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All Reviews on Books on military subjects are included in the provisions of K.R. 535(c) (*1935*).

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THE SHOP.

(Reprinted by permission of the Proprietors of "Punch.")

You gunners of the past, give ear;
  Old sappers, hear my call;
I do not come to give you cheer,
  Far from it; not at all;
Let none, however tough his clay,
  Withold a manly drop;
To put the matter shortly, They
  Are closing down The Shop.

O Academe of deathless fame
  Where we, green snookers, met
To bear awhile the noble name
  Of Gentleman Cadet,
Whom one of those unmanly slurs
  That sting one now and then
Defined as almost officers
  And not quite gentlemen.

'Twas there our young career began
  With that *al fresco* plunge
To which by iron law we ran
  Clad only with a sponge;
Icy the bath, and no mistake;
  Whistling the wintry air;
'Twas hard, but doubtless helped to make
  The fellows that we were.

The halls where graver men instilled
  The lore of sap and gun,
The gym, the front on which we drilled,
  I see them now, each one;
And here, with many a strangled yawn,
  A sad defaulter paced
The "hoxter" which at crack of dawn
  Was little to his taste.

A dark thought comes. On yon green sward
  In a most vital match
I dropped a man before he'd scored;
  It was a sitting catch;
He made a hundred. I have known
  Much sorrow since and kissed
The penal rod, but I bemoan
  Still, still that man I missed.

But do you sometimes live again
  Those hours when we were free
To gather with our pipes and drain
  The bland but social tea?
And stands the popshop where it did
  Whither one hastened down
To glean a temporary quid
  For a mild day in town?

We long have walked our several ways
  And are not like to meet,
But, brethren of those early days
  Whom from afar I greet,
May it be ours again to mix
  As oft of yore, and swop
In some great tea-squad o'er the Styx
  Old memories of The Shop.

DUM-DUM.

GERMAN VIEWS ON THE DUTIES OF ENGINEER UNITS IN MASSED TANK ATTACKS.

By BRIG.-GENERAL SIR JAMES E. EDMONDS, C.B., C.M.G., D.LITT.

THE German views on the duties of engineer units in massed tank attacks, here stated, have been compiled from books recently published, but mainly from *Angriff mit Kampfwagen* by Oberstleutnant W. Spannenkrebs, published in 1939.

Engineer units must be attached to tank formations for battle. In a particular instance dealt with, a motorized engineer battalion was attached to an armoured division consisting of two armoured brigades, a motorized cavalry regiment, a light artillery regiment (containing three of our "regiments"), signals, an aeroplane flight, an A.A. detachment, etc. The engineers must be transported in armoured cross-country vehicles, with all the material required to carry out the special demands which will be made on them in a massed tank attack.

Tanks invariably move to their deployment area under cover of darkness, so the roads to be used by them to the front line must be made fit and if necessary others improvised. The enemy is certain to have organized special obstacles in any sector which is by nature favourable to tank attack, so measures must be taken to deal with them. The close co-operation of tanks and engineers is therefore necessary.

First, the engineers must ensure serviceable approach roads from the railway stations, or areas where the tanks are resting, to the positions of readiness. These positions must be cleared, bridged, etc., and be of sufficient size to allow the tanks to form up exactly in the same way as they will advance to the attack. This means depth as well as breadth.

From the positions of readiness plenty of tracks to the front line must be prepared, so that the tanks can start at once on a broad front and do not have to deploy in the face of the enemy; but facilities for a certain amount of lateral movement should not be forgotten.

The provision of assistance to the tanks once the attack has been launched is a more difficult matter. The first business then is to overcome the smaller natural and artificial obstacles *quickly*. A halt or wait on the battle field, if of any duration, is dangerous to tank formations: apart from artillery fire, it affords the enemy time to organize counter-measures. Engineers on foot can in certain circumstances assist the break-in of the tanks into the enemy's position, but they cannot keep up with tanks, and besides cannot carry the necessary material with them. Engineer units carried in unarmoured vehicles with a limited cross-country capacity will be held up by every machine-gun which springs up, as well as by quite slight difficulties of ground. Therefore the engineers must be transported in armoured cross-country vehicles with a material equipment suitable to the special requirements of the case.

Amongst the enemies of tanks, the foremost is the mine, and it remains to be seen what means the attacker possesses of eliminating this dangerous foe. A really effective one does not yet seem to have been found. According to some foreign opinion, the artillery must try to shoot lanes in the minefields.* But by firing shells with sensitive fuzes the ground is disturbed and the action of tanks will be cramped when later they go forward. As detonated mines give off smoke, by day a certain control of gun-fire is assured. The great objection to the above procedure is that the condition and exact extent of the minefields can seldom be known. The attacker must either first search for the mines or is compelled to shoot thoroughfares, systematically, in front of the main line of resistance. Further, any attempt at mine destruction by artillery and machine-guns costs much time and, more than that, daylight ; surprise is lost, and the early morning, which is the best time for a tank attack, cannot be used. All these drawbacks might be accepted if actual success could be guaranteed. By observed artillery fire the existence of minefields can in favourable circumstances be ascertained, but hardly more than that.

Another possibility is the employment of engineers to clear the minefields under protection of the other arms. This, however, is not worth trying, as like gun-fire it takes time, betrays the imminence of attack and, unless the exact position of the minefield is known presents many difficulties. Enemy fire on the clearing parties can never be entirely prevented. As the mines can be fired by men treading on them, the engineers would have an onerous task which might cost them many casualties.

Nevertheless, failing a better one being discovered, this method must be resorted to. It stands to reason that the engineers must be so equipped, protected, and supported that they can carry out their task.

It is certain that in all modern armies trials are being made to remove the mine danger to tanks. In this matter " mine finders " and " mine removers " must be distinguished.

* Fifty years ago, Captain Zalinski, U.S.A., proposed to clear lanes in sea minefields by means of his pneumatic gun-firing dynamite charges, and experiments showed that it did explode contact mines.

A "mine finder" is a vehicle which certainly can find mines, but cannot render a minefield in depth harmless. Even during 1914–18, an engineer tank was devised which pushed a roller in front of it. This was destroyed by the first mine it encountered and its usefulness came to an end. In Japan, experiments have been made with a tank steered from a distance. In attack, an unmanned tank is manœuvred at a controllable speed in front of every section of tanks. It can be guided round obstacles which are visible from a distance. If it has not been knocked out previously by fire, when it strikes a mine it ceases to be manœuvreable. If it meets a bad obstacle, which requires not only mechanical power but skill of the driver to overcome, it is more likely to break down than is a manned tank.

The use of mine finders certainly gives the leading waves of tanks a feeling of security. The reconnaissance work accomplished by such machines certainly provides some data for clearing work by the engineers; but the use of them has not yet solved the mine question.

A "mine remover" should be able to clear minefields in their whole depth by mechanical means. It is a matter therefore of devising a special tank which will detonate mines, but whose means of removing mines is not thereby destroyed. Such a vehicle has not yet been heard of.

It must not be overlooked that there will not be mines everywhere, and that they affect both friend and foe alike and limit the freedom of action of both parties. In particular, newly-arrived enemy formations and their tanks run the danger of entering their own minefields. In general, the defender will only lay minefields in the main battle ground, in the first place in front of the main line of resistance, and even these only at places where he has no intention of attacking for some considerable time. In any case, particularly in a war of movement, mines are a double-edged sword. Colonel Fuller has told us that in October, 1918, American tanks ran over a minefield, which the British Fifth Army had laid in the February of that year. Of 34 tanks of the 10th American Tank Battalion only 10 returned.*

Armoured vehicles must be provided for the transport of the engineers and their material, not forgetting mine-finding tanks. As these vehicles are specially exposed to the defender's fire, and on the other hand on the success or failure of the work of the personnel they carry will depend the issue of the tank attack, they must be very heavily armoured. Engineers in armoured vehicles with their apparatus, in trailers perhaps, must follow the mine-finder tanks in

* This incident is otherwise unknown to history; but certainly another Army which had laid mines was embarrassed when it was found in the advance in September that the site plans of the minefields had been mislaid. It was discovered, however, that the mine areas had been carefully wired off by the Germans and duly signboarded "Minenfeld gefährlich."

order to assist at once if required. Amongst other special tanks which are already in existence are bridging tanks and flame, projector tanks, as well as tanks for laying mines and discharging or projecting gas and chemicals. Materials should be carried to facilitate the passage of tanks without delay over simple obstacles such as wide ditches or small water courses. The position of these will usually be known beforehand from maps and air photographs. The attacker will also learn from these what major obstacles—excepting mines—will be encountered and direct his engineers accordingly. The engineer officers who are to take part, down to and including commanding officers of companies, must accompany the tank commanders when the preliminary reconnaissance is made by them. Some of the engineers must follow the first tank wave closely, in order to be on the spot if required.

In the attack of permanently fortified lines, the engineers following the first wave must try to penetrate between the "pill boxes," whilst these are shrouded in smoke, and put them out of action by firing special large charges carried for the purpose.

In defence and retirement they must prepare routes for the tanks which are detailed to counter-attack, or to cover the retreat.

GLASS FOR A.R.P. PURPOSES.

THE PROTECTION OF WINDOWS AND PREVENTION FROM GLASS SPLINTERS.

Compiled by the Editor *The R.E. Journal.*

WITH a view to ascertaining the behaviour of various methods of window protection against bombs, tests were recently carried out at the works of Messrs. Pilkington Brothers, St. Helens, the glass manufacturers, the results of which are of considerable interest to the general public, as well as to those whose task it is to design or adapt hospitals and other buildings which might be liable to damage by bombs.

One of the tests was carried out by exploding 2-lb. charges of blasting powder, 1 foot above ground level, at distances of 50 feet, 40 feet, 30 feet, 20 feet and 10 feet from a wall carrying window panes glazed with various types of glass and with glass reinforced or protected in various ways. (See Photograph 1)

It was assumed that the blasts would be more or less equivalent to those from a 500-lb. H.E. bomb bursting in the last three cases at distances 360–450 feet, 240–300 feet, and 120–150 feet respectively, though it was recognized that these estimates might be considerably in error.

Dimensioned sketches are included, together with explanatory lists showing the types of glasses and the nature of the " reinforcement " or " protection," if any, in the various apertures in the frames.

The blasting powder was in each case contained in a thin-walled glass flask of approximately 1 litre capacity, the neck of the flask being filled with clay over its whole length (4½ in. to 5 in.) so as to ensure that the flask would burst, the idea being to avoid any " squib " effect.

The glasses were mounted in the frame in the ordinary way, with putty, and to reinforce the putty, small strips of wood were nailed on all four sides of each opening in the frame.

THE TEST.

Explosion at 50 feet.

Specimens 1, 3, 7 and 9 were all four shattered. The glass splinters were, however, entirely held together by the mill-board backing on

No. 1, and were largely held together by the Cellophane strips on No. 3. Specimen 7, with paper strips on both sides, was shattered and a good deal of the glass had been torn out, though some remained held to the frame. Specimen 9 was entirely blown out.

The maximum distance to which the splinters had been projected in front of the wall was 10 feet. No other specimen was cracked or damaged in any way.

Explosion at 40 feet.

The glass and the mill-board in space No. 1 were completely blown out.

In No. 3 the glass was still mainly held by the Cellophane strips; from No. 7 most of the glass had fallen away. Specimen 16—¼-inch Special Hexagon Wired, ½-inch mesh—had cracked along four lines, making an irregular diamond shape, suggesting that the crack was due to some twist which had been suffered by the frame as the result of the blast. No. 23—18-oz. Sheet backed with mill-board, had been shattered and the glass with the mill-board had been torn out of the frame and was lying about 2 feet in front of the wall.

All the other specimens were intact.

1. 24-oz. Sheet, Mill-board on back.	2. 32-oz. Sheet.	3. 24-oz. Sheet "Durex" Cellophane strips on back.
4. ¼-in. Hexagon Wired, ⅞-in. mesh.	5. ¼-in. Special Wired, ⅜-in. mesh.	6. ¼-in. Special Wired, ½-in. mesh.
7. 24-oz. Sheet, Paper strips on both sides.	8. Double glazed 24-oz. Sheet with ¼-in. Georgian, Wired in front 1 in. space between.	9. 24-oz. Sheet, Surgical tape behind.

NINE SQUARES EACH 22″ × 18″

Explosion at 30 feet.

A good deal of the glass still remained in No. 3, but specimens Nos. 2, 4, 5, 6 and 8 still remained unbroken in frame No. 1. In frame No. 2, the 24-oz. Sheet (No. 10), the 24-oz. Sheet with wire behind (No. 13), and the 24-oz. Sheet with bar and Sorbo pad behind (No. 17) had all broken, most of the glass having left the frame. In all cases the glass had broken outwards towards the centre of the explosion.

No. 12—24-oz. Sheet with paper strips on both sides and No. 18—24-oz. Sheet with Cellophane strips on the back had shattered but a good deal of the glass still remained in the frame. In both cases the glass was bulged outwards.

None of the other glasses was damaged.

10. 24-oz. Sheet.	11. 24-oz. Sheet with paper strips on back.	12. 24-oz. Sheet with paper strips on both sides.	13. 24-oz. Sheet, Wired behind.
14. 24-oz. Sheet, Surgical tape on both sides.	15. ⅜-in. Special Wired, ⅜-in. mesh.	16. ¼-in Special Wired, ½-in. mesh.	17. 24-oz. Sheet, Bar and Sorbo pad at back.
18. 24-oz. Sheet, Cellophane strips on back.	19. ¼-in. Hexagonal Wired, ⅞-in. mesh.	20. ¼-in. Georgian Wired.	21. 24-oz. Sheet, Perforated paper behind.
22. 24-oz. Sheet, Paper strips both sides (staggered).	23. 18-oz. Sheet, Mill-board behind.	24. 24-oz. Sheet, Plywood shutter packed lightly behind.	25. "Armourplate."

SIXTEEN SQUARES EACH 15" × 15"

Explosion at 20 feet.

In the first frame, Nos. 2, 4, 5 and 8 remained unbroken, but No. 5—¼-inch Special Hexagon Wired, ⅜-inch mesh—had cracked. The cracks were more or less radial about a point near the middle of the glass, but the glass was not shattered, the number of radiating cracks being only seven or eight.

In window No. 2, specimen 14—24-oz. Sheet with Surgical tape—the glass was shattered but was held by the Surgical tape, which was still adhering strongly to the frame. No. 15—¼-inch Special Hexagon Wired, ⅜-inch mesh—had cracked along a number of parallel lines, again suggesting that warping of the frame might have been the cause of the cracking. No further cracks had developed in No. 16. No. 21—24-oz. Sheet backed with perforated paper—had been shattered and torn or burst outwards, but much of the glass was still held by the paper. No. 22—24-oz. Sheet with paper strips on both sides (staggered)—had shattered and blown out completely. All the remaining glasses, namely, Nos. 2, 4, 6, 8, 19, 20 and 25, were undamaged.

It was interesting to note that No. 3 still remained adhering to the frame. It was perforated in many parts, and hanging loosely on the Cellophane strips, but much less than half the glass had fallen away in spite of the fact that the glass shattered in the first explosion at 50 feet.

In No. 24—24-oz. Sheet backed with plywood shutter—the glass had shattered completely, but the plywood shutter still remained in position.

Explosion at 10 feet.

After the explosion at 10 feet the only glass remaining undamaged was the "Armourplate" specimen No. 25. All the Wired glasses were now cracked. No. 2—32-oz. Sheet—had been shattered, and the glass had been projected outwards to a distance of about 16 feet in front of the wall. Nos. 4 and 6 were cracked in a rather fine pattern and were slightly bulged outwards; No. 5, which had cracked in the previous explosion, had developed a few more cracks, but the pattern of the cracks was not so fine as in numbers 4 and 6.

In No. 8, the Georgian Wired Glass on the side facing the explosion had also cracked in much the same way as Nos. 4 and 6, and the back piece of 24-oz. Sheet had been shattered. It is interesting to note that the glass splinters of this piece of 24-oz. Sheet were found as much as 30 feet *behind* the wall and had evidently been projected very violently when the piece of Georgian Wired Glass in front of it cracked. Obviously a double-glazed arrangement with Wired glass outwards and plain glass behind, although resisting explosions to a very considerable extent, would be extremely dangerous to the occupants of the room if the explosion were sufficiently near to cause the outer wired glass to break.

In window No. 2 all the Wired glass specimens had cracked;

Nos. 19 and 20 were broken in a fine crack pattern, whereas Nos. 15 and 16 which had been broken in earlier blasts, had developed a few more cracks, but the pattern was not so fine as the pattern of Nos. 19 and 20. Nos. 19 and 20 also were bulged outwards, whereas Nos. 15 and 16 were practically flat.

As has already been mentioned, specimen No. 25—the "Armourplate" specimen—was the only glass remaining undamaged. All the glasses which had previously been broken and which were held in by strips of paper or tape, such as Nos. 3, 12 and 14 had been completely removed as the result of the explosion at 10 feet; the plywood shutter had also been projected about 20–25 feet behind the wall.

Summary.

The results of the tests as far as they go may be summarized by saying:

(1) that wired and toughened glasses exercise a much greater resistance to fracture by blast than any other type of glass;

(2) that no simple method of protection of glass against fracture by blast appears to be appreciably effective;

(3) that strips of paper, Cellophane and Surgical tape, also sheets of paper and mill-boards of various thicknesses, give a restricted measure of reinforcement, but their main value would lie in preventing injury due to flying splinters of glass. If, however, the glass burst outwards, as would appear likely in the majority of cases, prevention of flying splinters would not be of direct and particular interest to the inmates of a building.

The behaviour of example No. 8 is most interesting. Quite evidently double glazing might be very dangerous to the occupants of a building if the outer glass were stronger than the inner glass, as in this particular case.

It will be seen that windows are not strengthened appreciably by strips of paper or Cellophane or similar reinforcement. Rubber latex or lacquer coatings which would remain flexible over long periods, afford a limited measure of protection, but cannot be regarded as making windows safe. Fortunately, if a window is broken by a sharp explosion the tendency is for the glass to be sucked outwards by the suction wave which follows the compression wave due to the explosion.

To stop flying glass splinters in any satisfactory way, some form of loosely-hanging screen is essential inside the window, such as a ½-inch wire-mesh screen hanging three to six inches away from the glass, or a heavy curtain. Two or three sets of curtains separated by two to three inches would be more effective than a single curtain of the same total weight ; these could be made of some quite cheap material, such as hessian.

Wire Reinforced Glass.

Wire reinforced glass in Government Buildings near St. Paul's Cathedral, in the explosion last summer, remained in position though cracked, when other types of glass further from the explosion were smashed and destroyed. This type of glass is being used in important Government factories, telephone exchanges, etc., and is recommended in the Government publication *War Time Lighting Restrictions*.

Further proof of the value of Wired Glass is indicated in the Home Office publication, A.R.P. Handbook No. 5, *Structural Defence*, official tests having proved that Wired Glass offers considerable resistance to blast pressure from 500-lb. to 1,000-lb. bombs bursting on the surface of the ground at distances from 50 to 100 feet or more.

Wired glass as a fire-resisting material has been approved by the London County Council. With such a valuable material to hand, it would appear that to glaze buildings subject to blast with Wired glass would constitute at least an important safety factor when considering the question of the assessment of war damage and compensation both for lives and property.

Glass Bricks.

Contrary to popular belief, there are in existence other forms of glass which show considerable resistance to blast and, in buildings which have to be especially strongly protected, the complete sandbagging of windows and the shutting out of all daylight is not necessary.

For instance, Glass Bricks can be used where a window is to be made absolutely gas-proof without excluding light. Glass Bricks set in concrete frames have been proved by official and private tests to offer considerable resistance to blast and they and other forms of blast-resisting glass are referred to in Home Office publication A.R.P. Handbook No. 5, *Structural Defence*.

In several London hospitals, windows opening on to landings where special protection is required, have been partially bricked up, leaving a narrow vertical slit which is glazed with Insulight Glass Bricks. Light floods in through the glass bricks, thus affording considerable economies in artificial light, while at night the small aperture is easily and inexpensively blacked out.

Glass Bricks have been tested for fire resistance at the Building

1.—The Windows.
Front View. Before Test.
N.B.—This photograph does not refer to the particular test here described.

2.—Glass Brick Panel after an all night fire at Kendal Milne's, Manchester.

Glass for ARP purposes 1 & 2

3.—Glass Bricks for A.R.P.
The picture shows a method of protecting windows without excluding daylight at St. Stephen's (L.C.C.) Hospital, Fulham. The windows are partially bricked up, leaving a narrow vertical slit which is glazed with glass bricks.

4.—Glass Bricks for A.R.P.
An interior of a window on landing, using glass bricks.

Glass for ARP purposes 3 & 4

Research Station, England, and have been classified Grade D, under the conditions of the British Standard Fire Definitions 476, as a fire-resisting material.

Photograph No. 2 of Glass Bricks at a recent all-night fire at Kendal Milnes, Manchester, indicates the way they stand up to fire conditions.

"Armourplate" Glass.

"Armourplate" Glass—the glass which bends without breaking—has also been officially tested and found to be highly resistant to blast pressure, *vide* A.R.P. Handbook *Structural Defence.*

Amongst other tests to which this product has been subjected are the following :—

1. Flexibility. On a machine a piece of "Armourplate" 43 by 10 in. can be twisted through an angle of 12° in each direction, at the rate of 750 reversals per minute.

2. Bending properties. Equal loads give the same deflection on both "Armourplate" and Plate Glass, but the "Armourplate" withstands a much greater load and a correspondingly greater deflection before fracture.

3. Impact tests. These are usually applied by dropping a steel ball on the centre of the plate supported near its ends, and for ¼-inch glass the ball can be dropped about seven times as high for "Armourplate" as for Plate Glass before fracture. A piece of ordinary Plate Glass 1 inch thick was broken by a ball weighing 1 lb. 10 oz., dropped from a height of about 18 inches, while an "Armourplate" portlight ½-inch thick was unbroken by the impact of the same ball dropped from a height of 12 feet.

"Armourplate" has been used by the Services where light or vision is essential in places exposed to blast. Its resistance to blast or wave shock is five to six times that of ordinary Polished Plate Glass of the same thickness and it also withstands sudden large changes of temperature far better than any other type of glass. If broken, it disintegrates into innumerable small pieces, which are neither large enough nor sharp enough to cause serious injury.

There is also $\frac{13}{16}$-inch thick "Triplex" "Armourplate" which consists of three layers of "Armourplate" glass laminated by interplies of cellulose acetate and available in sizes up to 30 by 20 inches. This laminated "Armourplate" is not bullet-proof, but it affords considerable protection against flying splinters. If the outer layer of glass were broken by a splinter, the second and third layers would remain intact, unless the splinters were very heavy or travelling with high velocity, and the unit would not only remain gas-proof but would still permit vision.

" Armourlight " Roof and Pavement Lenses.

One of the most astonishing results from the A.R.P. point of view, however, is shown in tests on " Armourlight " Roof and Pavement Lenses. These Lenses used on concrete roofs have been shown to withstand the action of thermite and electron incendiary bombs. In these tests the bombs were placed on the " Armourlight " Lenses and allowed to burn out. The Lenses prevented percolation of any incendiary material and cracked only on cooling, and being fixed in concrete, they remained in position and gas-tight. Tests employing double-glazing with toughened lenses—to withstand impact and possible shattering of the top lens—have been carried out with entirely successful results.

" Armourlight " is the Manufacturer's registered trade name for toughened moulded and blown glasses. The process of toughening moulded and blown glass is a development of the " Armourplate " process. The " Armourlight " Lenses referred to are ½-inch thick and, in addition to being resistant to extreme thermal shock, are approximately twenty times stronger to impact than ordinary annealed lenses of similar type.

Recent official tests have been carried out on " Armourlight " Lenses which have proved that they will resist blast from a 500-lb. to 1,000-lb. bomb detonated at distances of 50 to 100 feet.

NOTE.—The accompanying photographs are reproduced by the kind permission of Messrs. Pilkington Brothers, Ltd., St. Helens, Lancashire, who also furnished the information for this article.

PUBLIC ADDRESS EQUIPMENT.

By CAPTAIN W. H. WARING, R.E.

I.

THE lay mind is apt to associate loudspeakers only with wireless, and so to regard them as things of mystery, understood by none but the elect, with which the ordinary human being is not concerned except as a passive listener. It is true that every domestic radio set includes a loudspeaker and a sound amplifier, and that the technique underlying these things received its greatest stimulus from the development of broadcasting, but beyond this there is no indissoluble bond. Actually the loudspeaker, entirely apart from wireless in any shape or form, is an exceedingly useful tool which makes itself invaluable in a great many departments of everyday life. That it can also constitute a powerful annoyance is a reproach which it shares with many another of the blessings of modern science.

In the ordinary telephone, a microphone at the sending end translates audible sound into an electrical facsimile. This is able to travel along wires over a long distance to the receiving end, where a a telephone earpiece translates it back into its acoustic form, sufficiently similar at least to the original to be recognizable. Once in the electrical form, however, more tricks can be played with it than merely transmitting it to a distance. Among other things, it can be greatly magnified, without being materially altered, by an amplifier, consisting of a train of thermionic valves, which are simply instantaneous relays of linear behaviour. If it is then passed to a loudspeaker, which is no more than an enlarged telephone earpiece, capable of handling a considerable amount of power, the sound will be reproduced at a substantially greater volume than the original.

A public address equipment is primarily a short-distance loud-speaking telephone working on this principle, the object of which is to enable a speaker to address a larger or more scattered or more distant audience than he could with the unaided voice. Its utility is often extended by working with an input signal derived from some source other than a microphone, such as from a gramophone record by way of an electric pick-up, in which case the apparatus becomes a high-powered electric gramophone. It can also be fed if desired with a radio signal, but only when this is being done is there anything "wireless" about the equipment at all.

The wide range of activities occurring in a peace-time military station in which a P. A. equipment can make itself useful, may be illustrated by mentioning some of the purposes for which a set kept at the S.M.E. has been employed during the last few months. The list is by no means exhaustive and new applications are continually turning up.

(1) Giving talks to accompany demonstrations to audiences in the open, *e.g.*, on the fieldworks ground.
(2) Providing music from gramophone records for drill and massed P.T. on the barrack square.
(3) Controlling, by word of mouth, tactical exercises in the open, rifle range practices, M.T. columns on the march and similar operations.
(4) Providing sound effects from records to enliven exercises and demonstrations, *e.g.*, sounds of machine-gun fire and zooming aeroplanes.
(5) Making announcements at sports meetings and other kinds of gatherings, both out-of-doors and indoors.
(6) Providing incidental music at all sorts of functions.
(7) Giving really audible instruction in noisy places such as workshops.

The purpose of this article is not to go deeply into the technical aspects of the amplification and reproduction of sound. It is rather to cover some points of practical application and working, designed to help any R.E. officer who needs to buy or borrow P.A. equipment and use it, and to give the benefit of a rather limited personal experience.

II.

Perhaps the first question to be considered is, how much noise is required for a given purpose, and how much power is needed to produce it?

There is a fairly close analogy between the distribution of sound and illumination, but, unfortunately, it cannot as yet be extended to the simple calculation by which, starting with the intensity of illumination required, one arrives at the size of lamp needed. There is a unit of loudness of sound, the phon, which corresponds to the foot-candle in illumination, although to suit the characteristic of the ear, phons follow an approximately logarithmic scale and not a linear one. But there is no means of expressing the quantity of sound emitted by a loudspeaker in units corresponding to lumens or foot-candles, and even if there were it would be extraordinarily difficult to measure. Even phons can only be measured by elaborate and costly apparatus of which not more than a few specimens exist.

What can be measured simply and directly is the electrical power which is developed by the amplifier and passes to the loud-speaker. This is in the form of alternating current, of a mixture of widely varying frequencies it is true, but capable of being indicated by straightforward electrical instruments. Amplifiers are always rated by the power in watts of sound-frequency A.C. which they can produce without any material degree of distortion. How much volume of sound a loudspeaker will emit with a given power fed to it depends on its electro-acoustic efficiency, which varies widely with different types. The loudness at the ear of the hearer depends further on the manner in which the loudspeaker distributes its sound, just as intensity of illumination depends on the type of lamp fitting employed.

The best guide one can give therefore is to indicate the sort of thing that a set of a given power rating can do in practice. It is generally considered that the minimum "undistorted" power that is of real use for P.A. purposes in the open is 10 watts. The set belonging to the S.M.E. is rated at 15 watts undistorted, and though this is not a generous allowance, it is sufficient for most of the work it has to do. With this set a high efficiency projector loudspeaker, mounted on the 600 yard firing point, can be heard all the way down the rifle range even when a good deal of firing is going on. In fairly quiet conditions and in still air every word can be heard distinctly and without effort at a range of a mile or more in the direction in which the horn is pointing. Another loudspeaker, also of high efficiency, but distributing its sound in all directions horizontally, was used in the middle of Brompton Barracks Square at a public display in connection with the R.E. at home. It was heard well by an audience 4,000 strong round the perimeter of some 100 yards by 50 yards, even above the noises made by M.T. on the move and a S.B.G. bridge being erected in racing time, but the 15 watts was only just sufficient for the purpose and 50 or 100 watts could have been used with advantage. Indoors, using low efficiency loud-speakers, 15 watts is more than sufficient to fill a moderate sized hall or small theatre with all the volume of sound required in normal circumstances. A great deal, however, depends on the amount of prevailing noise with which the apparatus has to compete. The loudspeaker on the barrack square was quite defeated by the massed bands with bugles in full cry, and the same equipment was barely audible in the gymnasium at the garrison children's party.

It should be realized that, even when the equipment is going full blast, the average power fed to the loudspeaker is probably no more than a fraction of a watt, and only occasional loud peaks come anywhere near the maximum of 15.

It is interesting to compare this with the power ratings of domestic radio receivers, realizing that the hornless loudspeakers with which they are equipped have a low efficiency. The general run of low-priced mains-operated sets can give an output, alleged undistorted, of about 3 watts, and battery-operated sets, whose power is expensive and must be conserved, produce about one watt. There has been a tendency recently to increase power capabilities, in an effort to avoid occasional distortion, up to the neighbourhood of 5 or 8 watts, and high-grade sets, capable of giving full orchestral volume and realism in the home, go up to 12 watts or more. One watt, however, will fill a small living-room with all the noise that is generally desirable, and the average power level for comfortable fireside listening is round about 50 milliwatts.

