under three heads: (1) demolition of damaged houses, owing to their being in danger of collapse, (2) demolition of houses, *e.g.*, in terraces, for the stopping of conflagrations, and (3) demolitions for the removal of large ruins and debris. The points, in common to all three cases, which have first to be settled, are: How far will the surroundings be endangered? Has the neighbourhood been shut off and evacuated? Have the gas, water and electricity been cut off? How can traffic be kept open, or quickly restored?

All demolitions should be so arranged that the walls adjoining a street fall inwards, and the structure must be studied to this end. Internal courtyards are useful for the placing of charges owing to the air in them being enclosed. As regards conflagrations the chief danger in rows of houses lies in their roofs, and the recent order for civil air protection, which forbids the storage of inflammable goods in attics, and prohibits carpenters, painters, upholsterers, etc., from having their workshops in top storeys, is applauded. If it happens that one house in a row is lower than the rest the destruction of its roof alone may suffice to stop the fire spreading, but this depends upon the distance of its windows from those of the adjoining house, from which flames may strike across.

As an historic instance is mentioned the great fire in Hamburg in 1842, when not only whole streets were blown up to stop the fire from spreading, but buildings were also knocked down by artillery fire.

The Standardization of Military Field-bridges of Non-service Equipment. In the interests of simplicity and economy standardization has become so much the rule in all branches of industry and engineering that the possibility of standardizing military field bridges for which equipment is not carried, suggests itself for study. This subject has hitherto been neglected in Germany.

According to Lieut.-Colonel Hajeck of the Czecho-Slovakian Army in an article which appeared in the *Vojensko-technike Zpravy*, February, 1934, the French have completely standardized three types of wooden bridge (with r.s. joists in the case of the two heavier types) for military purposes. They are for total loads up to 9 tons, 18 tons and 25 tons. The corresponding axle-loads are 4·6 tons (or 7 tons by increasing the number of road-bearers from five to seven), 13 tons and 17 tons, respectively.

The French class them all as heavy bridges. They have standardized the span at 4 metres and a scantling at 8 x 22 cm. The latter is used for decking and trestle-stiffeners single, and made up for other purposes, road-bearers, capsills, etc. Thus, the " medium " bridge, or lightest type of the three mentioned above, has as road-bearers these scantlings bolted in pairs, making up 16 x 22 cm. (say, 6½" x 9"); the " heavy " bridge has for the same purpose an R.S.J. with two 8 x 22's, bolted one on either side; while the " super-heavy " bridge has as road-bearer 2 R.S.J's with two 8 x 22's bolted between them.

Such a solution, the writer points out, might well be applied in the German Army for the lightest of the three types, as it would afford all the advantages to be expected from standardization; but only on one condition, viz., that the necessary components are really easy to find, or easy to send forward. In the case of the size chosen by the French the former would be very doubtful. Local timber prepared for the building trade is not likely to be found in Germany except up to 12 x 16 cm. (roughly 5" x 6½"), while planking is not likely to exceed 4 cm. (1½") in thickness. Stout planks are always the most difficult to procure, harder still than very large scantlings and round timber.

We may take it, therefore, that 9-ton bridges, unlike lighter bridges, will not generally be made of local material. Their purpose is usually in the first place to replace a pontoon-bridge. Consequently a certain amount of time will be available for getting up the material, and that material might be of standard pattern instead of having to be worked out fresh as each instance occurs. A trial might be instructive of the different performances obtained by " free " building, which must in any case remain the basis of the engineer's training, and by building with prepared equipment.

Sounding and Profiling of River-bottoms. Photographs are shown of an apparatus which has been devised for mounting in a motor-boat or pontoon and which, when set at a certain depth (60, 70, 80 cm., etc.), is put into activity by means of a lever, and will then ring a bell when the boat gets into the corresponding shallowness. Another improved type will profile either by the pointer, which indicates the depth, being read as it moves round on a dial, or it can be made to record the profile of the river-bed, producing a section or squared paper, resembling a barograph record. The time taken for this performance is the time the boat takes to cross the stream, *i.e.*, a matter of minutes.