For public address purposes, the more power one has available the better. There is, of course, no need to use all of it, since the most powerful set can be tuned down to a whisper if necessary, but it is good to have an ample margin. Cost increases, of course, with power, but it is far from being in proportion. So also does the current taken from a battery when one is used as the source of supply, and this may impose a limit. Apart from this consideration, 30 or 50 watts will be found a convenient rating for general use, though 10 to 20 watts will cover most purposes.

Since the ear is approximately logarithmic in its response, the apparent loudness is not in proportion to power, and a power increase of 26 per cent, representing 1 decibel, is about the least which the ear can appreciate. Power must be increased in geometrical progression, *e.g.*, 10, 20, 40, 80 watts, etc., to produce equal steps in sound intensity.

III.

The heart of the P.A. set is the amplifier. There is no occasion here to discuss its inner workings, or to go into it in much more detail than is shown in Fig. 1. It is sufficient to regard it as a box of tricks into which a signal enters by one of the input channels to emerge at the output substantially unaltered but enlarged to an extent controlled by one of the knobs that emerge from it, known as the volume control.

The amplifier needs a supply of electric power, which may come from supply mains or a battery according to the type. Two types of mains-operated sets are available, that which works on A.C. only, and the "universal" type which works on A.C. or D.C. at will. The former is potentially the better of the two, since in it the voltage applied to the valves can be transformed up to any desired extent, whereas in the universal set the maximum voltage available is that of the supply. It is not impossible, however, to design a universal set to do all that is required, and recent developments in technique have enabled this type to compete on very favourable terms, provided the supply is not less than 200 volts. At least one manufacturer of good sets concentrates on it to the exclusion of the A.C. only type.

The D.C. only variety is a rarity nowadays, having been superseded by the universal.

The power demand of a mains-operated amplifier is of the order of ten times its rated output in watts. Even a moderately large set may thus be supplied from a lighting point, and the running cost is small.

When a main supply is not available, the set must be run from

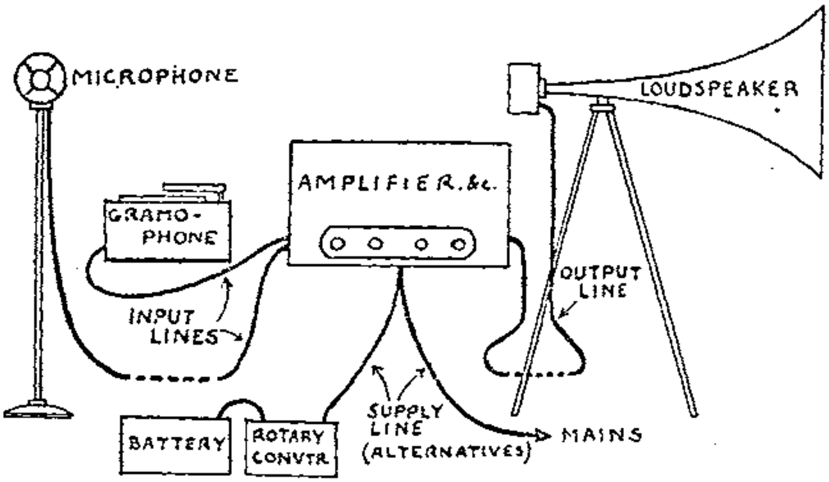

FIG. 1.—Components of a Typical Public Address Equipment.

batteries. High-tension batteries are out of the question on the score of bulk and weight for portable P.A. apparatus, and the supply takes the form of a low-voltage accumulator with the H.T. supply derived from it through a vibrator or rotary converter.

What one requires in practice is a set which can be used on the mains or a battery at will. One then has the choice between a set primarily designed for batteries but adaptable to the mains, and a mains set adaptable to battery supply. The former will be the more economical in battery current, and there is at least one set on the market developing 15 watts output with a demand of no more than 5 amps on a 12-volt battery. This type of set is ideal for purely mobile work, but its adaptation to mains supply is not entirely straightforward, and where much work is done on the mains the choice more often falls on the second alternative. One then has an ordinary A.C., or possibly universal set, supplied with A.C. from a portable rotary converter when necessary. Suitable small converters are available, working on any D.C. voltage from 6 upwards. Their efficiency is seldom better than 50 per cent, so that a 15-watt set will need somewhere about 300 watts, or 25 amps from a 12-volt battery. This is more than one cares to take from the battery of a car or lorry, except for very short periods, and it generally means carrying about a special battery for the purpose.

A similar converter taking D.C. at mains voltage can be used to run an A.C. only equipment from D.C. Mains.

An amplifier has certain controlling knobs, at least one of which will be the volume control already mentioned. In the simplest case with two inputs, which can be used one at a time, but not mixed, there will be a two-way switch marked "microphone" and "gramophone," or the control may be of the cross-fader type, working in the manner of a two-way tap. If provision is made for mixing two or more inputs, there will be a control for each of them and possibly another controlling them all simultaneously. There will be a main switch controlling the power supply, and preferably a second switch for silencing the set without turning off the main. The number of tone controls fitted may be none, one or two. None at all gives the least scope for mishandling, but to get the best results there should be two, one for treble and one for bass.

There are times when one has to think about the transformer which couples the amplifier to the loudspeaker. It is generally housed in the amplifier, and has to be of such a ratio as will correctly match the resistance of the loudspeaker to that of the output stage of the amplifier. If the matching is wrong there will be a loss of power and probably distortion of sound. Therefore if one is going to use different loudspeakers on different occasions, or to have sometimes one and sometimes two or more in series or parallel, it may be necessary to alter the transformer ratio. The ideal arrangement would be a tapped output transformer with the tappings easily changed and clearly marked with the resistance they suit, but this is seldom done, and one cannot always find out what the resistance of a particular loudspeaker is.

When the output valves are triodes a certain amount of latitude may be allowed, but pentodes are apt to be rather critical. Fortunately, there is a tendency to standardize the resistance of horned loudspeakers at 15 ohms, though hornless ones are generally lower. The latter type is sometimes supplied with its own tapped transformer built in, in which case one does the necessary matching here and not on the transformer in the amplifier.

The resistance referred to above is the dynamic, not the static or ohmic resistance. It is the apparent resistance of the instrument when working, analagous to that of a motor when running, including the effect of back E.M.F., and is not easily measured. It is sometimes said that the dynamic resistance may be taken as twice the static, which is, of course, quite easy to find. This is rather a guess, but better than nothing.

IV.

Although there are many types of mechanism available, it is very seldom now that anything but the moving-coil electro-magnetic loudspeaker will be met with. The field magnet which forms part of

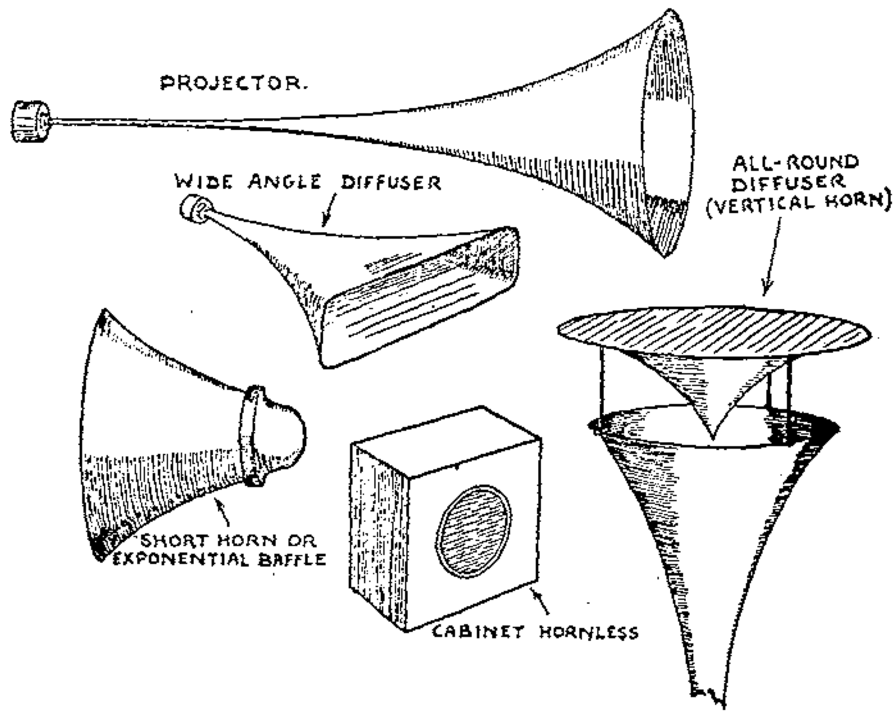

FIG. 2.—Types of Loud-Speaker.

this is often of the energized type in cases where the loudspeaker is housed in the same box with the amplifier or its power equipment. Energizing current is then available on the spot, and the field winding can be made also to act as a smoothing choke. But where the loudspeaker is separate and fed through a length of cable, as is usual in P.A. work, a permanent magnet saves complication and is nearly always employed. Permanent magnet materials have been developed to such an extent that an electromagnet no longer has any great advantage.

Loudspeakers may be horned or hornless. Briefly, the horn type has a high electro-acoustic efficiency (20 to 50 per cent), and can give the most perfect reproduction when size and weight are no object.

A horn 20 ft. or more long, with a mouth opening of several square yards, made of material perfectly rigid and acoustically dead, would be ideal. Horns for P.A. work are commonly 3 to 6 ft. long, made of spun metal, and have inevitable shortcomings. Their reproduction of music, though it can be tuneful and pleasing, would hardly satisfy a critical ear, owing to their failure to give full value to the bass, and there may be some tone coloration due to resonance of the horn material. On speech, however, they can be very satisfactory, since here the extreme lower register is not only not needed, but is often better suppressed.

The hornless loudspeaker, if well designed, can give a good level response over the whole audible range, including the extreme bass, and yet be kept within modest dimensions, such as a cabinet 2 ft. square or less, but good reproduction is obtained at the cost of efficiency, which is of the order of 2 to 5 per cent only. Hornless instruments capable of handling high power (*e.g.*, 10 watts or more) are often called " concert " or " auditorium " speakers.

The choice between the two types depends as much as anything else on whether outdoor or indoor reproduction is required. Out of doors, a large output of sound is required, generally from portable or semi-portable apparatus with a limited electrical power output, and, except in the case of band relays, the chief requirement is likely to be a highly intelligible speech. The horn speaker is the better performer for this purpose. Indoors, however, less acoustic output is needed, the higher sound level makes any imperfection in reproduction more noticeable and more offensive, bulk is more inconvenient, and the choice falls on the hornless type, particularly if music is involved.

An equipment to cover all purposes may well consist of one amplifier provided with alternative loudspeakers, horned for outdoor and hornless for indoor use.

There is an intermediate type which consists of a driving unit like that of a hornless instrument coupled to a short wide-throated flare, which may be regarded as either a short horn or an exponential baffle. This is favoured in some quarters for general purposes.

In their manner of emitting sound, horned loudspeakers may be projectors or diffusers, terms which largely explain themselves. A projector is a straight, narrow-throated horn with a gradual rate of expansion, circular or square in section, mounted horizontally and emitting most of its sound in a fairly narrow beam. The form of the horn is highly efficient and it has great carrying power, being at its best, of course, in addressing a fairly compact audience at a distance.

A wide-angle diffuser may consist of three or four small projectors radiating outwards, or a single horn of flattened rectangular or oval section, the purpose being to give an even diffusion over some 120 degrees in a horizontal plane while keeping the sound concentrated in the vertical plane. This is probably the most useful type for general purposes.

The all-round diffuser is ideal for serving an audience lined up round the perimeter of an area, as often occurs in demonstrations, provided the loudspeaker can be placed in the middle. It may consist of a large number of projectors or a smaller number of wide-angled diffusers radiating in all directions. Another type is a horn like that of a projector, but mounted vertically with a conical deflector in its mouth, to throw the sound out in all directions horizontally. When mounted mouth upwards, as in practice it must be when standing on the ground to bring the mouth up to a reasonable height, this type unfortunately acts as an efficient rain gauge, and in spite of the deflector the business end quickly fills with water on a wet day, to the detriment of long life and performance. This drawback, and also any encumbrance of the ground, can be overcome if it is possible to hang the horn mouth downwards from overhead.

Horns should always be mounted with their mouths well above ground level, at least as high as their length, otherwise a large part of the sound is absorbed by the earth. Suitable tripods are generally sold with them.

There are certain types on the market of an intermediate character, known by such terms as wide-angled projectors and projecting diffusers. Their names indicate their characteristics well enough.

Hornless loudspeakers act in general as diffusers, emitting a fairly even volume of sound both in front and behind. They have an inherent tendency, however, to focus the higher notes only into a narrow beam, which accounts for the fact that their reproduction often sounds more clear cut and distinct from immediately in front than it does from the side. In many modern types steps are taken to prevent this selective focusing.

The short-horn or exponential baffle type also acts as a diffuser in a forward direction, but throws little of its sound backwards.

V.

Of microphones there are two types in common use, the carbon (usually transverse current), and the electro-magnetic (moving coil).

The carbon microphone is highly sensitive and calls for fewer valves in the amplifier than do other types, to give equivalent results. It needs a small D.C. polarizing current, which is generally provided automatically from within the amplifier ; if it is not, a small battery must be used. The chief drawback of the type is its noisiness, which takes two forms. There is liable to be a continuous background hiss, though this is small in good modern specimens, and it produces crashing noises if anything is done to disturb the carbon granules. It performs well when mounted on a shock-absorbing stand and left severely alone, but it should not be touched or moved when in use, and it is unsuitable for use in the hand or where there is vibration.

The moving coil microphone is less sensitive, since it is merely a converter of energy like a dynamo, not a relay like the carbon type, and it therefore needs more amplification. But it is quite free from noisy habits and can be used in the hand or carried about without ill effects. Being less easy to use badly, it is possibly the better type for general purposes.

Both types are good on the score of quality of sound if they are good specimens, but a cheap and nasty electro-magnetic microphone is, in general, worse than a carbon one of the same price.

The early stages of the amplifier and its input circuits must be designed to suit the particular type of microphone, and consequently an odd microphone and amplifier should not be connected together unless one is prepared to make the necessary alterations. In some cases these parts of the amplifier are made into a separate " feeder-unit " or " pre-amplifier," which may be regarded as part of the microphone. This makes the equipment more flexible but adds complication.

In their outward performance microphones fall into two classes, " pressure " and " velocity." The pressure type is the commoner and has a diaphragm which is exposed to the atmosphere on one side only, and which moves in response to air pressure, like an aneroid. It is sensitive to sound coming from any direction, though naturally rather more so from in front than from behind. The velocity type has a diaphragm exposed to the air on both sides, which consequently is unaffected by pressure but responds to the velocity component of a sound wave. It is therefore fully responsive to sounds coming from in front or from behind, but quite deaf to anything arriving edgeways. It is also little affected by any general uproar arriving from all directions at once and impinging equally on both sides of the diaphragm. The advantages of a microphone which can turn a deaf ear to an unwanted noise are obvious, but it is awkward when an announcer wanders inadvertently into the insensitive zone.

The commonest version of the velocity type is the velocity ribbon microphone, an electro-magnetic instrument in which a metal ribbon functions as both diaphragm and moving coil. It is much favoured for studio work at the present time, but it has the drawback of being fragile, and once dropped it is seldom the same again.

Though microphones vary widely in their sensitivity, this does not in itself affect the user greatly, since a sensitive microphone with a low gain amplifier or an insensitive one with a high gain amplifier may well come to exactly the same thing. But the overall sensitivity of the microphone-amplifier combination needs to be chosen with a view to the job to be done. There are various ways of expressing this in mathematical terms, none of them altogether satisfactory or very informative to the non-expert. It will generally be found, however, that P.A. equipments for normal purposes are so arranged that an ordinary conversational tone of voice uttered about one foot from the microphone will load the amplifier up to its full rated output. It should be realized, in passing, that injecting more noise than this into the microphone will merely overload some part of the equipment and cause distortion, without producing any usefully greater volume of sound from the loudspeaker.

More and less sensitive combinations are required for specialized purposes. For instance, relaying a band or a number of speakers grouped round a single microphone, but none of them very close to it, calls for high sensitivity. On the other hand, when an announcer is among a crowd or in a noisy place, he is better with an insensitive combination, and a microphone which he can hold very close to his mouth without overloading it, so that it hears him and little else.

VI.

Gramophone components, consisting of a turntable and pick-up are sometimes built into the amplifier, and sometimes form a separate unit. The former means a saving in total bulk, but generally makes the interior of the amplifier rather inaccessible. Where the gramophone part is only required occasionally, a separate unit is more convenient.

The turntable may be clockwork or electric. Clockwork needs winding but takes no current, and saves connecting wires for the motor supply when the gramophone is separate. Electric turntable motors are either of the commutator type for A.C. or D.C., or the induction type for A.C. only. The former must be used in conjunction with a "universal" set, but commutators are liable to generate electrical interference and should be avoided unless necessary. Turntable motors take about 20 watts as a rule.

Two types of pick-up are in common use, the piezo-electric or crystal, and the electro-magnetic type. The former is the more sensitive, needing fewer valves for amplification, and it is capable of very fine performance. But comparative tests of various equipments at Chatham, and a few months' experience with one, have bred a dislike of the piezo pick-up, which seems to be associated with a shrill, harsh effect, suggestive of harmonic distortion. Apart from this, or possibly accounting for it, is the fact that crystals are fragile and will not stand knocking about, and when damaged they give low volume and distortion. They are, however, easily renewed at small cost.

Electro-magnetic pick-ups are more robust and do not suffer in this way. They are sometimes said to be hard on records. They are liable to deteriorate with age through the perishing of their rubber mechanical damping devices.

Apart from the inconvenience of frequent changing, ordinary loud-tone steel needles are as good as any, and better than many fancy kinds. In the needle-armature type of pick-up, where the needle actually forms the moving iron part of the movement, steel ones must, of course, be used.

Most purposes can be served without indulging in luxuries such as duplicate turntables and pick-ups, or automatic magazine-loading record players.

The ordinary commercial "record playing unit," consisting of turntable and pick-up, housed in a suitcase type of container and sold for attachment to wireless sets, serves simple P.A. requirements perfectly well.

Good results must not be expected from worn or damaged records. Reasonable attention to care in handling, needle-changing and dusting will prolong their useful life.

VII.

The best placing of the components of the P.A. equipment must vary with each particular job. Normally one starts with the loudspeaker, placing it or them (there may be more than one) where the audience can best be served. Whether to use a projector or diffuser if both types are available, or a combination of the two, will depend on circumstances. Direction of wind may need considering. If the audience can be arranged to suit the loudspeakers so much the better.

The position of the microphone must be that of the announcer, and will be affected by whether he needs to see the audience or to be seen by them, or to see the demonstration he is talking about, and similar considerations. But what affects the placing more than anything else is the question of acoustic feed back. Briefly, the microphone must not be placed so that it hears the reproduced sound louder than the original. If it does, any sound entering the microphone will return to it a second time via the loudspeaker, louder than before. The process repeats itself, the sound gaining strength at each round trip, until within a second or two the loudspeaker is emitting a continuous howl.

It is seldom practicable or necessary to have the microphone completely isolated from the loudspeaker, although if this can be done so much the better. Howl can generally be avoided by intelligent placing. The arrangement shown in Fig. 3 would obviously be fatal, although it is one often suggested by people who have not come to an understanding of the matter. It would probably be all right if the microphone were behind the loudspeaker instead of in front. Horn speakers, particularly projectors, throw little sound backwards, and the microphone can generally be brought within 3 or 4 yards of it behind, though the minimum non-howling distance in front of it may be several hundred yards. Fig. 4 shows an arrange-

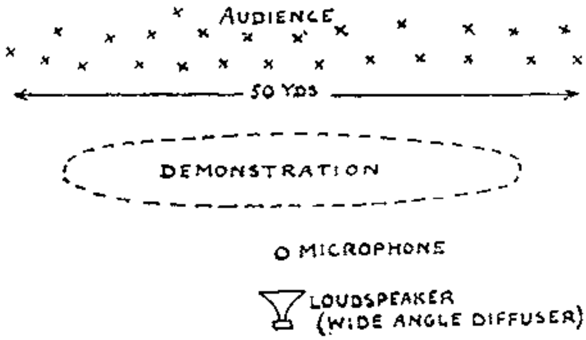

FIG. 3.—An Impossible Arrangement.

ment which very commonly proves the best and simplest. It also shows how a projector can be used to cover a strung-out audience, the horn being trained on the remote end of it, so that the nearer people are out of the strongest part of the beam.

Where the audience is scattered all over or round an area, the all-round diffuser placed centrally is often the best answer. This type

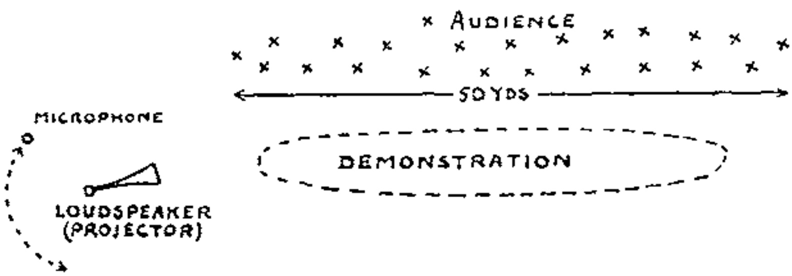

FIG. 4.—A Practical Arrangement.

has no quiet zone behind it, and the microphone must generally be placed outside the limits of the audience, unless it can be acoustically sheltered, as by being placed inside a building or behind a wall. A single central diffuser obviously needs a high power input if it is to serve a large area, and the difficulty may arise that if enough power is used to enable the people farthest away to hear clearly, those close by will be deafened.

One is often tempted to use two or more loudspeakers to serve a scattered audience, as in the case shown in Fig. 6, but this scheme will almost certainly be a failure. The chief drawback is that a large section of the audience will hear both loudspeakers at not very different strengths, but at appreciably different times, and to them speech will be unintelligible, and music a rhythmless and inharmonious blur. The effect is the same as if there were a very bad echo.

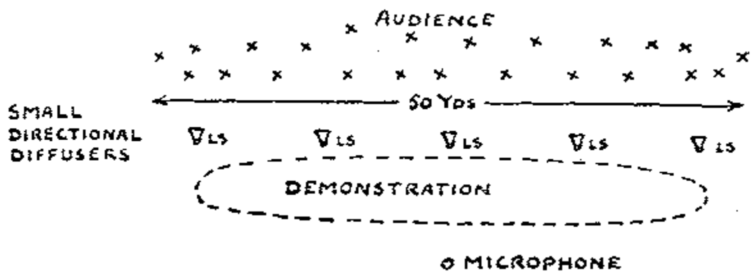

FIG. 5.—Good but Elaborate.

Another point about this lay-out is that it would be difficult to find a place for the microphone which was not in a strong field of sound from one or other of the diffusers. It is likely that better results would follow from using one of the loudspeakers only. The distribution of sound over the audience would be very uneven, but it

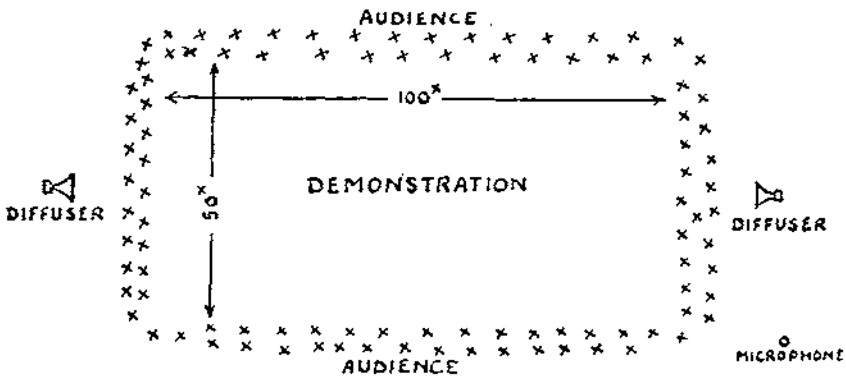

FIG. 6.—Bad.

should be possible to find a setting of the gain control which will enable everybody to hear within the limits of reasonable comfort.

Fig. 7 shows a much better arrangement using the same equipment as Fig. 6, but loudspeakers standing in the middle of the demonstration area, and the cables leading to them, might not be permissible. It might be worth installing a permanent line, buried or overhead, where the scheme is one often used, and it is sometimes possible to sling loudspeakers overhead, or to mount them on some existing structure, so that they do not take up additional space.

If multiple sources of sound are to be used, the echo effect is avoided by using a large number of low power sources spaced only a few yards apart, so close that at any point the two or three that are within earshot are heard simultaneously for all practical purposes. This method is shown applied in a simple form in Fig. 5 and it is fairly obvious that it gives the best distribution of sound with the minimum of power, since noise is made only where it is wanted. For the same reason it gives great freedom in siting the microphone.

In general, the best thing to do is to use a single high-powered source of sound for a temporary installation using portable apparatus, and multiple low power sources closely spaced for a permanent

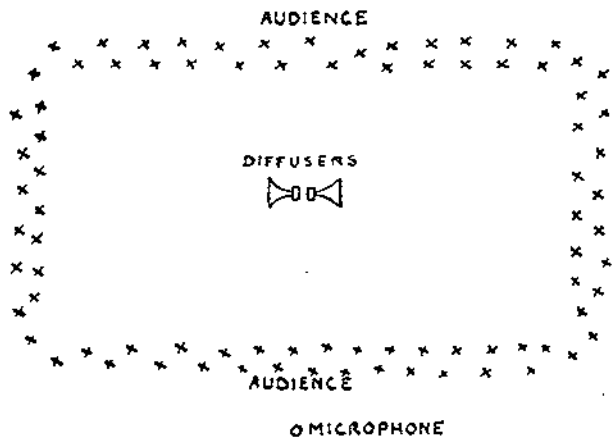

FIG. 7.—A Better Arrangement.

installation. A few widely spaced sources are bad, owing to the echo effect. This does not apply, of course, to the case where the audience is in two or more groups out of earshot of each other.

How near the microphone may be brought to the loudspeaker must be found in each case by trial and error. It depends on many factors, such as the sensitivity of the microphone, the gain of the amplifier, the output power of the loudspeaker and the manner in which it is distributed. It will depend, too, on the setting of the gain or volume control of the amplifier, and it will often be found that an arrangement which would howl with the volume full up will yet be quite satisfactory with the control at a lower setting.

Howling also depends on the outward behaviour of the microphone, and here the velocity type shows one of its advantages. Fig. 8 shows how loudspeakers may be mounted only a few feet from the microphone provided they are in its deaf plane. This is a very useful arrangement for use on a stage or platform. Alternatively, the characteristics of a velocity microphone can be turned to account by arranging it edgeways on to an interfering noise which is not to be broadcast, such as a pneumatic pick at a fieldworks demonstration, or an N.C.O. controlling the performers by word of mouth.

Loudspeakers connected up to work simultaneously should be correctly phased, that is to say, they must do their pushing and pulling of the air in step with each other. If they are out of step each will tend to cancel the effect of the other. Terminals should be marked or non-reversible plugs used, so that the units are always connected with the same polarity.

When the man at the microphone is in view of the audience, and its attention fixed on him rather than on what he is talking about, it is a good thing to try and arrange matters so that the reproduced sound appears to come from his direction. Fig. 6 is an example of this.

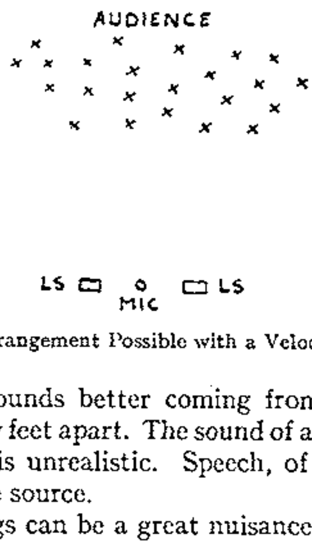

FIG. 8.—An Arrangement Possible with a Velocity Microphone.

Music generally sounds better coming from two or more loudspeakers spaced a few feet apart. The sound of a whole band emerging from a single point is unrealistic. Speech, of course, sounds more life-like from a single source.

Walls and buildings can be a great nuisance. A projector among buildings can produce extraordinary echo effects, as well as making it difficult to find a safe place for the microphone.

The amplifier can be placed wherever it is most convenient, which as often as not is close to the microphone. The operator can then switch on and off at the orders of the announcer, or the announcer can do it himself. But there is something to be said for placing it among the audience so that the operator can adjust volume and tone to the best advantage, or one may have a collaborator in the audience making signals to the operator. Sometimes the position of the amplifier is affected by that of the source of power supply.

Sooner or later, every user of a microphone gets caught out by broadcasting something not meant to be heard. The only safe way to avoid this is to have the set switched off at all times except when actually required. On the other hand, few things upset an announcer more than making a false start into a dead microphone. An alert operator can do much to avert contretemps. Attempts to muzzle a microphone by covering it with the hand or a hat are seldom even partially successful, and also produce thunderous noises from the loudspeaker, particularly if the microphone is of the carbon type. A microphone switch for the use of the announcer is a refinement which is not fitted as often as it might be, probably because it is difficult to prevent it from making a noise when used, and a red light to indicate when the microphone is alive is an even rarer luxury.

A set should always have not only a main switch for turning it on and off, but also a switch for silencing it temporarily, by interrupting the high tension supply or suppressing some part of the amplifier chain, while the main switch is left on. The reason for this is that indirectly heated valves take about half a minute to warm up and come into action when switched on from cold, but if the main switch is already on, the set can be brought into action instantly when required. A microphone switch, if fitted, will serve this purpose; the volume control will also do it, but it is often desirable to leave this alone once the best setting has been found. A silencing switch working on the H.T. supply is useful when the set is running from batteries, as it saves power during the silent intervals.

It is more difficult to find a good working arrangement indoors than out of doors. Sound in an enclosed space reverberates in all directions, and one may be hard put to it to get enough sound output without howling. Putting the microphone in a separate room, when this is possible, is often the answer. Arrangements light-heartedly requested by the uninitiated are frequently quite impossible.

(To be continued)

THE RESISTANCE TO COLLAPSE OF STRUCTURES UNDER AIR ATTACK.

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1.—INTRODUCTION.

THE necessity of ensuring that the buildings in factories are as resistant as possible to collapse when subjected to air attack, should need no stressing. While a direct hit on a factory can scarcely fail, by destroying plant or stores, to interfere to some extent with production, the damage will be much more widespread and costly if, at the same time, a main member is weakened and leads, as is possible, to the collapse of a large area of the structure.

Thanks to the somewhat conservative values of working stresses hitherto assumed in design in Great Britain, the great majority of modern buildings, though designed without any thought of attack from the air, will be comparatively resistant to collapse even when subjected to serious structural damage. Certain types could, however, be made much more resistant by slight amendments in design and detail which would not increase the weight of the structure appreciably.

No attempt is made in this Note to deal with particular problems but the attention of the designer is drawn to general points which he should consider when designing new structures, or when strengthening existing buildings.

The structures discussed fall into four main classes :—

(*a*) Fully-framed, steel or reinforced concrete, multi-story buildings.

(*b*) Single-story modern steel factory buildings.

(*c*) Older buildings, often partly framed and partly wall-bearing.

(*d*) Special types, such as erection sheds, with very long spans.

2.—FULLY-FRAMED MULTI-STORY BUILDINGS.

(*a*) Fully-framed steel or reinforced concrete buildings are comparatively resistant to collapse, since they are capable of adjusting themselves to heavy overloads for which they were not specifically designed.

(*b*) A near hit is unlikely to damage the main frame seriously.

It may demolish panel walls. These may fall inwards and produce a debris load which may cause collapse of an already heavily-loaded floor. Such a collapse will not be produced if the actual floor load carried is, as is often the case, considerably less than that for which the floor was designed. For instance, it has been possible to suggest, when dealing with basement shelters, that no strengthening of a framed building, steel or concrete, is needed :—

(i) where the actual load carried does not exceed 25 per cent of the superimposed load for which the floor was designed, and

(ii) provided that the floor was designed for a load of at least 80 lb. per sq. ft.

In a factory, the actual load may often exceed 25 per cent of the design load, but that design load may greatly exceed 80 lb. per sq. ft. Where this is so, the percentage can be increased above 25 per cent. As a rough guide, it may be laid down that where a heavy machine rests on a floor panel, and imposes on that panel a load approximately equal to the design load, the structure below that floor panel should be strengthened. The structure can be most economically strengthened, where space is available, by propping main beams and floor slabs. In the case of reinforced-concrete frames some care must be exercised in this propping, a knowledge of the position of the reinforcement being necessary, but the danger from high sheer stresses at the prop is not so acute as is usually supposed. Tests are being carried out on the strength of propped reinforced-concrete beams and more definite recommendations will be available in the near future.

(*c*) While a direct hit may wreck one bay of one floor, or more, complete collapse of a large part of the building is unlikely to follow even if some main members are cut. Debris is liable to fall in other bays, however, and, to reduce the structural damage, strutting as described in (*b*) should be considered in inside bays, even though no panel walls can fall on them.

(*d*) The resistance to collapse of framed buildings is due to the continuity in these structures, which is of a high order even in a steel frame with the usual, comparatively light, cleated connections. It may be said that wherever continuity can be introduced, it is desirable. For instance, in many factories there are gallery structures, carrying machines, the beams being supported on steel stanchions. The beams are not usually continuous over the stanchions but are connected into them or joined over them, as a rule, by web plates. If these connections were made to develop the whole strength of the beam, by welding or otherwise, resistance to collapse would be greatly increased, since, in many cases where this provision is made, complete failure of the beam would not follow even if a stanchion were cut.

3.—SINGLE-STORY MODERN STEEL FACTORY BUILDINGS.

(*a*) This very common type consists of lines of stanchions carrying roof girders—joist beams in small shops and heavy trusses in larger structures—on which the roof trusses rest.

(*b*) This type is not particularly vulnerable, but if an internal stanchion is cut the girders on either side will collapse, and may often involve an area of roof 100 ft. by 50 ft. or more. In many cases, a hit from a large splinter would cripple a roof girder and might bring down the roof trusses supported on it.

(*c*) These structures could be made much more resistant to collapse. In new construction, this would involve little or no additional expense. In existing shops, the alterations needed would depend on the details of the structure, but it should, in most cases, be possible to do a great deal at no great expense. Such work may necessitate the use of unorthodox joints.

(*d*) It must be remembered that these structures are designed to support the dead load of the roof, with wind loads and snow loads in addition, without a certain permissible stress, far below the yield stress of the material, being exceeded. What should be required of them, in addition, is the capacity of supporting the dead load of the roof only, when any one stanchion or any one main roof girder is cut by a direct hit. In this condition the usual permissible stresses can be safely exceeded. The simplified methods of calculation, used generally in design, are not well suited for the determination of the capacity of the structure to stand when damaged. An examination of the real strength of the structure must be made. It should be remembered, for instance, that failure does not necessarily take place when the yield stress of the material is developed at one section. It is probable that in many cases no increase in the weight of material in the main structure will be needed to ensure that collapse does not take place when one member is cut. Details, such as the connections from beam to stanchion, will, however, need revision and the most economical method will probably be to make the beams or trusses continuous over the stanchions.

(*e*) It has been stressed above that continuity is most desirable in structures which may have to resist air bombardment. The most efficient type is the rigidly-jointed frame or portal. The joints, in steelwork, can be made by riveting, bolting, or welding. Attention should be paid to the possibility of using this form of frame construction. Many structural engineers have had no experience of this form and may be under the impression that it is difficult to design. Advances have, however, been made in recent months and there are firms in the country capable of designing and fabricating portal frames quickly. Where heavy brick panel walls are demanded, as in certain vital buildings, their weight can be transferred to the bases of the stanchions, so making it possible to design the portals as fixed-ended. This leads to a considerable economy of steel. These portals can now be designed as quickly as any more orthodox structure.

4.—Older Buildings.

(*a*) Many older buildings, multi-story and single-story, though having steel beams and internal stanchions, have the ends of the beams or trusses carried on load-bearing walls. In these cases a direct hit on such a wall would have disastrous effects.

Additional resistance to collapse can be given by the provision of stanchions to support the beams if the wall is damaged. The best position for these stanchions depends on the distribution of any heavy loads on the floors and, of course, on the space available. In general, the best position is not in contact with the wall.

(*b*) Similar features to that mentioned in (*a*) are sometimes found in other types of buildings. For instance, in one works inspected, a shop mainly of reinforced-concrete frame construction was spanned by long steel joists supporting the roof trusses, the ends of the joists being simply supported on haunches formed on the reinforced-concrete columns. This is clearly objectionable, as a near hit would displace the ends of the joists with disastrous results. In such a case the joists should be so restrained that they could not move laterally relative to the stanchions.

(*c*) There are many older types of building which are not satisfactory and which do not lend themselves readily to improvement. In general, as reiterated above, the best steps to be taken are to provide as much continuity and bracing as possible in the load-bearing part of the structure.

5.—Special Types.

(*a*) Where there are excessively long span trusses supporting a roof, as in an erection shed, additional props may be needed, owing to the danger of existing stanchions being hit or a joint or member in the truss being cut by a direct hit.

(*b*) The principle of continuity explained above should be used as a guide in designing the propping system. Here again the object is to prevent complete collapse. Local over-strain in members is not seriously objectionable, so that it may not be necessary to insert props under every panel point. Strengthening of joints and additional counterbracing may further reduce the number of props required.

The greatest care must be taken to secure economy in this work. The structural designer, whose concern it has always been in the past to produce a structure with an adequate factor of safety, will probably not find it easy to consider with equanimity one on the point of collapse. There may well, therefore, be a tendency to over-strengthen the structure.

(*c*) Additional props and strengthening of the truss, as suggested in (*b*) above, appear to be preferable to the sand-bagging of existing members.

THE EMPLOYMENT OF DIVISIONAL ENGINEERS IN CONJUNCTION WITH OTHER ARMS IN WAR.

Lecture delivered at the S.M.E., Chatham, on 10th July, 1922, to the Senior Officers' Class by Brevet Major (now Brigadier) G. E. H. Sim, D.S.O., M.C., *p.s.c.,* R.E., Brigade Major, S.M.E.

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1.—NECESSITY FOR A CLEAR DOCTRINE OF ENGINEER EMPLOYMENT.

ENGINEERS exist solely to help the other arms to function. It is, therefore, most desirable that there should be some well-defined policy, doctrine, normal practice (call it what you will) governing the employment of engineers in conjunction with the other arms in war.

A lot of people are apt to jib at the word "Doctrine," but I think it is because they confuse it with the word "Dogma." A dogma is something we are asked to believe blindly without proof. A doctrine is something to be taught: evolved from accepted principles, logically deduced, based on experience and susceptible to variation in accordance with varying conditions.

The doctrine of engineer employment and the principles upon which it is based should be well known and understood, not only by the engineers themselves, but also by the commanders, staffs and troops of all arms. It is only where such understanding exists that the engineers of a force can be used to the best advantage.

The "Doctrine" crystallizes out into a "Normal Practice." Just as there is a normal practice for the supply of troops with rations and ammunition in the field, so must there be a normal practice for the employment of engineers, which everybody understands. The practice can, of course, be varied in abnormal circumstances, but it is advisable to stick to it, unless there is good and sufficient reason for departing from it. It will usually give the best results.

It is this "doctrine" or "normal practice" of engineer employment which we aim to put before you in this Course. You will find it clearly set out in *Engineer Training.* I want to explain the doctrine generally and the principles on which it rests, and, if possible, to enlist you as its champions.

2.—PRINCIPLES ON WHICH THE DOCTRINE IS BASED.

First let us see what are the principles on which any doctrine of engineer employment must be based. They are very few and very simple. They can, in fact, be boiled down to four. They are :—

(i) *Economy of Force.*
(ii) *Avoidance of Divided Control.*
(iii) *Continuity in the Execution of Works.*
(iv) *Conformity of Work to the Tactical Situation.*

There is nothing new or controversial about these four principles. A moment's thought will enable you to see that unless they are observed the work is bound to suffer. It is the application of them which presents so many practical difficulties, and attempts to dodge the difficulties by departing from the principles led to an enormous waste of engineer effort during the late war.

3.—Lack of a Doctrine before the War.

Before the war of 1914-1918 nothing was laid down anywhere as to how engineers ought normally to be employed tactically, except the somewhat nebulous doctrine that every main body of troops should have its complement of engineers, which was to assist the infantry (in particular) in every possible way. This was much too vague to be of any use. Some commanders and engineer officers had given little or no thought to the subject. Those who had thought about it evolved theories of their own, some of them sound, some the reverse of sound, and all different.

4.—Violation of the Four Principles and its Results.

During the early part of that war, therefore, this absence of an accepted doctrine led to various methods being employed by individual commanders, with the result that in most divisions, one might almost go so far as to say in all at that time, each of the four principles was violated almost daily.

Economy of force was conspicuous by its absence. The skilled engineers were frittered away on work, such as wiring the front line, which the other arms ought to have done for themselves.

Divided control was rampant. The engineers were usually serving several masters, who gave contradictory orders as to the work to be done.

Continuity in the execution of works suffered because there was no settled policy and in many cases the newcomer scrapped the unfinished work of his predecessor.

Work, in many cases, did not conform to the tactical situation because it was nobody's business to see that it did.

5.—Evolution of Two Schools of Thought.

As the war progressed, however, bitter experience led to the evolution of doctrines of engineer employment. I say " doctrines," in the plural, advisedly, because there were two of them, and they both obtained right up to the end of the war and both have their adherents and advocates still. To these two schools of thought I shall refer in future, for shortness, as the "Brigade Group School" and the "Divisional Control School."

(i) *The Brigade Group School.*—One school held that the way to get the best value out of divisional engineers was to attach a field company permanently to each infantry brigade of the division, to work under the orders of the brigade commander at all times. This resulted in the C.R.E. becoming in practice merely an adviser to the G.O.C. Division on questions of engineer policy and having no direct responsibility for the execution of engineer work. Having allocated all his engineers to brigades, he had none with which to carry out work not normally coming within the jurisdiction of a brigade commander unless he could persuade a brigade commander to lend him some.

(ii) *The Divisional Control School.*—The other school held that the best way was to concentrate the responsibility for all engineer work of the division in the hands of the C.R.E. and that he should normally have the field companies under his own hand to allot as he, under the general staff of the division, thought best for its execution.

It is this second system, namely, the concentration of the whole engineer problem in the hands of the C.R.E., that has now been officially adopted in our Army and on which the doctrine taught in *Engineer Training* is based.

6.—Comparison between the Two Systems in the Light of the Four Principles.

If we examine the two systems outlined above in the light of the four principles of engineer employment already enunciated, we will, I think, find that the Divisional Control System wins every time. Let us take each principle in turn and see which of the two systems is likely to give us the best results.

(i) *Economy of Force.*—There is always in war more engineer work to do than there are engineers to do it. But some is more urgent and important than the rest. It may be vitally urgent to concentrate all the engineer resources of the division on some particular work in one of the brigade areas, leaving the other brigades for the time being to fend for themselves. At another time it may be necessary to concentrate on work in which the brigades, at the moment, have little or no direct interest, such as rearward positions, artillery observation posts, burying cable for the signal corps, horse-watering points, preparations for demolitions far in rear in the event of a retreat, construction of roads, bridges, railways, inundations, hutted camps, etc. It is very difficult to arrange for this if every brigade has a vested interest in a field company and feels aggrieved if it is taken away, as it will if it is used to the Brigade Group System. The only person who can arrange that the engineer resources of the division are used economically (*i.e.*, used to the best advantage on the most important work at the most important place at the right time) is the C.R.E., after he has received his instructions from the general staff of the division. To enable him to put his plans into effect he must have his field companies at his disposal all the time.

It may at first sight appear that this " Economy of Force " will benefit the engineers at the expense of the infantry. Where the Divisional Control System was worked, however, infantry units soon came to take a great pride in doing without engineer assistance wherever possible, and they soon realized that it was to their advantage to set free the engineers for the work they could not do for themselves, but of which they reaped the benefit, either directly or indirectly, in the long run.

(ii) *Avoidance of Divided Control.*—This is a counsel of perfection in any case, and is usually unattainable in the case of the engineers. An engineer officer may consider himself lucky if he has to serve only two masters. This does not mean that he likes serving two masters. He gets used to it after a bit and puts up with it, but he does not like it. Under the Brigade Group System the field company commander always had two masters, the C.R.E. and the brigade commander, who often pulled opposite ways. When things were humming, the system could not be got to work at all unless all three, the two masters and the servant, were most tactful and reasonable beings. Any system which depends for its success on the tact and reasonableness of the individuals who have to work it must be radically unsound and liable to break down under stress. Take, for example, the case of a field company handed over to a brigade for an operation. The brigade commander makes his plan, which includes certain jobs for his field company. Everything goes swimmingly till the C.R.E. comes along and tells the field company commander that the division has ordered certain other work to be done at once and that he is to take half his company and get on with it. Not to do so will call down the righteous wrath of the divisional commander. To do so will seriously inconvenience the operations of the brigade commander, who is relying on having the whole field company for his own jobs and has made his plans accordingly. It may mean that some bridge that he is relying on to get his ammunition up at night will not get built in time. The result is generally a compromise. Neither job gets done properly and everybody is peevish about it. That is an example of divided control which occurred times without number during the war, where the Brigade Group System of engineer employment was in vogue. Under the Divisional Control System this difficulty is avoided as far as practicable. The C.R.E. has the whole of the engineer problem of the operation in his hands. The general staff decide what engineer works are necessary (among which, no doubt, will be the brigade commander's tactical bridge) and the C.R.E. details off his engineer companies to the various jobs, keeping an engineer reserve in his hands for eventualities. If it is desirable to do so he may allot a field company, or part of one, to a particular brigade for a specific job of work which, owing to the technical nature of the job, the Brigade cannot do for itself, but which must, for tactical reasons, be carried out under the direct orders of the brigade commander. In this case the C.R.E. knows that those sappers are out of his hands for the time being and that he cannot count on using them for work for which he is responsible. Under this system everybody knows where he is and the brigade commander knows what, if any, sappers he can count on. Everybody is happy and, what is much more important, the really necessary jobs of engineer work have a fair chance of getting done.

(iii) *Continuity in the Execution of Works.*—All engineer work takes time, sometimes an almost unbelievably long time, to do. Provision must, therefore, be made to ensure that, when brigades change and move on, the engineer work is continued on some settled line of policy. As a rule an engineering job is more or less useless until it is finished. Take a bridge, for example. It may take days or weeks to build but it is quite useless until the last plank of the roadway is laid and the first vehicle can cross. Unless the work is continued until that last plank is in position, all the work that has gone before is wasted and has done no good to anybody. The same is, to a greater or less degree, true of all engineer work. The best people to finish a job are usually in the unit that started it. When brigades are relieved or move on, the engineers must stay and finish their jobs. Under the Brigade Group System the field company moves with its brigade and leaves its jobs unfinished and therefore useless. The new brigade that comes along may continue them, but often the new brigade commander is impatient to get on with some pet scheme of his own and the old jobs get left. Then he, in turn, moves on, leaving the jobs his field company started also unfinished. In this way a theatre of war becomes littered with unfinished engineer jobs which represent millions of man-hours of absolutely wasted labour. Under the Divisional Control System the C.R.E. allots the jobs and is responsible for seeing that they get finished. He is in a position to do so, for divisions do not change nearly so frequently as brigades.

(iv) *Conformity of Work to the Tactical Situation.*—The division has a much more comprehensive view of the engineer requirements of the tactical situation than any brigade can possibly have. The C.R.E., who is in close touch with the G.O.C. and takes his orders direct from the G.S.O.1., is the best authority to advise as to what work is to be done, where, how, by whom, and in what order of priority. This is especially the case in rapidly moving warfare, though at first sight this would not appear to be so. Some say, "Leave the decision to the man on the spot, and the man on the spot is the brigadier." But is he? Undoubtedly the brigade commander is the "man on the spot" so far as fighting the battle is concerned, but is he as regards the engineer requirements of the situation? Surely he is not. The vital spot for engineer work may be, and probably is, right outside the purview of any brigade commander and can be located only by the man who can see the trend of the operation as a whole. That man in a division is not any one of the brigade commanders, but the divisional commander himself—and the C.R.E. is his prophet. In order that the C.R.E. may be able to put into effect the wishes of his divisional commander, he must have the field companies of the division at his disposal. Again, during a battle, the tactical situation is constantly changing, and with it the engineer requirements. Elasticity of the engineer resources and their adaptability to the changes of the situation are therefore essential. This elasticity and adaptability cannot be attained if the engineer units are rigidly attached to brigades.

7.—Liaison and Administration.

There are, however, two respects in which the Brigade Group System would appear at first sight to have the advantage over the Divisional System. These are Liaison and Administration. The permanent allocation of field companies to brigades renders liaison and personal knowledge between the engineer officers and the officers of other arms, with whom and for whom they work, much more easy of attainment. In the same way all administrative problems, such as supplies, billets, etc., are much more easily solved if the field companies are firmly attached to Brigades. But these advantages can be enjoyed to an almost equal extent under the Divisional System if it is properly worked, as I hope to show you later, and in any case both liaison and administration are only means to an end, not ends in themselves. The "end" is to get the right engineer work done as expeditiously, economically and effectively as possible.

8.—Description of the Normal Practice under Divisional Control.

I have gone into the arguments for and against each of the two systems at some length, because the whole accepted doctrine of engineer employment in conjunction with other arms is based on the assumption that the Divisional System is the normal practice. As *Engineer Training* is the first and only book that I know of that has ever attempted to teach a doctrine of Engineer Employment, it is as well to have a clear idea of the reasons which led to the adoption of that doctrine before proceeding to study the details of its application.

The normal practice of engineer employment in a division is, therefore, this ;—

(i) The control of the whole engineer problem of the division is concentrated in the hands of the C.R.E., working under the direction of the general staff of the division. He assists the staff in the drawing up of a programme of work to be done, allocates the work to the engineer units of the division, receives their progress reports and generally takes charge.

(ii) Brigades and other formations requiring jobs to be done for them by the engineers indent on the division for the execution of the job, not for a company or part of a company of engineers. It is then for the division to decide what, if any, engineers can be spared for the execution of the job and its order of priority in the general scheme, having regard to its urgency in comparison with the other jobs on the waiting list of the programme.

(iii) Engineer units will normally not be allotted to infantry brigades or other formations except for the execution of some specific job or operation which, for some reason, can better be done under the supervision of the brigade or other commander than it can under the C.R.E.

(iv) The abnormal practice of attaching engineer units to formations should be resorted to only when the formation is detached from the division on an independent mission. In such cases the engineer units so attached would be directly under the command of the commander of the formation and would cease to be available for work for which the C.R.E. is responsible. The normal practice should be reverted to as soon as the formation rejoins the division.

(v) To facilitate administration (supplies, billeting, etc.) it is usual to attach field companies to brigades for administration. It is desirable that this attachment be changed as infrequently as possible, but administrative considerations must never be allowed to outweigh the tactical which, in the case of the engineers, is the rapid and economical execution of the most important jobs of engineer work.

9.—Need for Good Liaison and Good Communications.

In order that the Divisional System of Engineer Employment may be efficiently worked, it is essential, not only that the C.R.E. be in the closest possible touch with the divisional staff, so that he may know what is going on and what is required, but he must also be able to get intelligent reports on engineer matters from all the formations of the division, especially the infantry brigades, sift them quickly and, having made up his mind what ought to be done, convey his orders to the engineer units under his command. This is especially necessary in moving warfare.

To provide for this, two things are necessary and must be arranged for :—

(i) An efficient system of liaison between the C.R.E. and the infantry and other formations of the division.

(ii) An efficient and independent system of engineer communications.

10.—How Liaison is Provided for.

The reasons for and the method of carrying out engineer liaison are described in some detail in *Engineer Training*, and are so important that I recommend their careful study. The idea is that each brigade commander should have attached permanently to his staff an engineer officer for liaison purposes. His duties and functions are described fully in *Engineer Training*. Here are some extracts :—

"The main objects to be attained by such liaison are :—

"(i) To furnish the formations in immediate contact with the enemy with :—

"(*a*) A channel of communication respecting works between the commanders of such formations and the engineer commanders furnishing them with engineer assistance.

"(*b*) Technical information and advice respecting works for which the formations are responsible."

"(ii) To furnish engineer commanders with :—

"(*a*) A means for obtaining under all circumstances immediate and accurate technical information respecting the engineer assistance required by commanders of formations, and of forming a close and personal link between the engineers and the formations.

"(*b*) An agency for effecting all purely local preparatory measures necessary to ensure the rapid execution of works required of the engineers.

"(*c*) An effective agency for the organization and execution of engineer reconnaissance.

"The duties of the engineer liaison officer include the following in addition to those specified above :—

"(*a*) To foresee and suggest to the staff of the formation to which he is attached the nature and occasions of the demands for engineer assistance.

"(*b*) To take all measures necessary and practicable to facilitate the rapid execution of any work for which engineer assistance is furnished.

"(c) Executive work is required in special circumstances in connection with the carrying out of works for whose execution engineer assistance is forthcoming."

Such a liaison officer can be an extraordinarily useful person at all times, but in moving warfare or when things are really humming the Divisional System of engineer employment cannot work efficiently unless one is provided, at least, with every infantry brigade headquarters. If possible, therefore, a liaison officer should be provided at all times with each infantry brigade. They may also be provided for other formations, such as divisional artillery, tanks, etc., as and when occasion demands.

11.—How Communications are Provided For.

It is also essential that the C.R.E. be able to communicate quickly and directly with the engineer companies under his command. The divisional signals cannot adequately supply this need. During a battle their resources are stretched to the utmost to deal with operations messages, and engineer messages get held up. Also the nature of engineer work often necessitates the field companies working, and even living, at a considerable distance from any signal office on the divisional signal system. To obviate this difficulty, there must be a small number of motor-cyclist orderlies at the C.R.E.'s headquarters, independent of divisional signals altogether, for conveying his orders direct. For the same reason field companies must have their own motor-cyclist orderlies.

12.—How the System Worked during the War.

That is the system that has now been officially adopted in our Army. It was tried in many divisions during the latter part of the war and, in spite of circumstances which rendered it execution difficult, such as shortage of engineer officers for liaison purposes and the difficulty of improvising an engineer communication system, it was found to give excellent results during the 1918 retreat and in the advance afterwards in those divisions where it was adopted.

13.—Comparison with the Artillery System.

If we compare it with the system adopted for the employment of divisional artillery, we shall find that the two are practically identical.

The whole artillery problem of the division is concentrated in the hands of the C.R.A., who issues his orders to his artillery brigades in accordance with the needs of the division as a whole.

Artillery brigades and batteries are not normally put under the command of infantry brigade commanders, unless it be for some specific operation, or when a brigade is detached from the division on an independent mission. They return to the fold of the C.R.A. as soon as the mission or operation is completed.

Infantry brigades ask the division for artillery support for a certain operation and the C.R.A. decides the nature and amount of support to be given.

A great deal of the work of the artillery does not come within the purview of the infantry brigade commander at all and must be arranged for divisionally.

The artillery have their own system of communications, the artillery brigade sections of the divisional signal company.

They also make extensive use of liaison officers with infantry brigades, whose duties are on all fours with those of the engineer liaison officers described above.

In fact, the problem of the employment of divisional artillery in modern war has been solved by the adoption of the system of Divisional Control. The engineer problem is capable of solution in the same manner.

14.—Comparison with the French System.

As a nation we are very apt to run ourselves down and to think that foreigners do things on a much better system than ours. It is, therefore, consoling to note that the French think precisely as we do on this subject of engineer employment.

I have here the translation of the notes of a lecture delivered at the French Staff College in March, 1918. The organization of the engineers in a French division differs slightly from ours in that they have two field companies instead of our three, but their teaching as to the duties of the C.R.E. and the employment of divisional engineers generally might have been written in close collaboration with the authors of our *Engineer Training*. As a matter of fact, the chapters in our manual were written without the knowledge of the existence of this pamphlet. I will conclude by reading you a few extracts from the French lecture which confirm our doctrine in a very remarkable manner :—

"(*a*) *Duties of the C.R.E. of a Division.*

"C.R.E's are alike technical advisers to their respective commanders and executive officers.

"As technical adviser the C.R.E. keeps his general posted as to :—

"(i) The requirements in time, labour and material of any proposed work.

"(ii) The method in which works are being carried out by subordinate formations.

"As executive officer,

"(i) He collaborates in the preparation of programmes of work (in particular of that part in which the engineers are to take a hand) ;

"(ii) He is responsible for the completion of work entrusted to him by the commander and carried out by the engineer units.

"The programme of work for engineer units is always drawn up by the commander.

"Decisions with regard to important works are not the province of the C.R.E.

"The C.R.E. cannot carry out his duties efficiently unless he is always familiar with his general's thoughts, and never ceases to work in close touch with the staff. He must likewise keep in close touch with the commanders and staffs of subordinate formations, help them with his technical knowledge, keep abreast of their needs, foresee them if possible, and concentrate all his resources on satisfying them.

"(*b*) *Employment of Engineers.*

"The normal work of field fortification, construction and repair of trenches, barbed wire entanglements, etc., must be carried out by the infantryman. These tasks call for a large amount of labour, and engineer companies will only furnish an insignificant amount of supervising detail in any case.

"Engineers will, therefore, only be employed on tasks demanding skill greater than that possessed by the infantryman.

"(*c*) *Distribution of the Engineers.*

"Engineers, like infantry, work in properly constituted units, if possible, in companies; it will only be in exceptional circumstances that they are employed by less than sections. A sapper only works well and gives full value when his organization is intact.

"An engineer unit, when engaged, must, like any other force, be given an objective. Hence, the attachment of parties of engineers to assaulting troops, without any definite reason, but as a matter of course, will be avoided.

"Engineers will only be attached to such regiments or battalions whose objectives involve types of work which justify the employment of technical troops.

"So we have established the principle that engineers are to be employed by whole companies, or, at least, by organized fractions, and that they are to be employed where their special skill will be of advantage. *It follows that they will not be permanently allotted to subordinate formations.*"

THE SUPPLY OF BULK STORES IN WAR.

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INTRODUCTORY.

1. The historian of the work of the R.E. in the War of 1914–1918, in his "Supply of Engineer Stores and Equipment" has produced a successful, if brief, record of the growth of the organization developed at home for the acquisition and shipment of engineer stores to various theatres of war. The last few pages are devoted to a sufficiently accurate record of the work of the organization in one of the theatres of war, viz., France, created to collect, hold and distribute engineer stores.

This history only carried the reader as far as June, 1918, at which period the Store Branch of the Director of Works organization was reformed into a Directorate under the Q.M.G.

The subsequent months included a period of mobile war, which presented different problems from those arising in the supply of stores to armies stabilized in one position.

The historian very truly observes "few subjects need studying with more careful regard to attendant circumstances."

2. The object of this article is to deduce from the cold facts recorded, and from the records of the Stores Service in France, lessons which may serve to guide officers called on at any future date to organize a service for the supply of engineer stores in a theatre of war.

It is fully recognized that the conditions which prevailed in France from 1915 to September, 1918, were those pertaining to one type of war only, viz., siege or trench warfare; that such conditions are not those for which a modern army is normally trained and organized; and that the arrangements requisite for supply of engineer stores during a long period of stabilization are widely diverse from those required to supply stores to an army "on the move."

Nevertheless, the study of the history of the British Army, and of the national organization, or rather of the lack of any such organization for war, may justify the conclusion that in any great continental war in which this country is engaged the British Army will probably again be required to act on the defensive as a covering force behind which the national resources can slowly be mobilized.

There would, therefore, appear to be strong arguments that we should be prepared for a considerable period of "trench-warfare," and that such preparations should include, if not an active organization, at any rate a considered plan, for the supply of engineer stores in great bulk to stabilized armies.

Moreover, it will be quite unsound to attempt to base such an organization upon any principles laid down by continental powers for the guidance of their army administrations.

In such countries supply to their armies can be organized in parallel lines of supply, running from areas of the country to the various formations. Supplies, however, for a British Army must inevitably pass through a bottle-neck in crossing the sea and then arrive at one or more bases from which lines of supply will radiate to the various armies. In consequence, the volume of supply is eventually controlled by considerations of transport facilities.