The remaining articles in this number include: *Concreting Under Water*, which mentions the Torkret Coy. of Berlin's " Pumpkret " process of pumping concrete " comparatively stiffly plastic " at up to 38 cubic metres per hour a distance of 200 metres, and also the application to under-water work of the method of pumping liquid cement into metal already laid, whereby much of the cement gets washed away; *Mining in the Seven Years' War; Exercises of English Pioneers*, " whose official title is the Royal Engineers," extracts from *The Times* and, as regards mix-in-place roads, from *The R.E. Journal*, March, 1935. *Gas-pioneers in the Great War*, of which the title is somewhat misleading, since it refers to a single incident, viz., a German gas attack south of St. Quentin on 11.12.17, which was unconnected with any intended operation. 1,300 cylinders were in position, and 387 failed. The range was 1,200 metres, and the breadth of target 700 metres; result, " patrols reported numerous casualties being removed from the trenches "; *Pioneers at a Broken Dam near Elbing*, which gives an account of four days' good work put in by a company of the Königsberg Pioneers in February last in E. Prussia, when a canalized river, the Weeske, broke through the bund in two places, 20-m. and 15-m. broad respectively, owing to ice floes having blocked the river; and *The Gold Cross for Military Merit*, an account of a decoration reserved for N.C.O's and men, the rarity of which is gauged from the fact that in an armed strength of 12½ millions only 1,760 M.M. Gold Crosses were awarded. Of these eleven went to the submarines and seventy to airmen, while the pioneers (including trench-mortar personnel) bagged 111.

F.A.J.

THE INDIAN FORESTER.

(*April*, 1935.)—The resolutions of the all-India Conference for wild life preservation, held in January of this year, are given at some length, and we can only hope that they will be speedily translated into legislation.

The Scottish Forestry Society excursion—a tour to the regions surrounding Loch Earn and Loch Katrine—visited areas where moorland and other unproductive parts are being afforested. The article is interesting as showing what is being done in this country.

An article of special interest to us is "Concrete flume damage," by N. C. Pring. The flume in question is part of the hydro-electric works, constructed by the late Colonel B. C. Battye (see *R.E. Journal*, December, 1932, p. 700), which supply Simla with light and power. A good deal of damage has been done lately to the flume by the roots of certain trees, mostly wild figs. Though the trees responsible for the damage have been cut down, and their roots injected with coal-tar, assafœtida, nitric acid and other preparations, the trouble still continues, and it has been found necessary to cut out the roots entirely. To provide the necessary soil cover which will by that means be lacking, it is proposed to replace the offending trees with *sanatta*, an evergreen shrub very plentiful in the lower hills in the Punjab and N.W.F.P., whose roots do not affect masonry. It makes in addition an excellent hedge as it is not browsed by animals.

An article on *shisham* from Changa Manga in the Punjab will be of interest to all those who have worked that useful and ornamental wood.

We read also that Mr. Henry Ford, nothing if not record-breaking, has just laid down a teak floor, 270,000 sq. ft. in area, for the main exhibition room of his Edison Institution Museum. In appreciation of the reception given to Ford cars in India, Burma and Ceylon, all of this enormous quantity was ordered from India and Burma.

The figures in "Drought from a wet planet," an excerpt from *Natural History*, an American publication, give one furiously to think. An acre of cabbages needs more than two million quarts of water in a season; half a ton of water is used by an average tree to make a pound of wood. It is impossible to say what would be the effect of say two or three years of universal drought on the animal and vegetable life on this earth. Further, as the causes of droughts are unknown, meteorologists are unable to give reasons why such a stoppage of rainfall should not last for so long a time.

(*May*, 1935.)—The question of the dryage of timber sometimes comes up during a Sapper's career, and here are some figures relating to the shrinkage by weight of *kosh* (alder) wood at Bhuin in the Punjab; 100 c.ft. of split firewood lost 33% by weight in 3 months, 37% in 6 months, and 39% in 9 months. The results with branch wood were practically the same. Presumably the percentage loss with harder woods would be smaller. The author, Mr. Naranjan Singh, of the Punjab Forest Service, has worked out two formulæ comparing the ultimate utilizable weight with the volume in c.ft. of the freshly-cut timber:—

Split wood, weight in maunds = ·27 volume in c.ft.

Branch wood, weight in maunds = ·135 volume in c.ft.

The corresponding figures in cwt. would be ·20 and ·10 respectively.

An extract from *Indian Engineering*, November, 1934, comments on an impregnation method of fireproofing wood, a German invention, which is claimed to succeed even where ignition bombs are used to try to ignite the treated timber.

The August, 1934, number of the same paper is quoted in connection with the reclamation of alkali soil. Most of us who have served in the East are familiar with the vast stretches of land which produce nothing but an efflorescence of salt; while in the irrigated areas of the Punjab, many square miles of formerly fertile soil have been rendered barren by the seepage to the surface of alkalis. The article relates how, in the U.S.A., a remedy was found in the application to the ground of a mixture of sulphur and gypsum. It is understood that similar treatment is now being carried out in affected parts of the Punjab.

F.C.M.