The principal considerations before a supply service are :—

(i) What will the Army require ?
(ii) How can it be obtained ?
(iii) How can the required quantities be transported to the critical point at the critical moment ?

Of these the third will always be that which causes the gravest anxiety.

3. In order to envisage properly the arrangements required, it is necessary first to consider the conditions imposed. In the following four paragraphs are enumerated, in broad outline only, the conditions which prevailed in France, as regards the existing lines of supply. Paragraphs 8 and 9 record a few general statistics of engineering stores supplied in France, gathered from the records of the Stores Branch.

TRANSPORT CONDITIONS IN FRANCE.

4. For an army reaching from north of Ypres to Albert and the Somme, there were in 1915 the following possible lines of supply :—

(i) Dunkirk—Hazebroucq } Lille.
Calais—Hazebroucq }
(With a branch line Hazebroucq—Ypres.)
(ii) Calais—Aire—Bethune.
(iii) (Single railway) Etaples—Arras.
(iv) Abancourt—Amiens—Albert ; Abancourt being connected to Havre, Rouen and Dieppe.

The principal lateral line connecting these lines of supply was the main line :—

Amiens—Abbeville—Etaples, Boulogne—Calais, with a single-line extension from Calais to Dunkirk. This was the only line available for the transfer of troops from flank to flank, for the movement of stores obtained in France, and for cross-movements, between northern and southern depots.

The line Bethune—St. Pol—Amiens was a supply line, rather than a lateral.

The incidence of this remark will be inferred from the following facts :—

(i) The bulk of the timber—constituting more than 50 per cent of the bulk of engineer stores—was obtained from areas south of the Somme.

(ii) The provision arrangements made in the United Kingdom involved considerable inter-depot movements in order to carry sets of stores.

(iii) A great offensive necessitated the use of the store reserves from both northern and southern depots on one sector of the front.

Of the rail lines of supply mentioned above it may be observed that :—

(*a*) The Calais—Dunkirk line was doubled in the winter of 1916–17.

(*b*) The Etaples—Arras line was doubled in the winter of 1916–17, the work being completed only just in time for the battle of Vimy Ridge.

(*c*) A double line direct from Dunkirk to Ypres salient was constructed in 1917.

(*d*) Finally, in the summer of 1918, the Etaples—Abbeville line was quadrupled but not opened, and a new line was opened leading up to the southern flank of the Third Army front.

5. The following elementary transportation statistics may be worthy of note :—

(*a*) For engineer stores, 1,000 tons required three trains.

(*b*) The whole of the above lines, except the Hazebroucq—Ypres line were operated by the French railway company throughout the war.

(*c*) Two hundred trains daily was the maximum number of trains which it was considered feasible to operate for the B.E.F. on the lines concerned, with reasonable efficiency. These included personnel and ambulance trains and any inter-depot trains. Even quiet periods demanded at least one ambulance train and one leave train per army per diem. For rough calculations the whole army was usually assumed to be equivalent to 60 divisions, each of which required one food train per diem.

The average number of trains of engineer stores required per diem, including supply of L. of C., was twelve.

(*d*) Engineer stores ex-U.K. represented about five to six per cent of the volume of traffic, but probably not in excess of three per cent of the value.

(*e*) When estimating transport possibilities, it must be borne in mind that what is required is maximum momentum, which obviously determines the quantity delivered at a given spot in a given period. It is futile to double the number of trains started, if that results in halving the average speed over the line.

During the battle of Passchendaele, supply services, etc., were actually starting at one period about 270 trains daily, but it was found that this reacted deleteriously on the tonnage actually received daily at the front.

(*f*) A single line of rail is only "good for" about 12 trains per diem each way.

6. It is instructive to recall the discovery and elimination throughout the war of the various "transportation limits." Unfortunately a "bottle-neck" is naturally discovered, like a weak link in a chain, by a test load; its elimination usually spells construction with attendant train-loads of heavy material.

The Q.M.G. staffs have then to decide whether to reduce supply trains by m daily, in order to obtain an increase of n trains daily at a later date, where n is, of course, hypothesized as greater than m. The answer to this conundrum must normally be "a bird in the hand is worth two in the bush."

Chronologically the limitation was discovered as follows :—

1915–16.—Slow discharge of ships in French ports resulted in the tonnage landed from the available ship tonnage imposing the limit on supply. This was met by development of wharves, and large increases to the number of cranes installed in peace.

This was followed in 1916 by the discovery that narrow rail exits at Havre and Dunkirk had insufficient capacity to clear away stores as fast as they were discharged.

This was met at Havre by the formation of the Soquence Canal Depot (later to be one of our bugbears) and construction of a new line to Dunkirk Harbour from Coudekerque rail depot.

1916–17.—The congestion resulting from establishment of store depots (food and ordnance) on dock wharves was eliminated by the move out of such depots from the ports. Next, supply lines were doubled and new lines constructed, necessitating lifting and transferring to France whole branch lines from U.K.

Then the limit was imposed by available rolling stock. This was met by importation of rolling stock in large quantities, and construction of repair shops.

These were only some of the major operations which gradually developed transportation efficiency, until about the summer of 1918 transportation had arrived at a stage when in effect as much stores could be carried as the armies really required, until, of course, the advance began.

7. The foregoing remarks are made in no spirit of criticism of the work of transportation officers. Of our relations with them stores officers have only the happiest remembrances of their willing, even self-sacrificing, readiness to co-operate and assist in every manner within their power, and often beyond their authority; of their tireless and incessant struggle to overcome the numerous obstacles; and of the efficiency eventually attained in the development of transportation to the fighting armies. But it does not appear fully to be realized by the fighting arms how intimately supply is interlocked with transportation. This somewhat long digression is intended as an attempt to present, from the aspect of a layman, a bird's-eye view of the transport problem, in order that it may be realized that whatever organization be adopted for a branch to supply engineer stores, it is essential to efficiency that it should take a form which allows for the closest and quickest co-ordination with the transport branches.

I have only dealt with sea and rail transport, but in 1918 it was beginning to appear that a stage had been reached when the limit was the rate at which distribution by road could be effected from railhead, a matter which will subsequently be considered.

Principal Engineer Store Statistics.

8. A study of the tables annexed to the History of *The Supply of Engineer Stores and Equipment* will reveal the following principal statistics for engineer stores :—

	Tons.
Average monthly supply to formations ..	110,000
Maximum " " " ..	140,000

Of this 110,000 tons more than half consisted of raw timber, 90 per cent of which was supplied by the Directorate of Forestry *ex* French forests; about one-third only of the gross receipts was imported from the U.K. The remaining one-sixth consisted principally of timber articles manufactured in base workshops.

Summarizing, it may be said that trench war requirements involved the supply per division per mensem of :—

	Tons.
Timber	1,000
General R.E. Stores	700
Articles manufactured at bases	300
Aggregate ..	2,000

9. To complete the collection of a few principal facts, the following table of rough values in 1918 may be of interest in these days of cost accountancy :—

		Value per ton.
(i) Engineer stores—	Timber	£15
	General stores ..	£25
(ii) Ordnance stores—	General	£50 to £100
	Clothing	£300
	Ammunition ..	£200
(iii) Foodstuffs	.. ..	£70

Based on these tonnage values and the known weekly importation of various classes of stores, it has been very roughly estimated that the total average daily consumption by B.E.F. of supplies and stores of all descriptions, including equipment and ammunition, amounted to about £2,500,000, of which engineer stores represented about £80,000.

The aggregate cost of the personnel engaged directly or indirectly in discharging, storing and handling these stores at bases cannot have fallen far short of £250,000 per diem. These figures, which, it is believed, are not exaggerated, are given with a view to emphasizing the necessity for the most efficient supply organization. An economy of only five per cent on these figures represents £50,000,000 per annum.

ENGINEER STORES AS A PORTION OF BULK STORES.

10. The historian has been at some labour, in his introductory remarks, to attempt a definition of engineer stores. A wider view would appear to be justifiable. Thus the stores required for an army may be classified as :—

(i) Food supplies.
(ii) Arms and ammunition—including guns, gun-carriages and "tanks."
(iii) Vehicles of every description (except gun-carriages), including rolling stock.
(iv) Equipment.
(v) Bulk stores.
(vi) Animals.

The fundamental distinction between "bulk stores" and "equipment" is that bulk stores can and must be forwarded in train loads to various "sectors" of the front, or "areas" of L. of C.

Equipment comprises those stores which require to be sent to a specific consignee unit on a detailed demand.

It must be realized that these two classes of supply demand entirely different methods of storage, accountancy, and above all, of transportation.

Bulk stores are loaded by the truck-load. A scientifically laid-out depot of bulk stores will, therefore, allow for loading any category of stores into a truck with the minimum of rail movement on the one hand and of " carry " on the other.

Equipment is loaded by assigning one truck (or covered van) per consignee unit. Long carries in a depot are unavoidable, but the aggregate weight so carried is not great compared to bulk stores.

Again, as regards accountancy, statistics for equipment are designed to show the average rate of consumption of each specific store per, say, division which the depot has to feed. This enables a forecast to be made of the next few months' requirements *ex* U.K.

Bulk stores, on the other hand, are in general supplied perforce on a " ration " basis, and statistics must be framed to record the quantity issued up to the ration allowed per, say, Corps.

Supply of equipment then means normally dispatch of one or two trucks to each Division daily. These trucks are normally attached to the Division's food-supply train : for this purpose the equipment depot must be adjacent to the food depot.

Supply of bulk stores involves the dispatch of complete train-loads to one or two destinations for each train, normally not the supply railheads, but stations further to the rear.

Bulk supply should, therefore, include the supply of such " vocabulary stores " as barbed wire, sandbags, screwposts, etc. In fact, it smoothed working when the Engineering Stores Directorate took on such stores at the ship's side at French ports. Bulk stores might with advantage also include such bulk supplies as blankets and tents, and should certainly include railway construction material.

A prospective advantage to be obtained during mobile war will be referred to later. Whatever be the reader's opinion, however, on the matter, it must be accepted as a transportation axiom that engineer stores must proceed in *complete train loads* : it will generally be accepted that they should comprise all stores used in bulk by the R.E.

11. It is possibly necessary to enunciate the processes involved in the supply of engineer stores in order that a true perspective may be obtained, before any visualization of the necessary organization can be attempted. These processes are :—

(i) Prevision.
(ii) Provision.
(iii) Sea transport.
(iv) Storeholding and sorting.
(v) Distribution.
(vi) Rail transport.
(vii) Reception and distribution in army zones.

No attempt will be made in this article to view these processes from any other aspect than that of the officer in the theatre of war, but it is now proposed to consider each of these processes *seriatim* and to enunciate the lessons to be inculcated so far as the trench war period in France was concerned. It must be borne in mind that the conditions were of a special nature and that, in consequence, it will not be safe to draw conclusions of too general a nature.

12. *Prevision.*—As regards field stores. This is a function—and no unimportant function—of the E.-in-C. Upon his forecast of the probable requirements of the field engineers, six months ahead, depends the whole efficiency of supply. It was found, even when the manufacturing output of the U.K. was strictly organized, that it took about four months for the first arrival of a new pattern store and quite six months before a steady flow was ensured. In the occasional event of a clamour from armies for some special store which has not been foreseen, or for abnormal quantities of a normal store, it is almost invariably the case that the demand has died before supply has developed. We were left at the Armistice with some considerable stocks which were obtained as a result of army pressure, but often not used at all, or absorbed only to a very limited extent.

The E.-in-C. has to foresee both types and quantities which will be required. He has also to decide on standard patterns, usually a compromise between the different opinions of several armies as to the best type, modified by consideration of the alterations required to obtain maximum supply. This modification is important and very essential: especially in details of such trench stores as "A" frames, trench boards, etc., modifications which did not affect strength but enabled "standard" sizes of timber to be used, resulted in most important increases of the output. Critical study of the country behind the enemy's lines was essential to enable a forecast to be made of the bridges, which would be required, and of the water supply plant essential to certain areas.

The R.E. generally do not sufficiently appreciate the extraordinary foresight which was displayed by the E.-in-C.'s staff in this respect. As one example alone, it may be noted that the bridges used in the advance of 1918 had, under E.-in-C.'s orders, been gradually accumulated for three years; whilst 1,200 steel cubes, manufactured in 1916, were absorbed suddenly in the 100 days' battle of 1918 at a rate which caused grave anxiety for a time; but they lasted out.

The three-year-old prophecy, in fact, was precisely justified by events.

To such prescience the whole stores branch also owes a deep debt of gratitude; for inevitably a shortage must have been blamed to their account.

13. *Provision.*—Once requirements have, however, been predicted, the compilation of indents is *prima facie* easy, but close co-operation with the home authorities is very essential. Doubtless owing to reluctance to worry overworked men in the theatre of war, the provision branches at home did not always confide to us their difficulties. When they did it was often possible to compromise. For example, in 1918 the ration of steel for engineer stores in France was about 20,000 tons, which did not meet the demands of E.-in-C. and D.W. The situation was met by reduction of the army demand for corrugated iron and acceptance of shell-discarded steel for some other stores (*e.g.*, screwposts). Again, the situation demanded minimum use of sea freight; it has already been pointed out that only one-third of the whole tonnage of engineer stores was imported. It will inevitably be necessary in all wars to develop to the uttermost the resources of the theatre of war: it may be hoped that such development will definitely be assigned as a function of a glorified Director of Works—let us say a D.G. Engineer Services. The total supply of timber from French forests attained to a figure of about 100,000 tons per mensem for R.E. and railways.

The maximum quarry output is not known to me. Both these development branches were originated by D.W.

Again, brick and concrete block factories were developed to a considerable extent.

The obvious lesson is to study beforehand the resources of the probable theatre of war, and in due course to take over to it the requisite staff of experts.

14. If a digression may be allowed at this point, it may be observed that peace and small war practice have inculcated on the R.E. the geographical organization by which a C.R.E. takes control of all R.E. services in his area, with the aid of a few junior experts. But in an extensive campaign a time will arrive when it may be advisable to scrap this economic organization for a generic organization in which experts in one branch of engineering are formed into a directorate or sub-directorate controlling, over the whole theatre outside the zone of the armies, the special operations assigned to their branch. Primarily this involves a large increase of officers, but :—Firstly, it will probably result in intensive work;

Secondly, it will, if due control be exercised, result in an economy of "labour," owing to the greater and more specialized supervision;

Thirdly, it is a system by which maximum results can be obtained from Civil Engineers, who are normally specialists in some one branch. This makes no difference in the function allotted to a Director of Works, but means that instead of directing C.R.E's he will command Directors of Engineer Services.

15. Under the head of "Provision" must be considered the subject of base factories. As is, no doubt, well known, shipping

tonnage is a matter of cubic feet, not of deadweight tons. My own general impression of engineer stores was that on an average it required about $2\frac{1}{2}$ shipping tons to make up one ton deadweight. It is therefore very necessary to use every endeavour to reduce bulk to a minimum. Great economy can obviously be effected if timber trench stores can be manufactured from raw material in the theatre of war.

The only question is, at what site in the theatre of war should this conversion take place. I have no quarrel with Army or Corps Workshops in principle; they are necessary for certain purposes, but I submit that they should be kept mobile, that normally they should be restricted to jobbing repair work and the manufacture of a few special "jims" peculiar to their own locality, and that iron-working tools should be rigidly restricted to those essential for rapid repairs to R.E. machinery. The objection to allowing Army shops to develop into factories is that they tend to immobilize field forces, absorb fighting men of category "A," and then, owing to dissipation of effort, do not, with the same amount of plant, produce in the aggregate the results that can be obtained from concentrated factories in the L. of C. in which prisoners of war, unfit men, women and even children—in fact, the "useless mouths"—can be employed.

As a result of the retreat of 1918 the E.-in-C. decided to concentrate manufacture at the bases Calais and Abancourt. The reader is referred to Table L on page 96 of the History and is invited to consider whether this decision was justified by the result.

16. Another source of provision is local purchase in the theatre of war—a subject that requires some control. Obviously C.E's must have power to acquire local stores, but if they continue to purchase for several years in a limited area, it is equally obvious that a very undesirable situation will be created. In France, in 1915, local merchants continued to import from Paris or elsewhere to the Army zone in order to sell to the local C.E. or C.R.E. in base areas. This entailed competitive buying with the resultant forcing up of prices, profiteering, by local merchants at the expense of the British public; and finally traffic of civil stores over railways whose last ounce of accommodation was required for the supply to the Armies of troops, ammunition and such necessaries. In effect, it amounts to a circumvention of the orders of the C.-in-C. as to priority of supply.

17. *Sea Transport.*—This concerns the R.E. in several matters. Firstly, it is a R.E. service to develop the ports so that maximum duty may be obtained. It may be—often will be—necessary to construct wharves: whilst it may be taken for granted that many cranes will be required in order to produce maximum discharge. Generally, the best type of crane will be found to be the Port of London type, three or five tons, carried on a travelling gantry which

strides the rail sidings. One powerful crane will be essential which can lift 30 or 40 tons. This will be a fixed crane; for the few lifts of this nature required, ships will shift their berth to come under the crane. Extra wharf sidings and cross-overs are sure to be required and, usually, a development of the connections between the wharf sidings and the railway sorting sidings outside the Port. The main objective is to reduce the time of discharge to a minimum.

18. Reference has already been made to the necessity for reducing imports to a minimum by development of the resources of the theatre of war; also to the necessity for reducing bulk by conversion of imported raw material to manufactured articles in the theatre of war.

19. Beyond this there is a distinct necessity for greater consideration than existed in the European War, between stores officers in the theatre of war and provision branches at home in dispatch of cargoes as and when required. In France we were assured that it was not feasible to create in England a receiving depot to accept stores as manufactured and to dispatch to the theatre of war as indented. That being the case, it was necessary to accept the disadvantages. It may be as well, however, to enumerate these, in order that in future wars the advantages to the home authorities may be fully weighed with the disadvantages to the Expeditionary Force.

The system which prevailed during the War was dispatch direct from factories at home to base depots in France. At the best this involves holding enormous stocks in the theatre of war, for manufacture must proceed steadily throughout the year, whilst demands are largely seasonal. For example, Nissen huts poured in steadily throughout the year with the result that we would be holding 25,000 or more ready to send up in October, November and December. This involves huge depots in the theatre of war with attendant risks from enemy aircraft and *saboteurs*; it also necessitates an extensive personnel, which is naturally more costly in the theatre of war than at home depots.

Directors in France were constantly pressed to reduce "reserves"; we unanimously agreed that we would cut our reserves to little over the amount consumed in the period necessary to fulfil a shipping indent. Nevertheless, I found it impossible to hold, under the prevailing conditions of shipment, less than 350,000 tons or three months' supply measured by tonnage. Nor, from our point of view, was this the worst. Owing to the existence of several base ports and two main base depots, the home system of shipment, from the port nearest to the factory, and of shipment as manufactured, it constantly occurred that a whole cargo of, say, Nissen steel work would arrive at Havre, whilst corresponding wood work arrived at Dunkirk. Also "sets" of machinery became separated in a similar manner. The requisite redistribution and resorting in France was not only a great strain on our organization, but involved further traffic on the one congested lateral railway between north and south.

We desired the existence of a central R.E. store depot in England which would collect all stores from factories, make them up into sets and hold in store until they were required in France. Had this been feasible, far smaller depots in France would have been possible, fewer personnel and less rail traffic.

20. When the number of ships (and their tonnage) which can be allotted for carrying stores to the theatre of war has been determined by the Admiralty, and when the ports have been developed so as to obtain the quickest possible "turn round" of those ships, it is even then almost axiomatic that the supply of stores may be placed in the following order of decreasing tonnage :—

(i) What the Army desires to receive.
(ii) What the provision branches can obtain.
(iii) What can be transported by sea.
(iv) What can be transported from bases to Armies.

(iii) and (iv) may change places at times, whilst for certain classes of stores (ii) is sometimes the limiting factor.

The C.-in-C. functioning through his Q.M.G. has then to decide the tonnage to be allotted to each category of stores. Some of them must be reduced; the reduction will only touch food supplies in extreme cases. Similarly equipment can hardly be reduced, nor does it really bulk largely in the tonnage programmes.

For the comfort and morale of the troops, reduction of canteen tonnage will, if possible, be avoided. Consideration of the classes of stores enumerated in para. 10 will show that reductions must almost inevitably fall upon ammunition and bulk stores, with due regard to the relative importance at the moment of destroying the enemy and his morale, and of preserving our own troops and their morale. Reduction in the bulk supply of engineer stores must therefore be accepted by R.E. officers as due to the considered decision of the C.-in-C., and not to negligence or lack of sympathy on the part of supply services.

STOREHOLDING AND SORTING.

21. Upon this subject a volume by itself might well be written; it is, however, necessary to economize space. I will therefore only attempt to enunciate some of the main principles discovered by experience, and to give a few statistics which may guide officers in future. We may consider this subject under the following sub-heads :—

(*a*) Size of depot.
(*b*) Site.
(*c*) Rail lay-out.
(*d*) Depot lay-out.
(*e*) Operation of a depot.
(*f*) Shops.
(*g*) Storeholding generally.

22. *Size of Depot.*—In para. 9 an estimate has been given of the average requirements of engineer stores, including huts, per division per mensem, viz., 2,000 tons, during trench warfare. This figure must be multiplied, of course, by the number of divisions to be supplied from the depot projected ; the resulting figure must again be multiplied by the number of months which is required for the fulfilment of a shipping indent. A shipping indent must not be confused with a provision indent.

A provision indent normally takes the form of an estimate of the stores required in the theatre of war by all services to be supplied (*e.g.*, E.-in-C., D.W., railways, etc.) during the next six months. Upon receipt of this indent the home services proceed to arrange a manufacture programme. A shipping indent is a definite indent for the shipment during a given month of named quantities of named stores, the total (ship) tonnage of which must not exceed the (ship) tonnage allocated by the Q.M.G.

In view of the fact that sudden developments at the front may involve rush demands for trench stores, bridges, or water supply stores, it is further necessary to add to the figure obtained as above a considerable percentage to cover reserves of such stores. Similarly a percentage must be added to allow for the collection throughout the year of huts ready to be rushed up when the Armies " go into winter quarters."

For example, for a depot like Les Attaques we might proceed as follows :—

> 2,000×30 (divisions)×2 (months to supply a shipping indent)=120,000 tons.
>
> Add 50% for reserves, etc. We must arrange to hold 180,000 tons.

Now, under the conditions of siting to be considered in the next paragraph, land is of small value as compared to the importance of reducing labour : it is therefore undesirable to stack too high. A good rule was found to be, " allow for all purposes one acre per 1,000 tons."

The Les Attaques depot, including about 15 acres occupied by the factories, covered approximately 220 acres and normally held 160,000 to 180,000 tons. (See *Plan.*)

23. *Site of a Depot.*—It will readily be admitted by all concerned

that it was by a dispensation of Providence rather than owing to any realization of the principles, which were later discovered to be involved, that the depot at Les Attaques (except in one particular) was sited, in the autumn of 1915, exactly where it ought to have been.

The principles are :—

(i) A depot must not be in a dock area, for free space is necessary to quick discharge of ships.

(ii) It must not be so far from the port that haulage from port to depot involves the occupation of a main line "marche."

(iii) It must be beyond the rail-sorting station, into which pour a miscellaneous jumble of trucks loaded with every conceivable store ; in this sorting station trucks must be marshalled for their appropriate depots.

(iv) If, as is very desirable, inland waterways are available, the depot must be sited so as to permit of discharge from ship to barge, transit by barge to barge-discharging point and then allow room for trucks loaded *ex* barge to reach another sorting " triage " where they and trucks arriving by rail from the rail-sorting station may again be marshalled for delivery into the appropriate depot sidings.

24. Having these principles in mind it may be instructive to note the points in which inexperience led us to make mistakes in the original siting of our depots.

(i) The original Les Attaques Depot was that portion between the St. Omer Canal and main railway line—it was too narrow and only permitted the existence of short dead-end railway spurs. The depot was on top of the barge discharge quays. The principle enumerated in para. 23 (iv) was thus violated—and we suffered from that violation.

(ii) In the south the junction of the Havre—Rouen—Amiens line with the Dieppe—Amiens line gave cause for the siting of the Southern Depot at Abancourt in violation of the principle enumerated in para. 23 (ii).

In consequence, it was often difficult to obtain transport for stores direct from ship to Abancourt ; overflow dumps were formed at Soquence (Havre) and at Querilly (on the south bank of the Seine at Rouen). Owing to railway difficulties it was then difficult to get the stores out of these overflow dumps and impossible to get them out as and when required. With the intensive traffic of 1918 it was, in fact, found necessary to regard the bulk stores in these depots as " dead " stock.

(iii) Had the work to be done again, it would probably be found better to form a large group of depots on the Seine in the country between Rouen and Caudebec, to construct wharves on the north bank of the river and to double-track the Caudebec branch line.

25. The danger of air raids must be considered.

If possible two bases and two base depots are advisable so that all our eggs may not be in one basket. Again, if feasible, bunching of different store depots in one confined area should be avoided, as offering too big a target. It is, of course, very desirable to choose a base which is unlikely to fall within hostile shell-fire owing to the ebb and flow of war.

But the danger from aerial bombardment, even of the intensivity experienced by Calais, was almost negligible. Bulk store depots appear to be practically indestructible. " Hun Dump " at Bapaume changed hands three times during the war without any dislocation of its stocks or even of its accounts, which still exist as a continuous narrative of transactions recorded in German and English. Important sheds of machinery or workshops are always a source of anxiety, but the " probabilities " are so largely against a hit that normal fire risks may be considered as far more serious.

26. *Rail Lay-out of Depots.*—For a bulk store depot, the rail lay-out of Les Attaques depot south of the main railway line (R.E. grids) may be considered almost a type plan.

No scale has been attached to the *Plan*, but for guidance it may be stated that from Vampouille Farm to the branch road S.E. of Dimpre Farm is about one mile ; from Vampouille Farm to Pont des Briques about 1,000 yd.

Trains from the Calais and Dunkirk docks arrived from the N.W. angle of the map in No. 4 *triage* ; into this *triage* also poured trucks from the barge-discharge point about 800 yd. N.W. of the Château de Vendroux.

In No. 4 *triage* the trucks were labelled at night for the appropriate sidings (Nos. 1 to 20) in the R.E. grids.

Railway experts on the Director of Engineer Stores staff considered that these sidings were too long—over 600 yd. effective length—and that a double lateral gathering line should have been constructed N.W. and S.E. across them.

The best distance between double sidings was found to be 150 ft. for general stores ; 300 ft. for timber yards.

The sidings to the (timber) workshops should be noticed : one (on N. side) for receipt of timber from timber yards, one (S. side) for loading up manufactured articles and removal to stores yards.

A base depot is not laid out in principle for delivery of stores to road convoys, but as such delivery may be required, it is as well to run a siding (*e.g.*, E. siding of international sidings) alongside a neighbouring road.

27. It is inevitable that both the site and the rail lay-out of a depot will be governed largely by considerations of facility of rail construction. But transportation officers should bear in mind that in the event it is facility of railway operation which will make or mar efficiency of transportation. For example, No. 4 *triage* was for several months far too small (four lines), whilst Nos. 2 and 3 *triages* were unnecessarily large. As a result, until No. 4 was enlarged it was found impossible to work a truck through the depots in less than five days. As an example of the difficulties of railway operations, which were insufficiently appreciated, it may be noted that it required normally 48 hours for the transit of a certain daily express truck from Fontinettes station (two miles from the depot) to a named siding at Les Attaques.

28. It will be obvious that facilities of construction will demand for the site of a depot any fen district which may be available. It is then essential that pipe culverts be laid in any ditches which sidings and *triages* may traverse.

If this is not done it is necessary to fill in the areas between sidings up to rail level—a most expensive and extravagant procedure which a small amount of foresight and delay in construction will render unnecessary.

29. *Depot Lay-out.*—It must be assumed that officers concerned are gifted with sufficient prophetic insight to foresee the eventual size of the depot. At any rate the following principles should be adopted; if the depot increases beyond what has been foreseen, the necessary re-organization must be undertaken to relay the depot in accordance with those principles.

(i) Alternate sidings with inflammable and non-inflammable stores.

(ii) On any given siding of inflammable stores, alternate stacks with wide "fire-breaks."

If space is becoming valuable, fill in the fire-breaks with non-inflammable stores. A chess-board lay-out is theoretically desirable, but it is not always very practicable, in so far as it is not consonant with the measures to be adopted for economy of labour, described in the next section.

(iii) "Store Groups" demand separate "yards" (*e.g.*, one siding for water-supply stores). Each yard will require a small office for tally cards and store accounts. Each group will normally require one or more closed sheds for small stores (*e.g.*, pipe accessories); and for stores which demand protection from the weather (*e.g.*, cement).

(iv) A 4-in. fire-ring main is very desirable, with hydrants and hoses. One central engine, of internal combustion type for choice, is necessary to force water into this main under pressure.

Fire-engines are of little use for the greater part of a depot. A liberal supply of chemical extinguishers is essential to enable watchmen to scotch a fire at its inception.

(v) Factories: allow *ample* elbow room; it cannot be foreseen how much will be required. You are sure to underestimate and will not be far wrong if you allow for development to four times the size which you consider ample at first. Better waste land than be cramped later. If possible, choose a site which is open to the country at one end, so that sidings and shops may be extended.

Lay out so as to economize carry. A siding for the reception of selected timber from the timber yards will allow for stacks on the sidings, thence direct carriage to rip-saws; then to cross-cut saws; thence to nailing-benches; thence to stacks alongside a removal siding; 400 to 450 ft., approximately, between arrival and departure sidings.

Do not attempt to combine a store yard and a factory —it is false economy; *i.e.*, do not put a factory in the timber yard, nor attempt to store manufactured articles in the factory yard. In this respect it is necessary to be deaf to the blandishments and to the growls of transportation officers.

(vi) As, however, one exception to this rule, it will be necessary to convert much timber to "scantlings." Les Attaques had to produce 1,000,000 F.R. of scantlings in a month at times. It is then economical to lay down some rip-saws (motor-driven and portable if possible) in the timber yards.

(vii) Generally the only rough advice that can be given is "think big and then multiply by four."

30. *Operation of a Depot.*—The essence of efficient operation is to reduce to a minimum the number of transportation moves and the "carry" of stores, two conditions which are not, *prima facie*, compatible. By co-operation, however, this apparent incompatibility can be overcome.

(i) Loaded trucks *ex* ports (including barge ports), etc., arrive in the night, in a reception *triage*. The port has in the meantime advised, by telephone, truck numbers and general contents. Armed with these advices and "periscopes," a special staff must rapidly label these trucks for appropriate sidings.

(ii) The railway officers then have trucks shunted to the working sidings, including any empties required for loading. After the hour of commencing depot work, say 7 hours, no rail movement must occur in the working sidings until the dinner-hour; it will probably be necessary then to allow the railway officers 1½ hours for operation.

(iii) Of the trucks thus put into working sidings it will normally be possible to reconsign a fair percentage (10% to 20%) without off-loading. As regards the remainder, it is obviously very desirable to discharge straight to a stack alongside the truck, and similarly to load an empty from a stack alongside the truck—all without further truck movement (*prima facie* impossible). If any system is to be introduced into storage, as is of course essential, this result can only be obtained by "repeat" grouping of stores. This system is difficult to explain.

Essentially it consisted in the adoption of the following measures. Bulk stores were considered under two categories:—

(*a*) Those which required one or more sidings to themselves. For example, timber was classified generally in eight principal groups of sizes. Stacks were then laid out between two sidings, four deep between sidings; two such lines provided the eight groups.

The next group would be reversed.

Thus any group size could be loaded with a maximum of about 60 yd. of carry.

Water-pipes, again, were stocked in four principal sizes, 4 in., 2 in., 1½ in. and 1 in., and stacks of these sizes alternated along one siding.

Corrugated iron and steel shelters similarly required one siding each; cement about half a siding; steel joists, half a siding; bridges, two half sidings, etc. Sand-bags and barbed wire alternate well on one siding.

(*b*) Stores stocked in bulk which demanded only small frontages.

For these stores one of the store branch officers—Major Crossley, R.E.—invented what was subsequently known as the "repeat group system." Stores items, usually about 12 in number, were selected, *e.g.*, tanks, coir lewing, wire netting, wire weaving, etc.; proportionate quantities of each of these were formed into stacks about 50 ft. on the siding front, 75 ft. deep and 15 ft. to 25 ft. high, each store item forming a vertical column in the stack. One 600-yd. siding would contain about 15 to 18 of such stacks. As a result a truck arriving for discharge could be off-loaded to the stack opposite which it chanced to be placed by R.O.D.

Similarly an empty could be loaded from any stack opposite which it stood.

This system worked well, was obviously economical of labour and is strongly recommended for use under similar conditions.

(iv) During the depot working hours, from 7 hours to 17 hours, with the exception of the dinner interval, the R.O.D. must avoid any rail movement on the depot sidings. The dinner hour must be made long enough to enable the R.O.D. to move out loaded trucks, place more empties as required, and put in any trucks for discharge left over at 7 hours in the reception *triage*.

The work of making up and dispatching trains will be performed by R.O.D. from 17 hours to midnight: from that hour until 7 hours they will be receiving trucks from ports and shunting to sidings indicated, also in placing empties.

(v) During the afternoon, information and instructions will have been received as regards :—

(*a*) Number of trains allotted to depot for dispatch by Q.M.G.

(*b*) Railheads vacant (from A.D.R.T.).

(*c*) Stores to be expected *ex* ports during the night.

The balance of the monthly ration of stores due to each railhead being also known, a conference of the depot staff must be held after working hours to arrange the next day's programme of loading, reconsignments, and discharges, which in its turn may have to be modified by later information and instructions received up to midnight.

Instructions have to be issued to the labelling parties referred to in sub-para. (i).

(vi) It will be obvious that a flexible organization is essential, which will admit of rapid decisions being taken and the acceptance of considerable responsibility by subordinates on night duty.

During periods when the front line was quiet, that is, when no major operations were in hand, it was found, under the conditions prevailing in France, that by arrangements with armies, the monthly ration "stores" for various Corps could be dispatched in "pack" trains with considerable advantage to all concerned. Acting on the railway principle that a minimum train must consist of 30 trucks and a maximum train of about 40 trucks, it was arranged that 30 trucks in each train should consist of a fixed consignment:—

So many trucks of timber.
So many of huts.
So many of corrugated iron.
So many of steel shelters, etc., etc., up to 30 trucks.

The balance up to 10 trucks consisted of stores specially or urgently required by one Corps.

Thus, if at the last moment, as frequently occurred, the railhead of "X" Corps was not cleared for receipt of a train, the 10 trucks special to "X" Corps could be cut off the train, and the 30 trucks remaining consigned as a minimum train to "Y" Corps.

Normally we could send one such train to each Corps every fourth or fifth day. This system had the advantage that a Corps received its ration in regular consignments, the quantity of each consignment being known beforehand.

31. *Shops.*—These must be considered under the sub-heads of:—

(*a*) Factories.

(*b*) Repair shops.

(i) As regards factories, manufacture in bulk at bases has been considered in para. 15.

The general principles of the lay-out have been dealt with in para. 29 (v).

The base factories for timber trench stores in France were required to convert each about 300 tons of timber daily. The imperative necessity will therefore be apparent of an organization which admits of a continuous flow of operations from raw material to completed article in a straight line, thus involving the minimum amount of carry. The proportion of rip-saws, cross-cut saws, and nailing-benches must also be calculated to avoid "bottle-necks." All cross movements must be avoided and subsidiary stores, such as nails, which will also run to tons per diem, must be fed in with the minimum of labour to the right point at the right moment. Organizing capacity is, in fact, of far greater importance than mechanical engineering science.

Moreover, a change of manufacture will involve alterations in the lay-out of plant which may cause a loss of a fortnight's output. It is, therefore, essential to foresee the total requirements over a long period (12 months, if possible), and to manufacture a monthly average which must be stocked in the depot—not in the shop area—ready for heavy issues when the seasonal demand arises.

Any attempt to manufacture to indents is fatal to efficiency in the form of maximum output for a given plant and labour. For prisoners of war, task-work ; and for civil labour, piece-work, are very desirable. The output on piece-work will be a good guide to the possibilities of task-work.

(ii) Similar principles control the manufacture of articles of ironwork : as a general rule, however, base factories should only manufacture in ironwork new standard patterns required by the E.-in-C. until supply can be developed. The reasons for this limitation are sufficiently obvious.

(iii) Factories for construction of such timber and iron articles will obviously best be sited adjacent to a bulk store depot which can supply the raw material and receive and store the output.

But the general rule for siting a factory must be to place it where the principal raw material can be obtained with the minimum transport.

(iv) Thus factories for concrete blocks for "pill-boxes" or other constructions, will obviously be sited at a gravel pit.

Brick factories will be sited adjacent to clay pits and, in so far as this may still leave an option, to such clay pits as may permit of coal being obtained with the minimum transport.

(v) It may be necessary to consider the manufacture of cement which will certainly be required in large quantities. As, however, a ton of coal is required for the manufacture of a ton of cement, no advantage will be obtained by manufacture in the theatre of war, unless coal can also be obtained and transported to the factory with less disadvantage to transport than is involved in importing cement from the U.K.

(vi) Before leaving the subject of factories, it may be worth while to consider what at first sight many will regard as a minor point ; that is to say, what hours should be worked. On this matter, whilst holding no strong convictions, it appears to me from considerable experience, that the following factors should be given due weight.

(*a*) Engineers are not unanimous, but the weight of opinion appears to hold that machinery, like the animal creation, requires a daily rest.

(*b*) It was a noticeable fact that many men who were certainly indifferent to the danger of the front line, who became further inured to its squalor, found almost unendurable the incessant noise. Now base depots and factories, except for a few of the superior staff, must be run with prisoners of war and men unfit by reason of age or infirmity (often both). It always appeared to me that I could maintain their efficiency better if they could be ensured a few hours' quiet every day. Railway shunting is surprisingly quiet at anything over 100 yards' distance, provided the drivers can be induced to refrain from using their whistles.

(*c*) A night shift is never so efficient as a day shift, and is very liable to interruption by air raids.

Having in view these considerations, eventually a two-shift arrangement was adopted which gave peace from the scream of high-speed saws and rest to the plant from 23 hours to 6 hours. I am still of opinion that we obtained maximum results from a given number of men, and probably from the plant installed, by working two shifts instead of three.

32. As regards repair shops—this has always been debatable ground and the matter has not yet been decided.

Metal repair shops are required in a theatre of war, supplementary to Army mobile repair shops, for the repair, *inter alia*, of :—

Armament.
Locos and rolling stock.
Mechanical transport.
Engineer plant.

Each of these operations will involve the occasional use of some heavy plant. It is an open question whether repair shops should not be entrusted to an organization separate from any at present existing in *Army Establishments* who would organize "groups" of shops on, say, each line of supply. The tonnage of material required is not of such proportions as to render proximity to a store depot, or even to a port, essential. Again, facility of transport between armies and shops will be the controlling factor in determining a site.

At any rate, they should be kept quite distinct from "factories."

33. *Store-holding, generally.*—Only the fringe of this subject can here be considered.

(i) Generally engineer stores may be divided into a few definite store groups, as :—

Timber.
Trench stores.
Huts and hutting stores.
Water-supply plant and stores.
Electric-light plant and stores.
Workshop plant and stores.
Bridges and bridging stores.

It will be found that it is easier to define a store by its eventual use than by such generalizations as "textiles," "hardware," etc. Such definition will also result in better depot organization. In France we made "machinery" one store group. This resulted in difficulties which need not be specified; but my own experience is against a repetition of what I now consider to have been an error.

(ii) An area of a depot must then be assigned to each of these "store groups"; with a separate store-holding staff and a yard staff. The functions of the store-holding staff is to keep the tally records of the stocks of the group, to check receipt and issues, and to know exactly where every store in the group lies, and to see that their area contains no stores belonging to other groups; in general with the *custody* of the stores. The yard staff are assigned the function of stacking in accordance with instructions, generally in accord with the principles laid down under "Depot Lay-out" and "Depot Organization"; with the supervision of labour discharging, sorting, and loading; and with safety precautions against fire and theft: that is to say, generally with yard maintenance.

(iii) These group and yard staffs are controlled respectively by a Chief Storekeeper and a Chief Yard Officer.

(iv) An inspection staff is essential with plenary powers to pry into everybody's business, with a view to checking correctness of the tally-card stocks, and statistical records, investigating returns, discoveries, stores mislaid in wrong group areas. In addition to such general spy work, they are assigned the duty of obtaining, by short circuit methods, information required as to the exact position at the moment of any of the multitudinous stocks. Higher authority is apt to expect such information to be telephoned within half an hour of receipt of an enquiry.

In a depot covering 220 acres this cannot be done by constitutional methods following the normal chain of command.

(v) Finally, an Accounts Branch is, of course, essential.

Unfortunately the Army Accounts System in vogue in 1914–1918 with a view to the prevention of fraud was based on a system which did not lend itself to the recording of the statistical information essential to the E.-in-C.'s control of the distribution of Engineer Stores. As a result a separate statistical set of records was necessary.

34. The general organization of a depot of engineer or bulk stores will therefore normally be as indicated in the following table :—

- O. i/c Depot
  - Chief Storekeeper.
    - Group Store Staffs.
    - Stock-taking Staff.
  - Chief Yd. Officer.
    - Yard Staff.
    - Labellers.
  - Inspectorate.
  - Accounts.

35. An Assistant Director will control the O. i/c Depot, the various factories, and the port staffs in his area.

36. A Port Officer with a small staff is required at each port, charged with the following duties :—

He will in general watch the interests of his service ; report any undue rough-handling of stores ; label trucks for his depot ; use his best influence to procure, so far as is reasonable, homogeneous loading of trucks *ex* ship ; report to O i/c Depot by telephone each evening truck numbers dispatched and approximate contents ; and will see that no stores consigned to his Director are mislaid in Dock areas.

This is a task which requires considerable tact and energy.

37. Economy of man-power is a most important consideration. In this respect, officers in a theatre of war are apt to lose their sense of proportion and to indulge too much in opportunism. The temptation to do so is very great, for a supply officer is naturally judged rather by his efficiency than by his economy ; rightly so, indeed, but nevertheless he must obtain efficiency at the minimum cost.

It is, therefore, only just that he should be given such orders concerning economy of man-power as will take some of the responsibility off his shoulders. He can, if the necessity is brought home to him, so organize work and lay-outs as to reduce the number of " handlings " and the distance of carry to a minimum. He can also curtail the number of " employed " men.

Two orders were, therefore, issued to engineer store depots in France.

(i) Involved the calculation set forth in the History of the *Supply of Engineer Stores and Equipment*, page 86.

The fundamental idea was that :—

(*a*) On the average no store required to be handled more than three times, once into the depot, once in the depot for sorting, once out of the depot.

(*b*) An efficient lay-out would reduce each handling to an average of 25 yd. carry and 10 ft. lift.

(*c*) That even low-fed prisoners of war could handle, under conditions given above, 6 tons daily.

Therefore, the allowance of labour could be restricted to one labourer for every two tons received into the depot in the average day.

(ii) Involved the principle that it is the duty of a C.O. to maintain his men's morale, reduce "casualties" to a minimum, and cut down all "employ" to a minimum ; that 5% was about the maximum which could be on leave at a time. Therefore, for every 100 British Military personnel on the strength of his depot he must produce 75 "on the works." The remaining 25% must include all leave, sick, and all "employed" men. On the whole it was found feasible to work to these two restrictions.

Distribution.

38. It has already been observed that engineer stores have inevitably to be issued on the basis of "rations"; for Armies' demands far exceed the possibilities of supply. It is perhaps doubtful whether Armies could have used all the stores for which they asked ; probably demands were framed rather with a view to obtaining, and maintaining, in Army zones a large reserve against any such contingencies as a breakdown of transport or the necessity of constructing an entirely new defence line.

Be that as it may, the demands had to be cut at G.H.Q. to the average of the E.-in-C.'s forecast of six months' requirements.

The ration for the month for each Army having thus been decided by the E.-in-C. on the basis of :—

(*a*) The monthly provision.

(*b*) Special consideration of the operations on the front of the Army concerned.

(*c*) The retention of an adequate E.-in-C. reserve.

The C.E. of each Army communicated to the affiliated depot, his sub-division of this ration between Corps.

In the spring of 1918 the situation altered with such rapidity that it was found necessary by E.-in-C. to order weekly instead of monthly rations ; this fact is worthy of note, inasmuch as the long "settled" conditions of the western front cannot be regarded as normal; but the general system of distribution was determined by the existing conditions and must not, therefore, be taken too rigidly as a guide to action in future wars.

39. From time to time Corps endeavoured to fix the dates on which trains should arrive, or to fix an order of priority for dispatch. This is frankly unworkable. Depots must be given a free hand to get up the stores ordered within the period ordered. Bulk stores dispatched cannot be organized on a parcel post system.

40. Moreover, it is necessary that the tonnage to be sent to each named destination should be so divided up as to represent a definite number of train loads. As has several times been observed, it must be accepted as a fundamental axiom that the dispatch of single trucks, or indeed of anything less than a train-load, is prohibited by transport conditions, and, moreover, that one train-load cannot be divided between more than two stations, which must, in addition, be on the same branch line.

41. This condition is somewhat less rigid for distribution in the back zones (L. of C.) but even so the period of transit of isolated trucks is a very uncertain factor.

42. The principal feature to be noted under distribution is that the "ration" is determined by the E.-in-C. and the G.S., based upon information supplied by the supply service as to quantities available in depot.

RAIL TRANSPORT.

43. Having received from E.-in-C. instructions as to the ration allotted to the various Armies, and the indents of the Director of Works and other branches, the stores branch must now reduce these to tons and train-loads, and then calculate the number of trains required in the month for dispatch of stores.

It will be ascertained from the Q.M.G. staff whether there is a probability of the allocation of the required number of trains. If operations or other considerations render it improbable that a sufficiency of trains can be allocated, it will be necessary to inform the E.-in-C. at once so that he may decide in what respects to reduce his allotment of stores.

44. It did occur that C.E's of Armies were on occasions urging the dispatch of stores whilst at the same time the D.Q.M.G. of their Army was allotting all the trains allocated to him for the transport of other stores. The remedy in such event is obviously not in the hands of the supply services.

45. The general principles of rail transportation have been enunciated in foregoing paras. (5, 6 and 7, 10 and 41); the system of dispatch of "pack trains" has been detailed in para. 30 (vi).

46. If the front line be stabilized for any considerable period, it

may be possible to relieve rail congestion to some extent by establishing a line of supply by an inland waterway. In general, however, inland water transport is most efficient when employed for bulk transport between fixed points, and in France was, therefore, of the greatest value in relieving the strain on railways when clearing stores from ports to depots.

Similarly, in a river war it will normally be employed working between fixed points on a line of supply, and will not be found to be at its maximum efficiency if employed as column transport following up an advancing force.

47. As regards rail transport, the principle to be noted is that the (inevitably) insufficient transport accommodation is allotted by the Q.M.G. and his staff ; in consequence the E.-in-C.'s allotment of engineer stores can only be fulfilled if circumstances, or the instructions of the C.-in-C., permit the Q.M.G. to allot sufficient transport.

Decisions giving priority to any special category of store must obviously rest eventually with the General Staff. For example, it is only the General Staff who can decide that engineer stores shall be forwarded at the expense of ammunition, or personnel trains.

48. The vast quantity of engineer stores and, for that matter, ammunition required for a serious attack on entrenched enemy positions, must in effect be got to the required zone, before troop concentration commences. The difficulty of so doing without "giving away" the intended attack to the enemy gives rise to serious reflections which more appropriately belong to the ensuing section.

Reception and Distribution in Army Zones.

49. There was at times some consensus of authoritative opinion that R.E. Corps dumps became of excessive volume during the long period of stabilization from 1915 to March, 1918, on the Western Front. It is not difficult to schedule the arguments both for and against large Corps dumps ; it is necessary to do so before attempting a solution.

50. Pre-War regulations and organization envisaged the establishment of an advanced R.E. park for every two Corps, the park to be an "accounting" unit.

In effect, the R.E. park either formed the nucleus of a Corps dump in some cases, or in others became a "paper organization" accounting for stores which it never handled. In certain cases it was the actual custodian of stores "blacklisted" by the C.E. Army ; that is to say, stores which could only be issued on his authority, and were not at the disposal of C.E. Corps.

In the French Army it was apparently a sort of transit store for two annexed Corps dumps. In effect, in the British Army the Corps ump was the recipient of stores *ex* base and was sited on a railwa y at a safe distance from front line. From it stores were issued both for Corps use and for the Divisional R.E., involving in the latter case heavy road transport. Divisions were, as a rule, somewhat "independent" in their execution of siege works, and were not compelled to work to an area scheme of works, under control of Corps H.Q. directed by Army H.Q. Under these circumstances C.E. Corps appears to have retained control of trench stores with a view to preventing wasteful use on works not entirely approved by the Corps Headquarters.

51. Reference has already been made in para. 48 to the disadvantages of rushing up large quantities of stores, just before an intended operation. C.E's had also an uneasy feeling at all times that rail transportation might be unavailable just at the moment when a forward move of either side rendered necessary the construction of a new trench system requiring heavy consumption of engineer stores. This feeling was, of course, more prevalent when the absolutely front-line trench was considered to be the main fighting line, and was less apparent when this trench began to be recognized as the outpost line.

The result was a heavy accumulation of reserves in the Corps dump, which was again reflected in the accumulation by lower formations of their reserves.

52. Whilst this view must meet with some sympathy, it is essential that the disadvantages inherent in the consequent accumulation of reserves should be more fully realized than was the case.

(i) Such accumulation tends to dissipate and immobilize the E.-in-C.'s reserve of stores. It may well occur, and did in fact occur, that stores urgently required on one sector were not available, because they were locked up in another sector.

(ii) It is very wasteful of stores; one unit has accumulated reserves and is relieved by another unit which regards, and treats, such reserve as an excellent means of enabling it to execute sundry unauthorized works.

(iii) A Corps dump is not an accounting unit, and although statistics of its stocks were kept, no reliable statistics could be obtained of the stores locked up in minor dumps of lower formations. In any case, not only are the stores immobilized owing to the practical impossibility of moving them back by rail, but they are quite beyond E.-in-C.'s control and are lost to him as a reserve.

(iv) Should the Army make a considerable advance, it must either :—

Abandon its stores dumps ; or

Drag them forward, thus encumbering itself with heavy transport ; or

Leave men behind to guard the dumps, thus extending its tail at the expense of its fighting head.

(v) If the general organization involves all engineer stores passing through the Corps dump, this spells heavy road transport to the front line, for obviously such large dumps must be kept behind zones liable to heavy shell-fire.

53. The system now to be enunciated is put forward as a suggested solution; it met with the approval of one or two Army C.E's, at any rate in principle.

To some extent it presupposes and is contingent upon another suggested general principle, which is that an Army zone should be fixed at a certain depth dependent upon long-range shell-fire. Let us suppose it to be 20 miles deep from the outpost line. This zone would move with the outpost line. Up to the 20-mile limit all administrative operations, such as engineer works of all descriptions, transportation and supply would be conducted by the services of the rear zones (bases and L. of C.), with all the accountancy and other control prescribed for rear zone services. Forward of the 20-mile line, administrative operations would be conducted under orders issued by the Army Command concerned, according to the conditions and circumstances of the moment. For example, as regards rail transport, the line would be treated as a frontier; trains passing across it forwards would be freed from all traffic regulations of the rear zone and would be operated by an Army railhead staff.

54. As regards engineer stores, an advanced depot would be created just behind the Army zone, into which could be poured such stores as the C.E. Army, subject to the approval of the E.-in-C., might desire to see within his reach as an emergency reserve, which could in emergency be obtained by Army road transport.

The stores would, however, remain on charge of, and be accounted by, the stores branch; and would remain an E.-in-C. reserve.

It is suggested that, with such a reserve within reach, independent of rail transport, issues of stores for current works in progress might be made direct from base to the point on rail nearest to the work, that is to say, to the nearest point on rail which can be operated.

Under such conditions C.E. Army and C.E. Corps would retain control of store expenditure, without actually having to hold and handle stores intended by them for works to be executed by Divisional R.E.

When the Army moves forward it will feel no responsibility then for accumulation in its zone; the advance depot will be transferred back to base upon the close of the period of stabilization.

Or, if the forward move is only temporary and followed by another period of stabilization, the depot might be moved forward. In the event of retreat, the loss of stores would at any rate be no greater than under the circumstances which prevailed on the Western Front, and might well be far less.

SUPPLY OF STORES IN MOBILE WAR.

55. It must frankly be admitted that the war on the Western Front afforded little experience which can be used as a guide for the future.

During the final advance in September and October, 1918, the records of the Directorate of Engineer Stores show that considerable quantities of trench stores were still dispatched at the request of Armies. Perhaps we all had a feeling that another period of stabilization might ensue at any moment. For the most part these stores were subsequently found in various dumps staged in the trail of the advance. Conservatism causes the continuance of established habits after such habits have become anachronisms. It can hardly be assumed that an army on the move will normally require trainloads of trench stores. It will require bridges and bridging stores in considerable quantities, and often water pumps, hose and canvas tanks.

56. A bridge may well require the dispatch of a special train to one point, which presents no difficulty. But as regards all other engineer stores, the demands which may be expected require the dispatch of a few trucks at uncertain intervals to various points. It is further obviously very desirable that such trucks should arrive at the front within 24 or 48 hours of dispatch; for an Army on the move will not demand stores before they are actually required.

Unfortunately it is just this class of transportation which appears to be absolutely hopeless; to collect various consignments into a mixed train at all is apt to congest railway sorting stations; and, if an attempt to do so is actually made, the results are usually most unsatisfactory from the aspect of rapid transit.

Try, even now, with slack traffic on the railways, to consign a "parcel" of goods from the Midlands to the South of England by rail and note the number of days or weeks which elapse between dispatch and receipt. In war the difficulties of the railways can but magnify the delays.

57. There is then a difficulty which must be faced, and the solution found.

It was with these difficulties in view that a recommendation was made in para. 10 that all bulk stores should be collected in and dispatched from one depot. There would then be a reasonable prospect of making up complete trains with stores for various consignees, such as blankets, tents, sandbags, and engineer stores. It was actually found in 1917 that this method had to be adopted to get forward the bulk stores supplied by R.A.O.D. to R.E. parks and Corps dumps. Ordnance depots were then included in R.E. base depots. Later we actually took over these stores.

The inclusion further of railway construction materials amongst bulk stores would render it certain that complete train-loads could be made up. It is absolutely certain that railway materials will be required in the vicinity of any bridge to be constructed.

Design of Field Structures.

58. One subject upon which opinion was fairly unanimous was the necessity of designing any structures, whether bridges, huts, steel shelters or pill-boxes, etc., intended for front-line use, so as to be as nearly fool-proof as possible. They will meet with very rough handling, transport over the barest apologies for roads, may have to be carried down communication trenches, will be erected often in the dark, and then by semi-skilled men. It is therefore not merely "very desirable," but almost essential, that they shall be designed to have a minimum of "parts." Steel shelters, for example, should consist merely of 8-gauge or 12-gauge curved corrugated iron sheets with one type of bolt. All the extras which make the shelter look pretty, and incidentally more expensive, when erected as a sample in a manufacturer's yard, are encumbrances and nuisances to the field engineer.

The new type of steel bridge now under trial appears to be exactly what was, and is, required, provided that no fancy trimmings are added at some future date.

59. For all such stores the ideal is a sausage; the field engineer should be able to demand so many feet run of large shelter, small shelter, "M" type-hutting, or even of bridge.

With every 100-ft. run supplied of any such article would go automatically a fixed weight of the (one) type of fastener peculiar to it (nails, hooks or bolts).

60. This principle might even be adopted for hutting. The vision before me is of a demand for 1,000 ft. of Nissen hutting.

This would be met by supply of (say):—

1,500 curved corrugated iron sheets.
5,000-ft. run of purlin scantlings.
250 T-iron ribs.
50 doors.
200 windows.
50 stoves,
and so many cwt. of hook fasteners.

Or in lieu of the doors and windows:—

50 "A" type }
50 "B" type } gable ends might be supplied.

This roofing would be erected on walls made of filled sandbags, or over a pit, thus giving more headroom, whilst providing splinter-proof protection against air-bombs.

The floors would be provided either by materials found locally or drawn from timber stocks or by supply, where necessary, of marquee floors.

It may be worthy of note that timber floors amount to half the cost and half the bulk of most types of hut and really impose the limit of supply.

The principles advocated are :—

(i) Provision of roof covering (of the simplest design) from bases.

(ii) Such provision to be on a basis of feet run.

(iii) Provision of either gable ends, or preferably only joinery to be built into sandbag walls from bases ; to obviate the field troops requiring skilled artisan labour.

(iv) Construction of walls and floors *in situ*.

This suggestion clearly means the sacrifice of quality to quantity. Climatic conditions and transport facilities will, no doubt, decide on the extent to which such a course is desirable.

Army Organization.

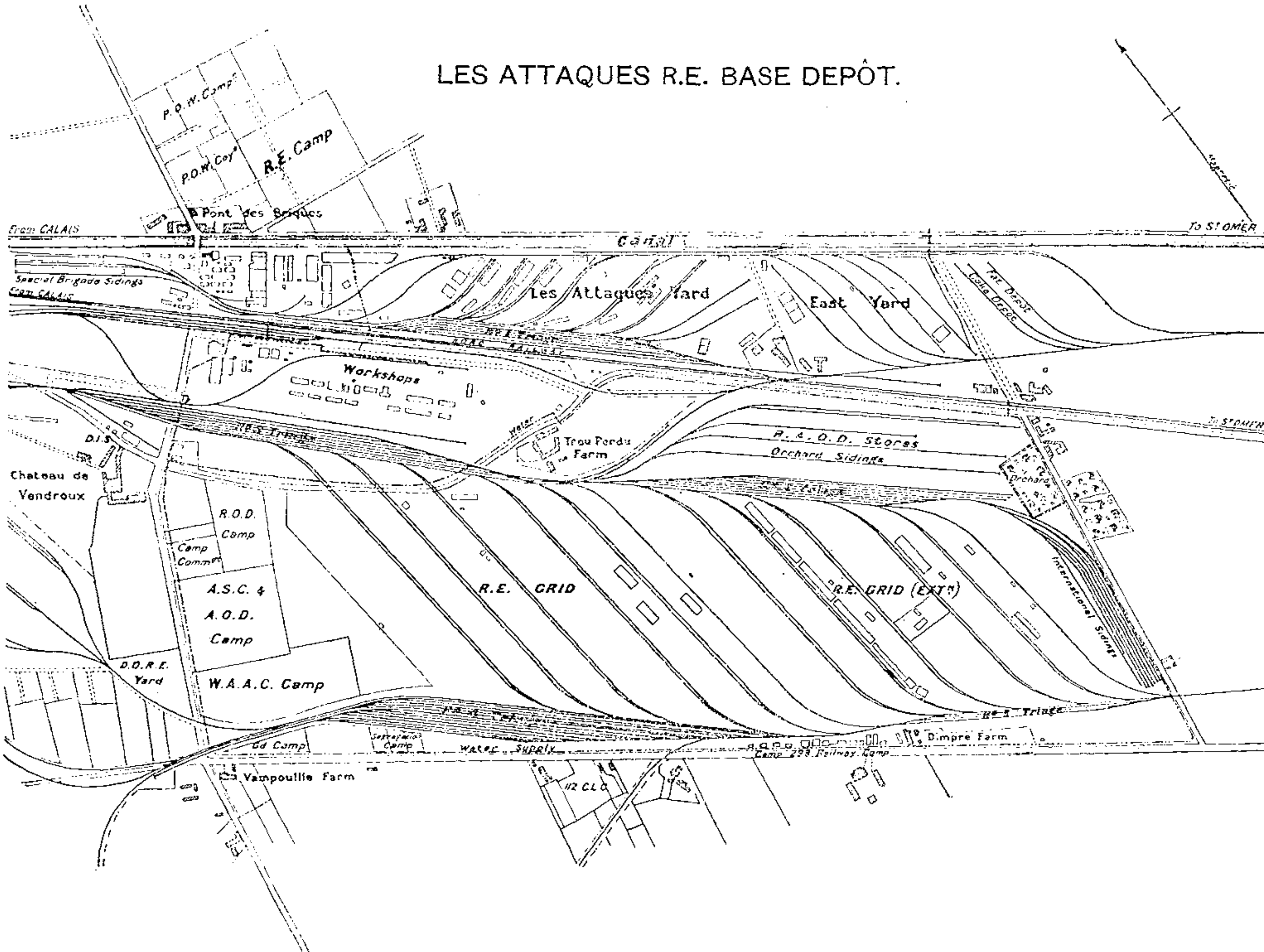
61. During and since 1918 many R.E. officers have appeared to attach great importance to the subject of the relation of the stores branch to the Higher Command.

At the moment the *F.S.R.* state that " the C.-in-C. will exercise his functions through three principal staff officers." There are no doubt many excellent reasons to be adduced for the alteration of the word " three " to read " one," " two," or " four." Until such alteration has been decided and functions allotted to the *x* Principal Staff Officers it would appear somewhat futile to attempt to fit the stores branch into any hypothetical new organization of the Field Command.

So far as " co-ordination " is concerned, this word can perhaps be given undue weight ; the co-ordination wanted is that which will ensure the maximum supply of the right stores at the right moment at the right place.

Clearly, so far as field engineers are concerned, the E.-in-C., and, so far as rear zone engineers are concerned, the Director of Works, whatever be the organization of the Higher Command, can alone decide upon the class and quantity of stores required and the locality in which they are required. Those problems have their own inherent difficulties, but when these are overcome it must not be forgotten that the real crux of the problem lies on the ability to

LES ATTAQUES R.E. BASE DEPÔT.



transport the stores from factory to site, a problem for solution by Q.M.G. branches at home and in the theatre of war. Far too many, not only of R.E. officers, but of civil business men, fail to grasp that bulk stores cannot be got to the site of the work by mere indent for transport on a R.T.O. or the methods of a parcel freight agency.

Stores of the best type and in ample quantities are useless to the R.E. unless they can be got to him; to do so involves the most intimate, constant, and rapid co-operation with all transport services.

Whatever be the higher organization adopted, it must provide for such co-operation as the prime essential. Depots and depot organization must similarly be designed in the first place with a view to facility of transport operation.

62. At the same time, the organization must be one which is in sympathy with and "speaking the same language" as the R.E. whom it serves. To this end many, if not most, of its higher staff should be R.E. officers fresh from the command of R.E. units. The ideal staff for a depot would probably be a triumvirate of a R.E. officer, a "Q" staff officer, and a transportation officer.

"ON LOCATION."

SIDELIGHTS ON FILM-MAKING IN THE SUDAN.

By "AJAX."

THE British Army is called upon, at one time or another, to fulfil many functions outside its normal duties. Tattoos and tournaments have become almost part of the regular routine of the fighting forces, and it is, perhaps, a welcome relief in these times of stress to think of such peaceful occupations, instead of the acute preparation for war which is the predominant thought in most minds just now. Some account, therefore, of the part played by troops, British and Native, in the making of one of the biggest films of the present time may be of interest, in the intervals of studying more serious topics.

The first indication that the filming of "The Four Feathers" required some military assistance in the Sudan arrived in the form of a visit to Khartoum by two representatives of the company concerned. They came in the early summer, which is the hottest and, in many ways, the most unpleasant season of the year in those parts, and were principally concerned in looking at the countryside, to see if it was suitable for the purpose they had in mind—the filming of those parts of Mason's story which occurred in the Sudan. To the uninitiated, it may seem that the obvious way to get the best results, when filming incidents of that sort, is to take them on the ground on which they are actually supposed to have occurred. But the minds of the film magnates do not work like this at all. In the present instance, some shots of the battle of Omdurman were required, this having been introduced into the original story. The experts, when they came, took one look at the actual battlefield and decided that it was useless to them. They then went some fifty miles from Khartoum, on the other side of the river, and found a site which they thought would do, and decided to film the battle there. The results they obtained are ample justification for using the terrain they selected instead of the original, but this sort of thing cannot but tend to make one doubt the authenticity of a great many film scenes which purport to be pictures of some historic place or event.

The two advance representatives having returned home and reported that the Sudan was a suitable place in which to film Sudanese scenes, and having made tentative enquiries as to the possibility of getting some troops to take part, no more was heard of the venture for some time. Then a letter arrived from the Film Company asking definitely for permission to make the film and for the co-operation of the troops. The suggestion was " approved in principle," and the work of arranging the details passed to the various subordinates concerned. The negotiations had scarcely more than started when the September crisis came along, and such frivolities as films were quickly forgotten. One day, when military affairs were just about at their most hectic, a cable arrived from England asking, if there should still be no war in November, whether the troops would still be available to take part in the film. Apart from providing one of the very rare laughs at that time, it is regrettable to admit that no action was taken! Eventually things quietened down and we were able once more to think of ordinary affairs. Negotiations were resumed and, before they were completed, the first two members of the company arrived in Khartoum to discuss details and make preparations.

These two gentlemen were perfectly charming and, apart from trying continually, though most pleasantly, to get charges reduced, hardly discussed money at all, although that had been the main theme of the letters which had passed hitherto. They were far more concerned with getting what they wanted than with what it cost, although one of them was the financial representative and did his best, without ever appearing to be mean or grasping, to get estimates cut whenever possible.

It was still very warm when they arrived, and they soon realized the folly of an earlier suggestion on their part—that the unit should come out in July to make the shots. Had they done so, few of them would have stayed the course, and the troops would not have been so amenable or useful! In spite of the weather which greeted them, they announced their intention of working right through the day when once they started " on location." In spite of this resolution to behave like mad dogs or Englishmen, when they did move out to camp, they weakened considerably, though they did work much longer hours than any Sudan official or British soldier thought right!

The labour involved in making the preliminary arrangements was considerable. Transport, accommodation, food, were all arranged by the military. The entire film unit, some forty strong, was to be accommodated by the unit which was finding the soldiers for the film—the East Surrey Regiment. The native troops gave less trouble, as was to be expected in their own country, but their Headquarters acted as the link between the film people and the various Government departments, most of which were involved at one time or another. While these plans were being made, the remainder of the film party were arriving. At last the day came when they moved out of Khartoum to Shabluka, the place selected for the actual shooting. The rank and file of the film unit never reached Khartoum at all, for Shabluka lies to the north, and these unfortunates were whipped out of the train at the nearest station, before they got to the capital, and planted straight into their desert camp.

Zoltan Korda, the director of the film, arrived some days before the move out to camp, and was taken round and shown the various sights and sites proposed. He was far from being impressed at first, and not at all pleased with the people who had carried out the original reconnaissance, saying that he had been entirely misled, that it was impossible to make any pictures at all in the Sudan, that he was ill and hated the country, the climate, the people, everything about the place. He calmed down later, and even appeared to be quite pleased with some of the shots he got. From the finished article, as seen on the screen, one must deduce that he has an extremely high standard and that the results exceeded even his hopes. As he himself pointed out, the camera can be arranged to "see" only a tiny portion of what is visible to the human eye. One flat piece of ground, when photographed, can look like part of a limitless desert, though it may be, in fact, surrounded by hills and rivers. It is this fact, so obvious when stated, but so little realized until then, which justifies the shooting of the battle of Omdurman some 40 miles from where it happened, in country as different from the original as the Sahara from the Nile valley.

For the first few days in camp the technical members of the film unit were kept fully occupied unloading and unpacking their mass of equipment. The troops, British and Native, were impressed to help with this, for the quantity of stuff was terrific. They had arranged to bring it into the country free of Customs duty, as it was all to be taken out again when they left, but they were a little shattered when asked to pay the 1 per cent quay dues which are levied on all goods coming in at Port Sudan. Although they are accustomed to dealing in thousands of pounds where the ordinary man thinks almost in shillings, a bill for some £300 in this respect shook even them, but there was no getting round it.

While the technicians were preparing their apparatus, the director and his assistants were going round the country spotting likely scenes and experimenting. Korda was most anxious to get some good pictures of vultures, to give atmosphere to his desert and battle scenes. When a man in his position wants vultures, he is not going to be content with an odd one or two, and during these first days he bought a number of goats, killed them, and laid them out as bait, to see how many vultures he could attract. He tried this on several occasions, but had no very good results. Once, having waited for an hour or more without seeing more than an odd bird, he and his party were just abandoning the vigil when a hawk arrived and came down close to the bait. Having decided that the lure was satisfactory and the coast clear, the hawk flew away and told his friends. A few moments later they came, and Korda saw what he wanted. Reports of the number of vultures that collected round the carcase varied from 50 to 200, but there is no doubt that there was a grisly crowd, and the director was satisfied that the atmosphere he wanted could be produced. Unfortunately, he had provided so much meat in the course of his experiments that all the birds of prey in the neighbourhood ate their fill, and later on, when they were wanted to appear before the camera for a real shot, they were all so gorged that not even a nice young donkey would tempt them. It was not until all the Shabluka scenes were finished and the crowds had gone that Korda eventually got the shots he wanted.

The water supply and other services for the camp had been erected by the Engineer Troops, Sudan Defence Force, whose aid was also invoked by the film people for various other jobs. First, they asked for a sand-proof tent or structure, to enable films to be loaded into the cameras without being damaged. The idea of excluding Sudan sand from anything is quite laughable to anyone who has lived there and become accustomed to sand in the soup, in beds, in baths, and in all other unwelcome places. Nor, in point of fact, was there time or material available on the spot to build anything substantial. The inevitable compromise was reached by putting up a tent, flooring it with wood clear of the ground, and building in the walls at the bottom to prevent some of the sand from being blown in. Although this must have been only a poor substitute for what they would have had in the studio, the technical experts concerned agreed that it would serve the purpose admirably and that the troops had done the job much better and more quickly than they would have got it done at Denham.

Then the sound engineers came and wanted a truck fitted up to take all their complicated equipment. An ordinary 15-cwt. Morris was used for this, and suited very well. Shelves fitted round the body, inside, provided seats for the crew and took the batteries underneath, while the main control board fitted neatly into the centre of the body, with room for the operator to sit at it when working. The whole job was done in half a morning, and again the head technician was satisfied.

At last things were more or less ready, and the decision was announced that shooting would actually begin the next day. One thing only was lacking for the first scene—some camels. A plan had been made with the civil authorities to produce camels, horsemen, donkeys, footmen, every conceivable type of native, when required, but it had been clearly pointed out that ten days' notice was necessary when these were wanted. Many of them had to be collected from some distance away, and the fact that the Ramadan fast was in progress made it harder than usual to move natives at all quickly. The film company's promise to give ten days' notice meant nothing when something was wanted urgently, and anything they asked for was almost always wanted in a great hurry. Accordingly, when Korda demanded camels for the first day's shooting, camels just had to be produced. The job of finding them fell to one David, who was business representative, secretary and general assistant to the director. He was a little Frenchman of remarkable determination and energy, as the case of these camels showed.

One of the local Sheikhs, Surur by name, had been told by the authorities to give all the help he could to the film people, and had already been of considerable use. It was extremely fortunate that the location was in his district, as he is one of the very few men in his position who speaks good English—he had been educated at the Gordon Memorial College until his father died and he returned to take charge of his village. Surur was the obvious man to produce these camels which were required so urgently, and about midday David sent a note to him by the hand of his hired native driver. This man had only the ordinary taxi-man's command of English, so David took the precaution of getting an officer of the S.D.F. to explain to him that the note was very important and that if the Sheikh was not at home when he got there, he was to wait for him, and on no account to leave the note with anyone else.

The driver set off in the car, and nothing more was thought of him until that evening. By half-past nine, when there was no sign of him or the car, much less of any camels, David became a little concerned. At ten he decided that something must be done, so he borrowed a lorry from the British troops and set off himself in search of the driver, the car, or some camels. On arriving at the Sheikh's village he found the driver, sitting with the people there having his Ramadan breakfast, patiently awaiting the return of Surur—the latter had gone into Khartoum, and nobody knew when he would be back. The driver had been told definitely not to leave the note with anyone but Surur himself, so there he was, waiting till he could carry out his orders!

Luckily, Surur's nephew was there, and he, too, had a little English. With considerable difficulty David managed to persuade the driver that the nephew could take the place of the Sheikh, and explained what he wanted. Although he had been fasting all day, and would ordinarily have been enjoying a night of eating and drinking, the nephew agreed to abandon his pleasures and set off, with David, to hunt for camels. They drove all night, visiting all the villages in the neighbourhood, impressing one camel here, another there. At first the young Sheikh was full of optimism, and assured David that they would have no difficulty in collecting the forty or fifty camels he wanted. As the night wore on, his hope faded, and eventually he admitted that, even if they found forty, it would be a matter for surprise and congratulation if twenty or so arrived in camp at the appointed time! By the time they had tired out one British driver, returned to camp and roused another to take his place, and continued their tour, reaching camp again at eight the next morning, they had bargained for some twenty camels. When shooting commenced, two had arrived. A few more trickled in during the morning's work, but they were hardly numerous enough to be impressive. In any case, the shooting went on as if nobody had ever mentioned camels and the scene, as far as one can make out, is none the worse for their absence. Possibly, in the picture business, one gets used to having one's work quietly ignored, but outside it there are not many men who would have been so unruffled as David, when his labours came to nought.

That first day's shooting made us realize what a slow and dreary business picture-making is. Having had an early breakfast, we were to be " on the set " by seven. In our innocence, and determined not to miss anything, we all turned out at that time. The director knew better, and put in an appearance an hour later. The preparations, before even the actors were wanted at all, seemed interminable, though we got used to them later on. Each separate team of technical experts had to have its say; the camera crew, the sound people, the technicolor expert, all had ideas, and over them all the director and the military adviser took control. The scene was a parade of a detachment of the " Royal North Surrey Regiment," prior to marching out on a special mission into the desert. On the screen it is over in what seems like a few seconds, yet it took two days and more to get it all right. At last everyone is satisfied, the soldiers have been instructed and rehearsed, and the director says, " All right, we shoot it." His assistant says, " Quiet, please," then " Turn 'em over," which is the cue for the cameras to start turning. The operator shouts " Speed " when his motors are running properly, a boy speaks the number of the shot into the microphone and another holds up the clapper board, recording the details of the shot, so that it is photographed on the film. Then the director says " GO," and the scene begins. If all goes well, it runs to the end, and then each technical crew reports " O.K." or otherwise, a test of the film is made to check the exposure, the length of film shot is recorded, with other details, by the continuity girl, and that " take " is finished. But not the whole scene, by any means. It may not have been quite to the director's liking, but even if it was, he will still want several more takes of the same scene before it is finished.

Even in the studio they make a number of takes of every scene, and on location it is even more important to do so. Many things can happen to any particular piece of film between the time it is made and the time it is finally processed and printed in the laboratory. It may not have been perfect in the first place; it may have got scratched in the loading or unloading; it may be damaged by the heat, in spite of being kept on ice as much as possible; and the impossibility of reshooting scenes taken on location, if they turn out to be no good, makes it essential to have a number of takes of every important shot.

The sound was normally recorded for all scenes, but in a general shot, one including a number of people, or taken at some distance from the action, they did not pay very much attention to the sound. For close shots, on the other hand, the utmost care had to be taken to ensure that no noise but the particular sound they wanted reached the microphone. In camp it was not always easy to avoid unwanted noises, as they found when they were taking close shots of that same first scene. At the first attempt, a lorry drove across the background of the picture, which ruined it completely, as lorries did not accompany Kitchener's expedition. The second time, the picture was all right, but another lorry chose that moment to start up and race its engine somewhere just out of sight, which ruined the sound track. Steps were taken to prevent this occurring again, and they started off for the third time. An officer was taking the opportunity of making a private record of the events in camp on his own cine-camera, and had taken up his stand close to the big camera, to get the same shot. Unfortunately even the ticking of the little clock-work motor in his tiny camera was more than the sound expert could accept without spoiling his film, so that was no good. At the fourth attempt it really looked as if they would get it through without a hitch, and they got the first part perfectly. Then a soldier in the lines nearby awoke from his nap, decided that his tent was not all that it should be, and started to drive in the iron pegs with a sledge hammer, accompanying his work with whistling of a not very musical order. Another length of sound film was wasted, but the company seemed quite used to this sort of thing, and started again quite cheerfully. At the fifth try they succeeded in getting right through without interruption, to the relief of everyone there.

This particular scene, which occupied the whole unit and many soldiers for the first few days, included a speech by one of the "officers" of the detachment, explaining to the men that they were just going out into the desert, that it was not going to be a soft job, but that he knew they would carry it through, etc., etc. Everyone in camp knew this speech by heart before they had finished with it, they had heard it so many times. It was a little ironical to find that the whole of it had been cut from the finished film! When they were paying daily wages to over 1,000 troops and natives, irrespective of whether they actually worked or not, a complete waste of two or three days seemed a pity, but that is the way the money goes in the picture business.

From the time that the news of the film company's impending arrival first reached Khartoum, the demand for copies of Mason's original *Four Feathers* had considerably exceeded the supply, but quite a number of the officers and men in camp had read it fairly recently, or at any rate remembered the story in some detail. It was therefore rather a shock to find that some of the members of the film unit had never read the book at all and that others remembered very little of it. That was our first impression, but we soon found that those who had never read the original were almost entirely the technical staff. Others, who were vague about Mason's version, knew well enough the story as arranged for the film by Sherriff. Frequently, Korda told us, when a book is adapted for the film, particularly in America, it is so cut about and altered that there may be not a single one of the author's original lines left. Mason's story has given them a magnificent background and framework, and the cutting, adding, telescoping time and altering dates which has been done at Denham is only what is necessary to translate the novel into the exciting, interesting and vivid picture which is now shown on the screen.

Throughout the shooting that took place at Shabluka, it was very noticeable how little of each scene had been decided beforehand. The director knew, of course, the outline, what had to happen, and the story which had to be told, but the little details were always decided on the spot, and were frequently changed in the course of rehearsals. To get the best out of local materials and people it is, perhaps, essential to build up the actual scene on the spot, but it wasted a lot of time and tried the patience of the poor soldiers who were not used to such methods, and would have preferred to do their day's work and have done with it.

The next sequence to be tackled was that in which the detachment of the North Surrey Regiment, out in the desert, camps in a zariba for the night and is attacked and practically annihilated by the Khalifa's hordes. A site in the midst of some rocks, quite close to the camp, was chosen for this scene. Though tactically horribly unsound, and the last place one would choose to camp in enemy country, it suited their purpose and certainly produced some wonderfully effective shots on the screen. The zariba was made of bramble and pieces of bush gathered in the vicinity. As it had to be remade after each rehearsal, and as they decided to increase the size of it at least three times in the course of the next few days, the troops got very tired of carrying this material in to make the fence, particularly as they had to go farther and farther afield each time.

While examining the site before beginning to make the zariba, Korda had the brilliant idea of letting the raiders set it on fire. Even the officer in charge of the party who had to make it was bound to admit that this would be a wonderful sight, the fence burning all round the gallant British soldiers, and the savages leaping through the flames. He did so with some reluctance, though, as the burning of it considerably increased the labour involved in maintaining and rebuilding the zariba.

The shooting of this sequence brought out one point which few of us had realized before. The troops were brought to the site in lorries, as were all the various bits of apparatus which go to make up a film unit. So was tea for the men to drink in the middle of the morning, first-aid equipment, water for the natives, and many other things. The director's assistants rode about all over the place putting people in their positions and the Sudanese cavalry, impersonating dervishes, also rode through and through the scene. But every one of those tracks, whether motor or horse, had to be obliterated before the shooting could begin. The scene was supposed to take place in complete desert, far from any traces of habitation, and it was rather pathetic to see a small army of men go out, after rehearsals were complete and before the actual shooting began, and laboriously sweep the desert clean of tracks.

Korda now appeared at his best—and worst. For some shots preliminary to the actual zariba scene, where he wanted to show some dervishes spotting the British detachment from afar and making their plans to attack it, he assembled the people before even he had decided where he would make the shot. When he had found the place, and worked out the details, he really got down to rehearsing the native actors. Knowing not half-a-dozen words of the language, and scorning the help of the few interpreters who were present, he took each native by the hand, when necessary, and showed him exactly what was wanted. Clambering about the rocks, he shouted and yelled in pseudo-Arabic, and in the end got the men worked up to such a pitch of enthusiasm that it was all we could do to stop them from going on being dervishes long after the scene was over. They are born actors, in the way that children are, and when once they were told to be dervishes, they would go on being dervishes until all was blue, even to the extent of staging mock attacks on cars, horsemen and visitors, quite apart from the film.

The zariba sequence had its lighter side, too. Sentries were to be posted, and one they put on the top of a rock near the camp. He looked very imposing, silhouetted against the clear sky, but in actual fact he could only reach his post by means of a ladder, which had to be removed when he was in position, or it would have spoilt the picture. On one occasion they forgot about him after the shot was made, and he was left, perched on his rock, for half an hour or more, until someone brought the ladder again for him to climb down. At the first rehearsal, when Korda had explained to the British troops that, at the beginning of the scene, they were supposed to be asleep in their bivouacs, some of the men thought they would improve on the script, and started some good, soldierly snores. Korda heard them, was taken by the idea, and said: "Go on, I want more bigger snores!" After that, the noise of them almost drowned the sounding of the alarm.

When it came to explaining to the natives what was wanted, it was thought desirable to point out very clearly that it was only a game, and that no damage was to be done to the men inside the zariba. Nobody really expected trouble, but you could not be quite sure, when the savages got really excited, and a little chat on these lines might prevent a "regrettable incident." The ordinary natives understood quite well, but it was more difficult to explain to the Fuzzy Wuzzies, who had arrived the day before. These men, of the Hadendoa or Beja tribes, had been brought up from the Red Sea hills especially for the film, and were a great source of excitement to the film company, who all thought them marvellous, picturesque, and in every respect grand. They have a language of their own, and although they had brought with them a few interpreters, it was no easy matter to get an idea into their heads. They would not pay very much attention to their interpreters, who were as likely as not to have got the idea wrong, in any case. So, when it came to telling them that it was not real war but only a game, one of them took a look at the soldiers in the zariba, saw that they had rifles, and said, very thoughtfully, to Korda: "Yes, but do they" (pointing at the troops) "know that we are only playing?"

Korda took a great fancy to the Fuzzies, and would spend almost hours at a time playing with them. Some of the time he would be rehearsing them for particular little bits of the film, but quite often he was merely playing, as one would with children. They responded well to this treatment, so it was probably well worth while, though he rather tended to spoil them by giving them presents. They have already been badly spoiled in places by the tourist traffic, and will pose affectedly to have their photograph taken, if they do not insist on being paid before they will face the camera at all.

After many rehearsals of little bits and of individuals, the time came to try out the combined attack on the zariba. In order to control the masses, it was arranged that a bugle should sound. At the first call, the dervish army was to advance on the zariba. The second call was the signal for the troops in the zariba to open fire, while the third was the "Stand Fast," at which everybody was to remain still, so that adjustments and alterations could be made before repeating the rehearsal. The first two calls had the desired effects, and the battle was in full swing, the Fuzzies having the time of their lives tearing down bivouacs, hurling the soldiers' clothing and equipment all over the place and destroying our carefully prepared zariba.

Korda had seen all he wanted for the moment, and gave the order to the bugler to sound for the third time. The man did his best; he went on sounding the Stand Fast until he had no breath left in his body, but it had absolutely no effect whatever; the battle still raged.

Everyone who had with him any means of making a noise used it; whistles blew, car horns sounded, people shouted, but all to no effect. The dervishes were playing their parts, enjoying themselves thoroughly. In the end all the officers and spectators rushed into the zariba, seized natives by the arms and dragged them forcibly out of the way. They were past listening, and only by force was order re-established. It took most of the remaining daylight to restore the zariba and the troops to their proper condition, ready to repeat the rehearsal. Many people had told Korda at the beginning that, with natives, their first performance of any particular scene would always be the most natural, the most vigorous, and the best, even if it was not exactly what he wanted. Had he acted on this advice, he could have got some wonderful shots during that first rehearsal of the assault on the zariba, but they probably would not have been in keeping with the seriousness of the occasion, so perhaps he was right to let them work off steam and then reduce them to the state of mind he wanted.

Having seen the Fuzzies in the full heat of the attack, brandishing their swords and shouting fierce cries, it was disillusioning to find that most of them, when the scene was over, ran straight to the first-aid man to have their wounds dressed. It was unfortunate that the iodine bottle was disclosed that first day; for after that, the demand for it increased steadily. Some of the men even uncovered week- and month-old wounds, which had nothing whatever to do with their present occupation, and demanded dressings for these! Some of them had good reason to ask for dressings after the assault, for they were badly burned by blank ammunition fired at close quarters. The first time this happened even Korda was disappointed in them. Assuring everyone that the ammunition was exactly the same as had been regularly used in the studio without complaint, he stood up in front of a rifle at about three yards range, and allowed himself to be shot at. He gave no sign of discomfort, but he had to admit in the privacy of the camp that it had stung considerably, and that he could not expect the naked savages to stand up to it.

Ordinary blank ammunition gives no smoke, and would therefore show no effect in the film, so they had brought out this special stuff. After much discussion and experiment, to see if they could get the cartridges dismantled and refilled with a reduced charge, or whether they could fit shields to the rifles, it was found that they had two different sorts of ammunition with them. The firm who supply all their explosives had had rush orders during the crisis in September, and when the time came to fill the order for their blank to come out to the Sudan, they had not had enough of the right type, and had made up with something else that was just that little bit different, to the discomfiture of the Fuzzies. When once this was realized, all was well, for they had just enough of the right kind of rounds to use when the enemy was close, and could keep the bad stuff for occasions when there was no target near enough to get hurt.

At last the scene was staged and rehearsed to the satisfaction of the director and his staff. Then came the business of setting the zariba on fire. The "effects man," who was responsible for this, assured Korda that he could produce a magnificent fire, all round the zariba, at the right moment, merely by pressing a button. He laid his cables and placed his charges, and sprayed petrol over the thorn of the fence. The attackers were in position and the defenders sleeping, and the signal was given to begin. Because of the damage the fire would cause and the time it would take to restore the zariba afterwards, they wanted to shoot the scene the first time, so the cameras were turning nicely when the signal to light the fires was given. At once a flame shot up in one corner of the zariba, quickly followed by others in other parts. Unfortunately they failed to spread very far, and the result was little more than the effect of some picnickers lighting matches and throwing them down on the grass, which smouldered for a few moments and then went out.

Korda was furious, but he gave the expert another chance. The second attempt was better, but by no means impressive, and this time there was an added set-back. The Fuzzies in the attack came quite close to the zariba, but the moment it burst into flame they turned and ran—not at all according to plan. A third attempt was equally futile, and the company broke up in a strained atmosphere. One could not help noticing how any reverse or failure which annoyed the director quickly affected the rest of the company. When that happened, tempers soon became frayed and nerves on edge. However bad this was in the daytime, it passed away in the evening, and everyone would be on the best of terms again. So on this occasion, the evening was spent, not in recriminations or arguments as to whose was the blame for the morning's fiasco, but in reconstructing the scene for the next day. The fire-maker said he really would produce the goods, the battle was redesigned so as to give more control, and next morning we started, bright and early, to shoot the reorganized attack on the zariba.

Starting with the easiest part of the preparations, they first laid out those who were to represent the dead and dying on the battlefield. Many of the natives were either too old or too young to take a sufficiently active part in the attack to please Korda's ideas of a wild rush, and to them fell this less strenuous job. One of these has been mentioned, as a result, in several English papers. This old gentleman, when told to lie down and be dead, objected strongly. He had been in the original battle, he said, and had not died then, so why should he die now, when the whole thing was only a picture, anyway? This was the story that was spread round the camp and later published, but it was not quite as true as all that. The old man probably had been present, as a small boy, in the vicinity of the battle of Omdurman, but the words were more or less put into his mouth by one of the civil officials who happened to be on the spot that day, helping the film people to deal with the natives. However, it gave the publicity man of the company great scope, and he promptly got photographs taken, not only of the hero himself, but also of a number of other old men who claimed to be survivors of the battle. These, with accompanying flowery comments, have found their way into several editions of the English Press.

The burning of the zariba that day was really magnificent. Where a few flaming spears thrown into the thorn fence would in reality have produced a number of small fires which might eventually have joined themselves up into a blaze, we saw the fiery spears thrown, and immediately the entire zariba was on fire, flames bursting from every corner and flaring up into a regular furnace. The heat inside the zariba was almost unbearable, and one of the British soldiers defending the post, who had been detailed to be a "casualty," fell in his appointed place, only to find that in a very few minutes it was too hot for him. Fortunately for the film, he was sufficient of an actor not to move, and fortunately for him some of his friends saw the position he was in and pulled him a bit farther away from the flames. They had to do this a second time before he was finally safe, and his clothes were badly scorched—such devotion to duty was worthy of the British Army, and a lesson to the braves of the Hadendoa!

The attack with the fire was shot several times, and the result on the screen was truly magnificent. A number of shots of details followed, to complete the sequence. Some of these, such as when they wanted to get an individual Fuzzy doing some particular act, lighting a flaming spear, or jumping over the zariba, or encouraging his companions, took nearly as long as the big scene, but Korda really enjoyed and excelled himself in the making of such shots, and they certainly were effective.

Other sequences which they shot out at Shabluka followed much the same course—interminable delays, a good deal of argument, hours of waiting about, and then the final shooting. On several occasions Korda came into conflict with his technical adviser, an ex-officer of the Indian Army. This expert had made a detailed study of the period and the campaign, and was a mine of information on all the small points of uniform, customs and drill which make the difference between an accurate film and a slip-shod one. But Korda was not going to be dictated to by him or anyone else when military details clashed with artistic effect. He was ready and anxious to be accurate when it mattered, but strategy must in every case give way to art, on that point he would brook no argument. On several occasions one or other of the local representatives, civil or military, would point out to him that something was not quite in order, was out of character or out of period. As often as not his answer would be that he was interested to know this, but could not alter it in that particular scene. In any case, he would say, how many people, from among the millions that he hoped would see the film on the screen, would know that the thing was wrong? So few that they must sink their scruples, and extreme accuracy must once again give way to artistic effect. Sometimes he would go further, and point out that if some of those who know the country and conditions see the film and find something not quite right, so long as it is not a glaring error, it is all to the good, for they will talk about it, and that in itself is good advertisement.

The scenes of the battle of Omdurman occupied the whole company for some days. Firstly, they had to get the dervish army on the march and assembling for the battle, and the control of the mixed crowd of natives who represented the Khalifa's army was far from easy. Trying to get them into formation and keep them moving in the right direction at the right pace kept all the director's assistants and anyone else who was willing and available running and riding about the desert for hours at a time.

It was typical of the film routine that, on the day appointed for the shooting of the actual battle, the entire armies were assembled at a selected spot early in the morning, and had been there some time before the director arrived. A trial charge over the ground he had hoped would be suitable showed at once that it would not do. There were too many small rocks and rough places for a convincing cavalry charge to be safe and there was nothing for it but to go off and find another site. The natives were quite happy while he was away, doing nothing with their usual efficiency. The British soldiers and some of the technicians passed the time playing football, cricket and baseball, all with equipment improvised on the spot. Although the troops did not often show the impatience they felt at all the delays and hanging about, they could not resist a dig at the system when they held a smoking concert, shortly after this occasion. The comedian was telling the audience what hard work picture-making was, and what early starts they had to make, and he said: "Why, the other day they got us up at five o'clock—to play football!"

The spot finally chosen for the battle scenes was some two miles further away from the camp, and this extra distance was far from popular with the natives. It was the time of the Ramadan Fast, and they all objected strongly to starting out any earlier in the morning and to walking or riding their donkeys the extra distance. After much argument the film company had to arrange to transport most of them in lorries from their camp to the site—a further complication in the already difficult transport problem.

The natives, or more particularly the sheikhs, were not slow to realize that there was easy money to be made out of the film company. Whatever Korda or his staff wanted, they wanted urgently, and were prepared to pay for at almost any price. But the sheikhs were not shrewd enough to know where to draw the line, and overstepped it eventually. Korda wanted a few camels to shoot and have lying about the battlefield, so enquiries were made if there were any old or diseased animals in the neighbourhood which could be bought cheaply. Somewhat to their surprise, not one was forthcoming. The sheikhs assured Korda and David that every camel belonging to every man within reach was a good, strong beast, well above the average value. Not only this, but the owners were most unwilling to sell. Having got a free trip to Omdurman and Khartoum, to see if any cheap ones could be got from there, but finding none, they reported that there were some among their men who would sell camels, as a great favour, at ten pounds each. Even the film innocents were staggered at this price, and the local officials just laughed, but, after all, a very early rule in Economics is that a thing is worth what it will fetch!

The sheikhs would not budge as much as a millième from their figure, and in the end an agreement was made whereby up to ten camels were to be available at this price. Owing to the high cost, David made a proviso, that he would only pay for the number of camels actually shot, which, he told them, might be many less than ten; he could not say exactly how many Korda would want until the time came for shooting the actual scene. He thought he had made everything quite clear, but the sheikhs thought differently. Having shot three camels, he was presented with the bill for the full ten. When he, not unnaturally, objected, he was told that he had agreed to buy the ten; the sheikh had paid out the purchase price to all ten owners, and now wanted to be reimbursed! Even the long-suffering David jibbed at this, and the responsible District Commissioner was summoned to arbitrate.

Having heard the story, he went first to the camp where the camel-owners were living, and talked to some of them. Without giving any inkling of the reason for his enquiries, he quietly asked the price of several good-looking camels. Having had replies varying from three to five pounds, it was fairly clear that the sheikhs were making an even better thing out of the film company than had been suspected. Nobody wanted them to be done down, and it was generally agreed that the film magnates were fair game, up to a point. If the demands had been kept within reasonable bounds, nothing would have been said, the owners could have had a very good price for their camels and the sheikhs could have pocketed a handsome profit. As it was, the ordinary market price was paid, and the sheikhs, officially, got nothing but a rather bad mark with their own D.C. Greed is a stupid vice.

The battle scenes were followed by shots of Kitchener visiting his army in camp and leading them on the march. When these were done, the whole unit moved to the river. Here they embarked on Nile steamers and spent some days getting pictures of Kitchener's boats being pulled up over the rapids by hordes of natives. For the first three days on the river, little was achieved. Something always went wrong, and it looked as if the Nile sequence would have to be shot on the Colne at Denham after all. But they stuck to it, for, whatever else these film people may have been, they were nothing if not persistent, and they were determined not to admit defeat by difficulties, even though these might be unknown and unexpected. For financial reasons, too, they had to get these river shots. The cost of this part of the trip, not counting such overheads as the salaries of the permanent staff, worked out at more than £1,000 a day, and when they had wasted three days, they felt that they must go on until they had something to show for their money. Even in the film world, it seems, you cannot throw £3,000 into the Nile without some awkward questions being asked!

Perseverance won in the end, and they got the shots, or some of them, for which they had made the river trip. Beautiful as they are on the screen, and they are very beautiful indeed, and allowing for the fact that, in the picture world, values are quite different from anywhere else, it is hard to believe that those few feet of film were really worth all that trouble and money. But the director himself has said that they were much more than worth the expense and difficulties which they met and overcame.

For the greater part of their time in the Sudan they were paying out in wages alone, to soldiers and natives employed as extras, over £200 a day. Yet they thought nothing of keeping the whole crowd of them standing about, idle, for hours at a time, while the director and his staff discussed some detail, or wondered whether the site they had chosen was really the best for the scene in hand. They told us frankly that the principle on which the whole picture business worked was that it did not matter who or what was kept waiting, or for how long, so long as the production, that is to say the actual shooting, was not delayed for one moment.

The whole of their work in the Sudan was to produce well under an hour on the screen, as the rest of the film had already been made in the studios at Denham. On this basis, their rate of progress worked out at a little over one minute's showing time for each day's work. This, they said, was not abnormally slow, even in the studio, and was quite good on location, though black and white pictures were considerably quicker, easier and cheaper to make than the Technicolor which they were using for this film.

Apart from the actual work, it was most interesting to live with these people from another world. Everyone, I think, when they heard that a film company was coming, expected a collection of the most impossible people—loud, cigar-smoking, bad-tempered men with no manners. We found instead that they were interesting and quite charming people, completely wrapped up in their work, yet ready and willing to discuss it, broadly or in detail, with anyone. Korda himself is undoubtedly a genius ; as such, he is not beyond demanding the impossible—but he usually gets it. He worked hard himself, staying out in the African sun far longer than many British residents there would think of doing. When the picture demanded, no fatigue or inconvenience counted, for himself or for any of his staff. There was hardly one of the officers and officials there in camp who did not, at one time or another, become furious with him in the daytime, when he could be rude, obstinate, wasteful of time and labour, and utterly inconsiderate for all those working with him. But in the evening he would be so charming, explaining just why he wanted this or that, asking advice or discussing some point of detail, that it was impossible to stay angry with him for long, and everybody was genuinely sorry when he left the Sudan.

Now a naturalized Briton, he spent his youth in his native Hungary, and fought against us with the Austro-Hungarian Army. Some of the tales he told of the discipline and conditions there made one realize the truth of stories one had heard or read and classed as improbable exaggerations. Absolutely wrapped up in his art, and generous to a fault by nature, money means nothing to Zoltan Korda, and he has therefore become an easy prey to the refugees from Europe who, in these days, launch at him a steady stream of appeals for money, work, or help of some other kind.

Living and working with these film people for a month or more made one realize why big films cost so much to produce and why the profits from them are often so small. One wondered at times that such films are ever completed at all ! To a tidy mind, particularly a military one, the apparent lack of foresight and organization were heart-breaking until one realized the difficulties with which these people had to compete. Whether one considers the artists, the technicians or the business men amongst them, it was no easy problem to have to face, with no warning, such specialized and varied problems as military evolutions, Nile navigation, and native habits or customs. Not only had they to grasp the problems, with no time available to study them, but also they had to see how they could best be solved to the advantage of the film, and how apparent difficulties could be turned into effective features on the screen, while always bearing in mind the limitations of the story, the place and the people concerned. In spite of all these difficulties, the team work, when they got to the actual shooting, was extremely good. But the general atmosphere of chaos and vagueness was quite enough to cure the most ardent enthusiast of any desire to go into the picture business—but it is a most fascinating game, for all that!

THE USE OF WEAK BRIDGES FOR HEAVY LOADS.

Comments on an article appearing in *The R.E. Journal* for December, 1939, under the above title.

BY LIEUT.-COLONEL H. A. BAKER, M.C., R.E.

This article which is, I presume, a precis of the original, appears to me to be so incomplete and confused that, if not challenged at once, it may lead to dangerous results. In the first place the title is rather unfortunate and would have better expressed the subject of the article if it had read, for example, " Increased carrying capacity of Civilian Bridges under Military Loads."

Whilst agreeing that there is considerable scope in this direction, I venture to disagree with some of the writer's arguments and deductions.

I am at a loss to understand the meaning of the fifth paragraph (at the top of page 562). How can an accurate calculation of the load carrying capacity of a bridge (the third method) be " only slightly easier than the working out of a demolition scheme " ?

If, as is suggested, it is the " application of a few simple formulæ, knowledge of some principles of bridge construction and the use of tables," it can hardly be classed as " accurate arithmetical calculation by Engineer Officers or other technically qualified persons."

I wish the calculation of the strength of a bridge were as easy as a demolition scheme, where exact calculation is impossible and only empirical formulæ can be used. In practice, working out a bridge backwards is anything but easy unless one trusts the designer implicitly and assumes he has achieved the ideal of perfectly balanced strength in all members, when it would be only necessary to calculate one or two numbers.

Again, what is meant by " So accurate a calculation is not important enough for many Units " ? Does this mean that some Units are not important enough for so accurate a calculation ? In that case some Units must be very unimportant, as we have been told the calculation " is only a little easier than a demolition scheme." I should not like to classify Units from this point of view.

When we come to examine the so-called Rules-of-Thumb we find even worse confusion of thought.

It is clear that a tracked or multiple-axle vehicle, due to the increased distribution of its load over a length of bridge, will reduce the bending movement in the main girders and roadbearers to a degree varying with the length of the span in each case ; but it may have no appreciable effect on cross girders. In any case, the effect will vary inversely as the span. Yet we are asked to believe that a lorry weighing $8\frac{1}{2}$ tons laden will require a bridge of a carrying capacity of only 7 tons. Nothing is stated as to the type of the lorry that produces this particular effect, nor is any reference made to the span, and many of our army lorries are now four-wheeled. It would, therefore, be extremely dangerous to paint such a figure on a lorry. As an example, suppose a vehicle having its rear wheels on tracks X feet long, carrying W tons on the tracks, is placed on a bridge or longitudinal member, span L feet. (The front axle is neglected, as it will be the same in both instances.)

The M_{ff} will be $\frac{WL}{4}-\frac{W}{2}\times\frac{X}{4}$ ft. tons.

If the lorry had a single rear axle

the M_{ff} would be $\frac{WL}{4}$ ft. tons.

From this it is clear that, if $X=L$ the M_{ff} is $\frac{WL}{8}$,

whereas the longer L becomes in relation to X, the less will the effects of the tracks be in reducing the M_{ff}.

Of the author's next two points, that included in (*a*) is obviously permissable and we might safely allow an addition of 25 per cent on this score alone if the bridge is in good condition.

But point (*b*) is really nonsense. It is usually considered that, under war conditions, impact effects will be greater owing to the deterioration in the roadway and approaches under military traffic, and I can see no reason why military vehicles should be more smooth running than civilian ones. It may be argued that, with efficient control of speed possible in war, impact may be reduced below that allowed in civilian calculations but this is not the author's argument. Later, he does make the proviso that there are no potholes and that vehicles travel smoothly and slowly but this conflicts with his remarks in (*b*).

But why must vehicles now travel singly ? What has this to do with impact except possibly to increase it ? He is surely mixing two separate influences in this second reduction factor. It would be better to have two factors, one for the reduction of impact, if admissable, and another for the reduction obtained by restricting traffic. The author's factor is presumably a mixture of these two, both of which vary with the span.

In the example given, the mysterious figure of 7 tons comes in again although the type of vehicle is not stated, beyond the fact that it is a motor lorry.

The result of the author's calculations comes to 7·5 tons but, in spite of this, he reduces the bridge to single vehicles which may not, in fact, have been necessary and will, if the bridge is a long one, considerably slow down the column, perhaps unnecessarily.

The formula given in Part II is indeed masterly in its simplicity and leaves all the work to be done, though we are advised to seek the answer in tables.

I wish I could rely on the R.E. N.C.O's to be able to do all this as the author suggests. I fear our training must be very backward.

I cannot agree that, if the longitudinal bearers will carry, say, army vehicles 50 per cent heavier than allowed for civilian ones, due to the distribution of load to tracks or multiple axles, the main girders or the cross girders will do likewise. My reasons for this have been already stated above.

I am afraid the article has probably suffered from translation and compression but the result is, in my opinion, liable to lead to dangerous practices.

The problem is not nearly as simple as we are led to believe and it is suggested that it is best for the engineer officer to use his technical knowledge to work out individual cases on their merit and to mark the bridges suitably, not the vehicles. Nevertheless, it might be safe to allow the drivers, at their own discretion, to cross civilian bridges marked for 25 per cent less than their own load, on the reduction in the factor of safety alone. Beyond this, I consider it unsafe to go until the bridge has been classified, except in cases of extreme urgency, when it may be worth risking one vehicle to try out the bridge.

COLLOIDAL CONCRETE.

COMMUNICATED BY THE DIRECTORATE OF FORTIFICATIONS AND WORKS.

THE following notes are intended as an introduction to a method of concrete mixing which, though likely to be of value in some branches of R.E. Work, is of recent development and may therefore possibly be unknown to many R.E. officers.

GENERAL DESCRIPTION.

1. *The Process.*—" Colloidal Concrete " is a colloquial term applied to concrete formed by a process recently developed by Messrs. Colcrete, Limited, Winchester House, Old Broad Street, London, E.C.2. This process consists essentially of pouring a specially formed grout of cement, sand and water into aggregate which has previously been placed in position, thus avoiding the labour involved in passing the aggregate through a mixer, and securing certain other advantages mentioned below.

If, however, cement, sand and water are mixed under ordinary conditions into a slurry sufficiently fluid to be used as a grout, and this slurry is allowed to stand in a receptacle, the solids will separate out before the initial set is taken. Such a slurry is therefore not suitable for grouting into an aggregate, owing to the difficulty of filling the voids satisfactorily, consequent on this separation.

In the Colloidal process, the cement, sand and water are mixed in a special " Colloidal Mixer " in which the cement is forced into a fine state of suspension in the water, approximating to a true colloidal condition. The grout thus formed is stable, and there will be no tendency for the solid particles to separate out, with the result that the voids in the aggregate can be filled completely, provided that no aggregate finer than ¾" is used which might prevent the free flow of the grout.

2. *Mixing in the Colloidal Mixer.*—The mixer consists of a tank, at the bottom of which is a housing in which a 12-in. diameter mehanite* disc has fixed to it radial impellors, which force the grout outwards with sufficient head (about 10 ft. static) to return it through the vertical pipe into the top of the tank.

* A specially hard cast iron.

The mixer at present on the market is driven by a 8 h.p. Ford engine, fitted with a governor, and with a clutch and belt drive. The whole apparatus, weighing about 12 cwt., is mounted on a single frame on wheels as shown in Fig. 2.

The latest model has a graduated water tank attached to the mixer to facilitate the addition of the correct amount of water when mixing. In addition, a conical shield is suspended in the hopper to prevent the sand or cement jamming the mix by being poured straight into the centre of the vortex.

Mixing is done in batches consisting of one bag (1 cwt.) of cement with the appropriate amount of sand and water. The mixer is first started and the water put in: cement is then poured in in a continuous stream by bursting the bag on the apex of the conical shield, and the sand afterwards added likewise. The whole mix is kept circulating until the full complement of sand has been added, when it is immediately drawn off by opening the turn-cock on the delivery pipe and clamping the tongs on the rubber portion of the circulation pipe.

3. *Use of Two Mixers in Series.*—The fact that the rotating disc in the Colloidal Mixer has only ⅛ in. clearance sets a limit to the coarseness of the sand that can be used without choking the mixer, and careful screening of the sand is essential in order to remove all large particles. The makers specify that the sand should pass a No. 7 British Standard square-mesh sieve. So far as the grout is concerned, however, there is no need for such fine sand to be used: coarser sand will remain in suspension equally well and will assist in filling the voids in the aggregate better.

To enable coarse and unscreened sand to be used in the machines at present obtainable, a method of mixing has been devised involving the use of two mixers. In the first mixer, which is of the normal colloidal type described above, cement and water only are mixed; the colloidal grout thus formed is delivered direct into a second mixer in which the sand is added. This second mixer is of a modified type in which the rotating disc is replaced by a plate, on to which four radial impellor blades are welded, and which is so designed as to mix the sand into the cement slurry without compelling its passage through an ⅛ in. gap. Grout can be delivered from this second mixer against a static head of about 20 ft. It is understood that the makers will shortly place on the market a twin mixer, in which both the above operations will be carried out.

4. *Delivery of Grout to the Work.*—In small works, where only one pair of mixers is used, the grout is delivered direct to the aggregate through a 25-ft. hose length (Fig. 3).

In large works the grout is delivered from as many pairs of mixers as are required into portable 150-gall. tanks raised above ground level, from which it can be fed by gravity as required to the work.

It is, of course, important to flush out thoroughly the mixers and delivery system at the end of the day's work, or at any pause in work which is likely to exceed half an hour.

5. *Aggregate.*—An advantage of the Colloidal process, and one which may be of great value in some types of work, is that it permits the use of a wide range of aggregates, many of which may be quite unsuitable for use in an ordinary concrete mixer. Large aggregates, in particular, can be used, the maximum size being limited only by the dimensions of the work. The aggregate should, if possible, be graded evenly down from the maximum to $\frac{3}{4}$ in.: the better the grading, the fewer the voids to be filled and the less the quantity of grout that will be needed. The fact that the aggregate must not be smaller than $\frac{3}{4}''$ is seldom a disadvantage, owing to the high cost of crushing to a smaller gauge.

Where great strength is not required, soft aggregates can be used, though materials containing moisture, such as chalk, must be avoided in localities where frost is to be expected.

6. *Properties of Colloidal Concrete.*—In their general properties, *e.g.*, time of setting and hardening, effect of frost, strength, etc., there is little difference between Colloidal Concrete and concrete mixed in the ordinary way, though the initial set appears to be slightly delayed in Colloidal Concrete. Rapid-hardening cements such as Ferrocrete can be used safely in the Colloidal Mixer, though difficulties may be experienced with quick-setting cements should any stoppage occur in the mixing or delivery of the grout.

A peculiar feature of Colloidal Concrete, which now appears to be firmly established, is that the initial expansion is reduced to some 30 per cent of that which would occur in ordinary concrete. This fact is of importance in mass concrete work.

It is sometimes stated that no shrinkage occurs in the setting of Colloidal Concrete. The grout itself undoubtedly shrinks during the initial setting, and any resulting deficiency should be made up by pouring additional grout after the lapse of about 45 minutes. On the other hand, the greater quantity of stone generally found in Colloidal Concrete, as compared with concrete mixed in the normal manner, reduces the actual shrinkage of the concrete, while the larger particles of the aggregate, acting as " plums," may well have the effect of distributing the shrinkage over a number of hair cracks.

7. *Organization and Output.*—A suitable gang for operating two pairs of mixers, delivering to a tank and thence to the aggregate, is as follows :—

1 foreman
1 engine driver
4 men on cement and water
6 men on sand
1 man on delivery hose
3 men on screeding.

Additional labour, depending on the site, will be required for the carriage of material to the mixers (including water if not piped), the placing of the aggregate, the bending and placing of reinforcement, the erection of formwork, etc.

With a little practice in the handling of the mixers and materials, it should be possible to produce 40 batches of grout per hour from each pair of mixers.

Owing to the heavy nature of their work the men on the cement, sand and water, should be periodically changed over with the screeders and delivery hose men if the above output is to be maintained over an eight-hour shift.

EXAMPLES OF APPLICATION OF THE PROCESS.

8. *Roadwork.*—The advantages of Colloidal Concrete are perhaps most marked on roadwork, where the ability to use any available aggregate, spread direct on to the road bed without being crushed or passed through a mixer, enables a rate of construction to be achieved which has hitherto only been equalled for good class surfacing by mix-in-place methods.

The road bed is formed and drained in the usual way, and the aggregate spread thereon as received, and levelled to the final road surface (Fig. 4). Side forms (which can be seen in Figs. 4 and 5) are placed in position to avoid spread of both aggregate and grout, the joint between the forms and the ground being rendered watertight by caulking with sand. If a large aggregate containing a small proportion of fine material is used, and many voids consequently appear in the surface of the spread aggregate, a topping of finer stone can with advantage be packed into the surface interstices.

Similarly, if a soft aggregate is used, a topping of harder stone may be packed into the surface to improve its wearing qualities.

On a porous subsoil, it is advisable to place a layer of building paper or similar material under the aggregate to prevent loss of grout.

The aggregate should be wetted before the grout is poured in.

A suitable mix for the grout is :—

1 cwt. cement
7 gallons water
1¼ cwt. sand.

The quantity of grout that will be required depends, of course, on the percentage of voids in the aggregate. One batch (containing 1 cwt. cement) will, however, grout approximately $1\frac{1}{2}$ sq. yards of concrete, 6 in. thick, with an aggregate containing 35 per cent voids.

After grouting, the concrete should be screeded off in the usual way (Fig. 5) to correct levels. For rough work nothing further is required, the surface being left as illustrated in Fig. 6. Should a hard wearing surface be required, grit can be worked into the surface before final screeding. Any surplus water that might have been lying in the aggregate as the result of rain will be driven to the surface by the grout: deficiencies in the grout caused by this displaced water should be made good when the shrinkage in the grout due to initial setting (para. 6) is rectified.

The organization described in paragraph 7, *i.e.*, two pairs of mixers working together, is suitable for road woık. Such a unit should be able to grout approximately 150 yards of 6-in. concrete road, 20 ft. wide, in an 8-hour shift.

9. *Aerodrome Runways.*—The construction of aerodrome runways and aprons is a type of work in which the advantages of Colloidal Concrete apparent in roadwork are very marked. Details of the process and the mix of grout will be similar to those described above for roadwork.

Where large areas are to be concreted, it may be advisable to employ more pairs of mixers with a larger storage tank and several delivery hoses, with suitable increases in the numbers of delivery hose men and screeders.

10. *Floors and Pathways.*—This work should be carried out as described for roads, the same mix of grout being used. In order, however, to obtain a smooth and wearing surface, as much clean 1-in. gauge aggregate as possible should be added to the surface of the coarse aggregate before grouting.

Using one pair of mixers with a storage tank, a suitable gang for this work is:—

1 foreman
1 engine driver
2 men on cement and water
3 men on sand
1 man on delivery hose
2 men on screeding

together with such additional labour as is required for carriage of materials to the site, and the placing of the aggregate, forms, etc.

The output should be about 750 sq. yards of flooring, 4 in. thick, in an 8-hour day.

11. *Reinforced Concrete Work.*—The main advantages claimed for Colloidal Concrete, other than ordinary concrete, in this type of work are:—

(*a*) There is no tamping or ramming of the concrete to disturb the reinforcement, once it has been placed in position.

(*b*) Since grouting is a quicker operation than normal mixing, a greater volume of work can be completed in a given period and the number of construction joints considerably reduced. It is essential, however, that the shuttering be tight enough to prevent percolation and loss of grout.

12. *Cast in situ Walling and other Mass Concrete Work.*—The aggregate is first placed in position.

The method of pouring will depend on the height and volume of the wall, but care must be taken to ensure:—

(*a*) That the grout is distributed evenly throughout the mass of the work. So long as pouring is completed before the initial set takes place, this may be done by placing tubes of, say, 2-in. diameter made of metal lathing at 5-ft. intervals in the aggregate: funnels can then be placed in these tubes and the grout passed down.

(*b*) That the shuttering is strong enough to withstand the hydrostatic head of grout. This head is about 1 lb. per sq. in. per foot of depth and may be the limiting factor in determining the height and lift that can be poured in one continuous operation. The shuttering of a 6-ft. lift would be subject to a hydrostatic pressure of slightly over $\frac{1}{3}$ ton per sq. ft.

A peculiar advantage of Colloidal Concrete in this type of work lies in the fact that different kinds of aggregate can be used in the same stretch of walling; *e.g.*, a hard stone may be used on the outer face with a softer stone on the inner face.

It is claimed that walls made by the Colloidal process are remarkably free from cracks, compared with normal concrete work: if this is the case, it is probably due to the small initial expansion of Colloidal Concrete, coupled with the distribution of shrinkage on setting over a number of hair cracks where large aggregate is used.

For mass concrete work the organization described in para. 7 is again suitable, the unit of two pairs of mixers being capable of grouting about 22 cu. yards of concrete per hour.

NOTE. *The Institution of Royal Engineers would welcome the views of anyone who has had practical experience of the use of Colloidal Concrete.*

Fig. 1.—Core cut from Concrete Road grouted with Colloidal Grout, showing the completeness with which the Colloidal Grout penetrates the aggregate.

Fig. 2.—Colloidal Mixer.

Colloidal concrete 1 & 2

Fig. 3.—Grouting direct from the machine into the stone.

Fig. 4.—Roadwork: levelling the aggregate before grouting.

Colloidal concrete 3 & 4

Fig. 5.—Roadwork: Screeding the surface after grouting.

Fig. 6.—Finished road which carried traffic after 4 days.

Colloidal concrete 5 & 6

The amphibian afloat.

Entering the water. Note the propeller.

A Dutch amphibian opposite p 107

A DUTCH AMPHIBIAN.

A Dual Purpose Vehicle with Four-wheel Drive and Propeller for when it Takes to the Water.

(Reprinted by kind permission of the Proprietors of *The Autocar.*)

The inundation areas which form Holland's chief line of resistance would, as is believed, constitute an effective barrage against all known motorized land units, including tanks. A certain amount of activity would, of course, be possible with pontoons, rafts or other flat-bottomed boats, but the Dutch military force, naturally foreseeing this eventuality, has developed a particular type of armoured amphibian which is capable of moving freely on firm or swampy ground as well as over flooded areas.

The vehicle, of which the accompanying photographs give a fair idea, is manufactured by the D.A.F. concern at Eindhoven. It has an overall length of 11½ ft., an overall width of 5½ ft., and overall height of 5 ft. 3 in. The wheel-base is 8 ft. 3 in., and the weight is 24½ cwt. It is a small but remarkable vehicle, as it is capable of travelling at speeds as high as 45 m.p.h. in either direction.

The vehicle is fitted with one or two machine-guns and is manned by four men, seated in opposed directions, of whom two are drivers, each operating in one direction, while the other two serve the weapons.

As Holland has no motor-car works of its own, clever use has been made of Citroen components. The engine, gear box, clutch, the two complete front wheel assemblies, and many parts of minor importance are, in fact, of French manufacture. Suspension is, therefore, identical with that of the Citroen cars, by torsion bars. The engine is mounted transversely in the middle of the vehicle, with the gear box in front of the differential. The driving shafts, leading to both the front and rear axles, are provided with two universal joints and terminate in pinions of two supplementary differentials, interposed between the driving shafts of the wheels.

The vehicle has constant four-wheel drive, but the steering of the two axles is entirely independent. Under normal conditions the steering of one axle can be locked, but if necessary the second steering system can be applied, assuring then a degree of manœuvrability unprecedented on normal vehicles.

Being independently sprung on all wheels, the D.A.F. is of a thoroughly cross-country type when used on land. With a gear ratio of 20·50 in first, 11·30 in second and 6·8 in third, the steepest gradient negotiable is 51·5 per cent, which is certainly remarkable for a three-speed car and an engine of only 48 b.h.p. (78 mm. bore and 100 mm. stroke). Two independent brakes are fitted, the foot brake being of the Lockheed type.

Referring now to the capacities of the vehicle over flooded territory, propulsion is effected by a screw, driven from a supplementary bevel pinion from one of the two interposed differentials between the oscillating half axles. It is worth mentioning that provision has been made for all four wheels to revolve also when the vehicle is passing through water. This is an important feature when, owing to shallowness of the water, the wheels come into contact with the ground, for, so far from interfering with the propulsion, they assist it. The wheels have also proved to be quite adequate as rudders, thus serving a double purpose and minimizing further complications.

A careful weight distribution and a self-contained design of bodywork are the external features of this vehicle, of which more details have, for obvious reasons, not yet been released.

SOLDIER AND OFFICER.

By "SENTRY."

THE trouble about platitudes is that the truths expressed therein—often important truths—are liable from their familiarity to relapse into the background of the mind, when frequently they should be right to the fore. One service platitude is that one of the first duties of an officer is the welfare of the men. The particular trouble here is that the truth contained is of absolutely vital importance ; and at the same time, for fulfilment, it needs much thought, tact amounting in some cases to guile, imagination and real hard work. If at any time, therefore, this duty is allowed to lapse into the background, there is a very real danger of an officer letting down his men.

Since the war started, the writer has had the privilege to obtain the confidence of a number of soldiers, and to hear first-hand from them of some of the troubles and irritations which arise in their daily life. Soldiers are only too well aware of the saying that they are always grousing, and for this very reason do not (in some cases, dare not) put forward official requests about numbers of minor irritations, which in the aggregate undoubtedly cause much unnecessary unhappiness—and inefficiency. It is therefore essential that officers, if they are to give effective service to their men, should consider continuously all aspects of their men's lives ; but this service must be rendered unobtrusively, as patronage and interference are themselves major irritants. Luckily, if an officer knows what to look for, he can collect his information without fuss or advertisement.

As an indication of where trouble may lie, a few anecdotes are given below. The stories are all authentic, and all happened since the war started. Most of the regrettable incidents need never have arisen, and probably would never have arisen if a little more imagination had been used. The excuse for this article lies, therefore, not in any brilliant thought to lay before the upper sixth, but rather in the idea that it is sometimes necessary to revise lessons taught in the lower fourth. The writer intended to add flavour by introducing some of the picturesque phraseology employed in the original anecdotes, but a word which may be common, and meaningless, on the lips of a soldier, in print looks so startling as to detract emphasis from the inevitable moral of the story.

The biggest crop of soldiers' troubles arises probably from faulty or slack administration. Of these troubles, the commonest and most regrettable relates to food. A " volunteer " stated that he was ten days in a reception unit, and during that time he had not a single hot, adequately cooked or sufficient meal. He added that he never saw an officer during these days (this was an obvious exaggeration). On being asked how things had been since, he said, " O.K. I'm in a proper unit now ; everything is hot and there's always lots of it." Like all soldiers, he knew that each cookhouse gets roughly the same " raw material." The deductions he drew about his first unit have no chance of passing the censor—a pity, as they were a model of the power of the English language.

Another soldier had a somewhat similar tale, but this time the keynote was "stew." Apparently, in a unit on service a certain master cook had the hardihood to disgorge a diet consisting exclusively of stew, for no less than thirty-three consecutive days. He was, however, routed by a brand-new Second-Lieutenant (on his third day in the unit) on Z+32 (d. 33), after a battle which raged more or less in public for forty-eight hours. There is no doubt that it is wrong to consider the food problem as the exclusive property of the messing officer (subject to occasional sniping by the Orderly Officer). It is an essential element in the welfare of the men, and as such is the positive concern of every officer with men to command. Unless all officers interest themselves in the men's food, an indifferent messing organization can side-track complaints indefinitely. A good messing organization will always welcome inspection. It is probable that few officers have started on a better wicket with their men than the above Second-Lieutenant.

Pay muddles, especially those connected with the turnover from peace to war accounts, and those involving allotments, give rise to many grievances, and to much real distress. The comments of an ex-accountant can be imagined, when he was assured on receiving his " balance," that it left him 1s. 4½d. in debit, whereas he well knew he should still have about £4. The main interest in these comments to the listener was the able mixture of military and accounting jargon. The trouble here is the difficulty the man experiences, and the helplessness he feels, in getting matters put right ; so much so that he generally accepts the blow as his " kismet." The only real remedy is meticulous care in closing peace accounts ; anything less may lead to gross unfairness.

Leave is also an important matter. Last October, a unit retained its men until late on the afternoon they were due to go on embarkation leave, in order to inoculate them. The men all had long journeys by night, and most of them had at least two precious days' leave spoilt by fever and chills. Their comments were picturesque.

Contrast this case with that of a Company Commander who, having got wind early of a free travel concession, bullied his orderly room into issuing free warrants, and himself worked all night so that the free tickets could be available in time for his men to catch the earliest possible train on the first day of their leave. His Company got off eight hours before the rest of the Battalion. The Company Commander would have been very pleased to hear what a couple of his men had to say about it.

Arising from lax administration, there arises also the question of clothing on service. A few weeks ago, a couple of soldiers coming on leave began to compare notes. One man, from the " front of the front " was shod with the remains of his peace issue boots (he had been a " Regular "). All his efforts to get a change had failed, and his feet had about as much protection as if he had been wearing bedroom slippers. The other from the " back of the front," shod in a new pair, said he could have drawn a dozen pairs if he had wanted to. Unless a unit actively looks after itself, its interests may be squeezed out in a competitive world. A short unofficial motor-cycle trip to a depot may work wonders.

One last administrative point affecting the daily life of most men, is the organization of fatigues. It is fairly common for the system to be one of " catch as catch can." As a serjeant enters a hut, the quicker witted disappear through the windows; the rest peel potatoes or scrub for the next few hours. Alternatively, fatigues may in some cases be used as a form of unofficial pressure on men who tend to irritate N.C.O's. The matter is rather delicate, and provided the unit is a " happy " one—and therefore a well-disciplined one—it is probably best left alone, but if one becomes aware on joining a unit of an undiagnosed feeling of trouble, it is as well to watch this point. There are few things more depressing for an awkward man than any form of " fatigue blackmail."

There must be innumerable instances, either on service or during a period of expansion, of irritation due to administrative " bogs." The soldier is most extraordinarily hardy and patient; he will only under the most extreme provocation make a formal " complaint "; but he is extremely quick to differentiate for himself between troubles that are avoidable, and confined to the soldier, and those that are inevitable, and shared by everyone. This leads to the second main cause of hardship, which is the imposition of unnecessary standing orders, restrictions, and even punishments.

There is a saying that " Nothing damages dignity more than standing on it." The application of this saying to discipline is obvious, and all officers are fully aware of the general feeling in the Army against what the soldier (in his more polite moments) refers to as " red tape." Yet there are still innumerable cases in which over-conscientiousness, lack of thought, and sometimes sheer " inferiority complex " are still causing unnecessary grievances.

A soldier was heard discussing this matter the other day in the following terms, " It ain't so bad as it was, mate. There's only one officer left now that I think to myself when I meets him—' I'd like to slosh you one, you —— ——' " On being asked what the fuss was, he explained that this officer made an invariable rule of " criming " at least two soldiers on any guard or parade he inspected. He then explained, in picturesque language the gradual decline in " turn-out " effected by this system, as the men logically decided it was better to be punished for a genuinely bad turn-out, than for a good one.

The above case was one of simple over-conscientiousness. The following is one of " efficiency," untempered by consideration.

A unit one afternoon received some order affecting the validity of the existing passes in the possession of private soldiers. Unit orders that day, published at 5 p.m., cancelled all permanent passes. As a result, in conformity with this order, and the unit's standing orders, all privates were turned back at the barrack gate that evening, and for some reason the matter was *not* even referred to the Orderly Officer. The whole thing was obviously a misunderstanding which should never have arisen, and which could have been resolved if a single officer had queried the meaning and intended effect of the order. The soldier discussing this case confined himself to a very reasonable comment on " red tape."

Some recent instances of thoughtless disciplinary orders in units serving overseas may point another moral. It is difficult to credit the fact that during a period of wet and intense cold, the men in one unit were debarred successively from keeping their bedding dry, from using a stove " earned " from a derelict house in the unit area, and from wearing balaclava helmets during the hours of daylight. The first restriction came from a mistaken idea that in wet weather it was a good thing to " air " bedding by laying it out on the groundsheet ; it unfortunately took no notice of the inevitable leaks in new tentage. The second was a well meant, but in view of the locality, probably misplaced effort to preserve intact the property of our Allies. The third order was a search after smartness and uniformity, which was very properly quashed soon after its issue.

The above few cases are, one hopes, isolated ones, but are probably sufficient to show that, particularly on service, or during a time of rapid expansion, it is essential to the welfare of the men that the effects of all disciplinary or restrictive orders are fully examined, before such an order is issued. In a London hairdresser's shop the other day, a lady remarked to the assistant, " I'm *not* joining the ranks of the A.T.S. ; I'm only going in as an officer." The assistant murmured something about qualifications, and the lady answered, " I can give orders." Provided the problem is not over-simplified to this extent, and provided an officer has average judgment (and uses it) the attainment and maintenance of a really high standard of discipline is not difficult in a British unit ; and this without causing irritation or grievances to the great majority of the men (there will always be a few who are fundamentally difficult).

Two stories may indicate how reasonable is the soldier's attitude towards discipline. One man, discussing the deserter's "amnesty" early in December said, "It was all right, but it came down funny on some of us. I was up with my cap off the other day, with two chaps in front of me. The first had been away three years; he got off. The second had been away six months, and he got off. I was twenty minutes late off pass the night before, and I got a clatter of seven days' C.B." On being asked his views, he expressed himself quite satisfied with the logic of the officer's award. Another man, an ex-serjeant volunteer, was training with a lot of younger men, and was to some extent being indulged by the N.C.O's. One day, by accident, he was forced to a choice of missing first parade, or of going on unshaven. He chose the latter, and in due course came before his Company Commander. Instead of being admonished, like similar previous cases, he was given one extra fatigue, which the C.S.M. interpreted into no less than seven hours' scrubbing on a Saturday afternoon. His only comment was, "They'd been treating me well and couldn't know I wasn't beginning to swing it on them." Incidentally, he has got his serjeant's stripes back now.

On the other side, though the soldier is thus reasonable under what he considers merited adversity, he is equally quick to resent, circumvent, and in extreme cases obstruct what he considers unecessary "red tape." For this reason, it is easy to prejudice the discipline of a unit by over-anxiety, and at the same time to cause unnecessary hardship, and sometimes real unhappiness to the men.

Whereas officers should as an absolute and positive duty safeguard the welfare of their own men, as illustrated above, it is possible to go even further. There are innumerable cases, frequently trivial, in which an officer, if he keeps his eyes open, can be a "good Samaritan"; this particularly applies to London and overseas towns, and to lines of communication when the man is separated from his own officers. An example of a serious case arose when a man was discovered recently in London in a state of destitution, no collar, disreputable "civvies" with short trousers, ammunition boots. He had been given one pound, the above "civvies," told his discharge papers and credits would follow, and given "leave." He was ill, and his unit was overseas. He eked out his money for a whole fortnight, chiefly because he was too ill to eat much. Luckily he was spotted by an officer, who took up his case, and brought about quick and effective action.

Apart from the individual aspect of this case, it brought to light one of the inevitable weak points in a rapidly expanding organization, and it became possible to rectify a whole class of similar cases.

The theme of this article has, of course, been "welfare." There are numerous voluntary, semi-official, and official welfare organizations which are giving the most magnificent and devoted service to the soldier. These organizations must, however, be complementary to the efforts of the officers, and can in no way justify any relaxation of officers' responsibilities. Voluntary organizations can ameliorate only to a small extent the soldier's lot; the major contribution to a soldier's welfare can be made only by his own officers. If the men's lives are largely dependent on the quality of the leadership and training of the officers, the men's welfare is to an even greater extent dependent on the sympathy, knowledge and hard work of the officer.

"ARMY TRACK," AND A TOOTHLESS SERJEANT.

By CAPTAIN T. H. F. FOULKES, R.E.

"ARMY Track" is easy enough to lay. One simply spreads the netting on the ground and pegs it down; and then the traffic follows. The Books, naturally, have little to say on the subject. The usual problem is to get the netting there, and in country where it is likely to be wanted one must not expect to find arterial roads and broad-guage railways leading to the site.

"At Quetta on the 20th August, 1937, at thirteen hundred hours" (as the witnesses have it), the C.R.E. gave me orders to lay about two miles of Army Track on the Tabina Plateau. This is a rolling plain, seven or eight thousand feet above sea-level, on the crest of the hills which divide Baluchistan from the Province of Kandahar, at the water-shed of the River Helmund and the Indus. The Zaraband Pass makes a tortuous and spectacular ascent of the Toba Kakar hills from the Quetta side of the plateau; while, from Chaman, on the Afghan plain, a road runs steeply up the Bogra gorge, ending with a brief, but severe, struggle to surmount the col. The heads of the two passes are joined by a dozen miles of motorable track, and it was four or five miles to the east of this track, on the remoter side of the Tabina Plateau, that a portion of the Quetta and Chaman troops were in camp for Autumn Training, by the springs of Maku Kach. (The relative positions of these places are shown in the sketch.)

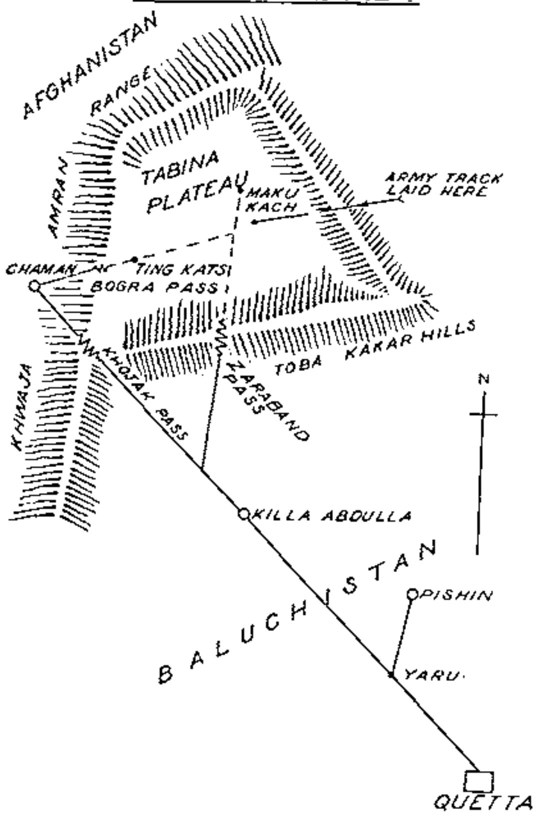
For part of these four or five miles the track was over clay, which had broken up so quickly into a sea of dust that supply lorries could hardly struggle through, and communications with Quetta or Chaman threatened to end abruptly. Something had to be done at once—by us.

The means at my disposal were 40 Punjabi Mussalmans of the Royal Bombay S. and M., as many lorries as I needed, and ample Army Track in store at Chaman; and by 5 p.m. that day the transport was ready in our lines, with tools and provisions for a week. It only remained to pick up the Army Track, 75 miles away at Chaman, and to nail it down on the Tabina—another 25 miles to go.

The troops and transport left at 4 a.m. next day, and I followed in a Ford van, with a bearer, an orderly, and stores for aligning the track. It was a sparkling Baluchi morning, and I felt more confident than one is entitled to feel about any plans in India.

Beyond Yaru, 25 miles out, we met an old, three-ton Albion towing another back towards Quetta; but I did not recognize the drivers, and continued to enjoy the morning. It was not until I had seen another venerable six-wheeler at Killa Abdulla, undergoing repairs to its gear-box, that I realized that I had already lost three of my twelve load carriers. The toothless Transport serjeant told me dispassionately that one lorry was being towed home because it had

ROUGH SKETCH SHOWING
TABINA PLATEAU



bumped another and bust its radiator, but that this-here gear-box would soon be O.K. I overtook the rest of the convoy more thoughtfully. At this rate we would not get far.

Although heavily-loaded, my elderly Ford, Model "A," stormed up the Khojak Pass with hardly a waggle of the gear lever, and from the summit we enjoyed a wide view of the hills and plains beyond Chaman, that vestibule of Kandahar and threshold of great enterprises.

At Chaman I rang up the M.T. Section to get a replacement for the Albions which had fallen out. A peevish voice replied: "Speak up, speak up! You sound a hundred miles away!" to which I meekly explained that I was speaking from Chaman, and that was seventy-five. As no more three-tonners were available, 30-cwt. lorries were being sent instead; and though these are much too short to carry a 12-foot roll of netting, I let them come, as something might have to be improvized in an emergency.

Having seen that my stores were ready for issue, explained my doings to the Station Commander, and obtained an escort of Levies, I refreshed myself in a friendly mess and waited for my convoy to arrive.

By one o'clock the men had rested and had their food in the shade, and the hard work of loading the netting had begun. To make two miles of track we needed 140 25-yard rolls, each roll weighing 480 lb. I still had 10 Albions, and if weight were the only criterion we could get 14 rolls into each lorry, and that would be just enough for two miles. In point of fact, the most we could load in one lorry was 12 rolls, as the roof got in the way—as is so often the case with Government M.T.; but this did not worry me unduly, as the bad part of the route had not been accurately measured and I believed it was no more than a mile and a half in length. My mistake was in supposing that such ancient vehicles could be relied upon to carry a full load up the Bogra: but I had seen them do it before, and as it turned out, only one failed.

Quite apart from its weight and bulk, Army Track is awkward stuff to load, and even worse to unload, because it is made of stout wires, usually hooked together at the ends, and the heavy rolls become firmly interlocked by these hooks. My subadar had experienced this before and suggested packing old planks between the rolls, but this was not a great success, as the planks got displaced and also took up too much room. The problem was solved by the timely discovery of a stack of plain galvanized roofing iron lying near the store, which we sandwiched between the rolls, especially at the ends, where the hooks are. Much time was thus saved, and unloading next morning was child's-play.

I had thought we would have to spend the night in Chaman, but things, so far, had gone well, and by 4 p.m. the netting was nearly all loaded. It was only 25 miles more to Maku Kach, but the formidable Bogra lay between, entailing low-gear work and several halts to change water. Even so, it would not be dark till half-past eight, and there was a quarter-moon: so I decided to chance my arm, gave orders for the convoy to follow as soon as possible, and set out—with a Levyman as escort—to choose the line of the track and make some "Q" arrangements for camp that evening.

One must always have a Levies escort in these hills, as the local Achakzai are rather less effete than other Pathans of Baluchistan, and are somewhat respected by the authorities. They are a section of the great Durani race and have easy access to their kinsmen over the Frontier. Long ago they defeated a British force in a pitched battle near Pishin: and only a few years ago they captured a lady and two officers (including Major Farley, R.E.) on the Khojak Pass, and successfully held them to ransom. The leader of this enterprise escaped at the time, but for years continued to live quietly in the neighbourhood, until a disgruntled neighbour mentioned the fact to the authorities, and the Levies captured him "with tact and courage" (as the Indian papers put it). Furthermore, there was a report of inter-tribal fighting not far off. Someone, it seemed, had had his camels stolen, and had retaliated by carrying off someone else's women—a form of reprisal which would seem quite inadequate in many parts of the East. But here, according to one of my jemadars who knew the Tabina well, a man has to pay anything up to two thousand rupees for a strong wife. "A man with three daughters," he said, "is a man of means, while the father of five is addressed as 'Khan.' In the Punjab," he added bitterly, "a man with three daughters is a beggar."

The Ford boiled furiously as it crawled up the loose Bogra road, but all went well and no bereaved husband or camel-man attempted to shoot our bodyguard. We were soon past the moorland of Ting Kats and out on the rolling Tabina downs, green in the evening sunlight, not with succulent grass, but only with camel-thorn and thistle. In fact, so inhospitable is this plain, and so parched in summer, that even the camels brought from the desert of Sind for the Afghan wars were unable to subsist upon it. Yet it supports the even hardier beasts of the nomadic Pathan, until the knife-edged winds from the north drive him helter-skelter to the lower valleys.

I chose an alignment which I liked, washed and refreshed myself at Maku Kach, and waited for my men. There was still no sign of them at dusk, so I went back to find out what had happened. The plain was now dotted with Achakzai camp fires, as the women cooked the evening meal beside their black wool tents. Far away at last I saw the yellow headlights of five lorries twinkling across the plain. The Albions were giving a lot of trouble, said the subadar, as we drew up, but the remaining lorries should be over the pass by now. I went on to make sure.

Face to face, beside a spring, two Pathans were sitting bolt-upright, eating from a pot, quiet and solemn in the dim moonlight. Later, we would be introduced.

Looking down from the crest of the pass, I saw lights on the zigzag road below, but none were moving; so I walked down to enquire. Lorry Number Six had "refused" at the steepest and curliest part of the pass, where the road was a mere ledge on the hillside: a scarped wall on the left, and a handsome drop to the right.

H.Q. Car.

Army track and a toothless elephant opposite p 118

The rolls have got hooked up.

Nearly a lorry-load. Roofing-iron is being used to keep the rolls apart, and the roof cover has been removed from the lorry.

Army track and a toothless elephant opposite p 119

The Sikh driver, just to air his knowledge of terms, declared that a main bearing had burnt, but could produce no evidence to support this statement. It made no difference: Number Six would not go, the road was completely blocked, and half a dozen lorries had closed up behind in the dark. The troops were looking rather dubious and seemed to expect me to do something.

There was nothing for it but to shunt the train backwards round the hair-pin bends and down the hill, to where the road was a trifle wider, and pack Number Six tight against the cutting. Even then it was a slow and difficult manœuvre to get the others past, and if the road had been six inches narrower the thing could not have been done. Most of the drivers were Sikh reservists, and they had to steer by feeble lights and an inadequate moon; but though they had a reputation for reckless driving in cantonments, no one could have excelled them here. One man looked too small and young for the job, but he so resented my idea of exchanging him that I hastily let him carry on.

The last lorry to arrive was driven by the toothless serjeant, as placid and efficient as ever. Three more Albions had broken down since leaving Chaman, one of them with three ailments at once, but he had got them all going again. He now looked at Number Six, and giving the handle a familiar twist, pronounced: "Dud valve. Half an hour's job, sir. I'll start right away." But it was already after ten, and the men had done more than enough for one day. So Number Six was abandoned, with a cold and indignant Levyman to look after it for the night.

The convoy moved on once more, and I followed in the Ford.

We had not gone a mile when I saw something very strange in the headlights, and alighting, found a gory Pathan lying across the road. "Are you badly hurt?" I asked. "Mortally," he replied, between his groans. I caught hold of his leg, where most of the blood was, to see if it was broken. "No, no! My arm," he cried, writhing in agony; but when I tried to examine his arm, he burst into a frenzied babble, gesticulating the while with the shattered limb, and it was soon apparent that only his composure had been injured. He stood up when told to, and another Pathan appeared from the darkness. It transpired that they had finished their meal by the spring and had been walking on by moonlight to Chaman, with their baggage on a donkey, and a foal beside. The foal had panicked at the headlights and had run under the back wheels of the last lorry—whence the blood. His friend, he said, was very excitable, and would not calm down for ten days at least. It was most unfortunate that this should have happened to him. So I took their names, with a view to compensation, and told the temperamental one to come with me: but getting no sense from him, I left him to his own devices.

By the time we reached Maku Kach the men had been on the road for 19 hours, but all were in good spirits, and no one would admit that he was tired or hungry. Tents and hot food were ready, and a long night's rest assured : and the Transport subadar and the toothless serjeant willingly helped me out with my beer.

The laying of the Army Track next day calls for no comment. Every N.C.O. knew how to do it. But without that toothless serjeant we would not have got it there so soon.

Lt Col Walter Alfred John O'Meara CMG

MEMOIR.

LIEUT.-COLONEL W. A. J. O'MEARA, C.M.G.

On Thursday, the 6th November, 1939, there passed away after a long illness a retired officer of the Corps who, with a little more of what the world calls luck, should have risen to a high position in the Corps and the Army.

Walter Alfred John O'Meara was born at Calcutta on the 28th January, 1863, the son of Mr. Alfred O'Meara, of St. Mark's, Simla. Educated privately, he entered Messrs. Wren & Gurney's well-known establishment in 1879 to work for the Indian Civil Service, but an offer of additional vacancies for the R.M. Academy, Woolwich, at the end of 1880, tempted him to compete at the examination in November of that year. At the Academy he worked his way up, passing out in February, 1883, eleventh out of a batch of twelve. At the S.M.E. he passed all his courses with distinction, gaining the much coveted Fowke Medal, which is given annually for the best work in the Construction School.

He did not interest himself much in games, and among his friends he was regarded as of a quiet, studious disposition. But, behind this quiet exterior, he was very ambitious of military distinction and on completing his courses, early in 1885, he applied to serve in India, refusing an offer of employment in the War Office under the Inspector-General of Fortifications. On arrival in India, he refused offers of employment in the Public Works or in the Irrigation Department, and in March, 1885, he was posted to the Bengal Sappers and Miners. In October of the same year, on the outbreak of the war in Burma, he was ordered on active service with the 5th Company, Bengal Sappers and Miners, with whom he was employed on the Lines of Communications. These were continually threatened by parties of Dacoits and O'Meara was frequently sent out with columns to clear the country.

On the 2nd January, 1886, he volunteered to take command of a party sent out from a post at Pagan to clear some Dacoits from a village. This was successfully accomplished, but in following the fleeing enemy, while he was reloading his revolver, a number of the enemy suddenly returned and surrounded him. He was knocked down and received in all eleven wounds from their *dahs*, which broke his jaw and disabled his right hand. His second-in-command, a native conductor, drove off the attackers in time to save his life, but the injuries were serious and necessitated O'Meara being invalided to England, where he was on the sick list for 19 months. For his services in this campaign he was mentioned in despatches and received the Frontier Medal with clasp; later, he was awarded a permanent disablement pension.

On returning to duty in June, 1887, he was ordered to Portsmouth, where he was employed under the C.R.E., Portsea, in charge of the defences of Southsea. In this capacity he took part in the operations at Langston Harbour of that year. After two years at Portsmouth he joined the 2nd Division, Telegraph Battalion, which at that time was employed in the maintenance of the telegraph system in the South of England. In 1890, he surveyed and supervised the construction of the first telephone trunk line through Kent, in connection with the London and Paris telephone service. For this duty he was temporarily detached from his section at New Cross and received his instructions direct from Major G. W. Addison, R.E., who was then commanding the 2nd Division.

At this time the work of the Post Office Telegraph Department was still hampered by an Act passed in 1863, when the telegraph systems were privately owned. This Act gave owners and occupiers of land, over which telegraph lines should run, a right of veto and in the case of parks and ornamental grounds, the owners had the right of objecting to the erection of lines on the roads or lanes skirting their property. The work of the officer planning a new route thus required much tact and persuasive power to obtain the necessary consent of the many occupiers on the route, some of whom demanded excessive money compensation. At this stage in electrical knowledge, cable could not be used for land lines except for very short distances. O'Meara had many interesting tales to tell of his experiences during the nine months he was occupied on this task; in one case, an irate lady raised a threatening fist and chased him off her premises; in another, a farmer asked him to mend his electric bells, which were duly put in order before the consent form was signed. The municipal authorities of the towns on the route generally objected to the line running through their streets and in several cases the poles had to be erected along the S.E. Railway. The original route selected for the cable across the Channel had been from Folkestone to Calais, but way-leave difficulties made it necessary to alter the landing-place in England to St. Margaret's Bay, and after some delay due to a storm, the cable, which had been specially constructed on a new and experimental design, was landed and connected, and Sir William Preece, on whose advice the line had been constructed, was gratified by hearing the first message from Paris. O'Meara received the thanks of the Postmaster-General for his work.

An unusual incident occurred during his time at New Cross. A number of the civilian postal employees went on strike and Major Addison assembled a party of about forty N.C.O's and Sappers of the 2nd Division, Telegraph Battalion, to help the Post Office authorities. O'Meara was placed in command of this party, which was at first billeted near Covent Garden. On the next day, the party was sent down to Whitechapel to carry out sorters' duties under the senior staff of the office, who had remained loyal, and another party was sent to the London Bridge area to deliver parcels. O'Meara was in charge of both parties during the week the strike lasted. One evening the party from Whitechapel was attacked by roughs and two men were injured, but no other serious incidents occurred during the strike.

In 1892, O'Meara, who had just been promoted Captain, was moved to the Aldershot Section and in the following year, on the rebuilding of Aldershot camp, the office of the Superintending Engineer, G.P.O. Telegraphs was moved to Basingstoke.

In 1894, on completion of five years in the 2nd Division, Telegraph Battalion, he was ordered to Cape Town to command the 29th Company at that station. At the end of 1895 there occurred the Jameson raid into the Transvaal and, under instructions from the Colonial Office, three officers were sent to Pitsani Pothlugo, about 30 miles north of Mafeking, the base from which the raiders had started. The officers selected were Colonel Morgan Crofton, the C.S.O. at the Cape, Major Plumer (later Lord Plumer) and O'Meara. After a two days' journey through Kimberley and Mafeking, these officers formally took possession of Jameson's base camp and O'Meara was then recalled for Engineer duty at Cape Town. But the experience of staff work had fired his ambitions again and he applied for permission to sit at the next examination for the Staff College, which was held in the autumn of 1896. He was the only candidate from the Cape and was successful in obtaining one of the three vacancies allotted to the R.E. After completion of his course at the Staff College in December, 1898, he was employed for a few months as Staff Officer to the C.R.E., Portsmouth (Colonel on the Staff), but in June, 1899, when the outbreak of the South African War was threatening, he was ordered to South Africa on special service, together with nine other officers. On arrival at the Cape he was appointed the observation officer for the Western Free State, with the special duty to survey a route for the march of an army from Colesberg to Bloemfontein. His intelligence duties took him all over the area allotted to him and as far as Kimberley, and when war became imminent he was ordered to stay at Kimberley.

Associated with him were Major Scott-Turner, of the Black Watch, and Lieutenant D. S. MacInnes, R.E. Kimberley was the centre of the diamond fields and was an important point on the railway from Capetown to Rhodesia, which ran a few miles west of the boundary of the Free State. It was connected by a regular coach service with Johannesburg. There were at the time divided Councils at the Cape, as the Government was decidedly pro-Boer and would not admit the possibility of war. But the High Commissioner, who had received secret information of the arming of the Boer republics, decided to treat Kimberley as an asset of Imperial importance, so that on the 11th September, 1895, Lieut.-Colonel Kekewich, who was commanding the 1st Battalion, Loyal (N. Lancashire) Regiment, at the Cape, was ordered to proceed at once to Kimberley to report on the military situation and to be ready to take command if hostilities were commenced. There were in the town at the time about 500 Cape Police, with a local Volunteer Force, consisting of a battery of Field Artillery armed with six 7-pdr. guns, the Diamonds Field Horse (200 all ranks) and the Kimberley Regiment. The population of Kimberley and district numbered about 50,000, of whom 30,000 were natives and 20,000 Europeans, the majority of the latter being of Dutch extraction; most of these were employed by the De Beers company, who owned the diamond mines. The Volunteers were much below establishment and the Cape Police were spread in small detachments in posts along the railway which ran north through Vryburg to Mafeking.

Kekewich, after consulting the Commander of the Police Force and the special service officers, reported that this force was quite inadequate, and on his urgent representation four companies of his own Battalion and detachments of R.A. and R.E. were sent from Cape Town and arrived at Kimberley on the 21st September. The R.E. were a section of the 7th Field Company, about 50 strong, under Lieut. R. L. McClintock, R.E. The three special service officers were detailed to Kekewich's staff, Scott-Turner becoming C.S.O., while O'Meara was in charge of Intelligence and also Press Censor, and MacInnes took over the charge of the engineer work, especially the construction of the defences. A scheme for these latter had been prepared at the Military Headquarters in Cape Town and was put into operation. This scheme provided for inner defences with a perimeter of seven miles, but there were a number of advanced posts, of which the most important was at the Premier Mine—four miles from the centre of Kimberley—where there was a good supply of drinking water. The redoubt at this point was garrisoned by regular troops. The tools and working parties for the construction of the defences were provided by the De Beers Company, who also placed at the disposal of the Military authorities a stock of machine-guns, rifles and ammunition, which had been purchased by the Company at the time of the Jameson raid.

Kekewich also arranged with the Mayor of Kimberley for the formation of a Town Guard and with the De Beers Company for the collection of horses and supplies of all sorts; also for the reception and, later, the enlistment in the local forces of a number of loyal farmers who came into Kimberley for protection, not only from outlying farms in the Cape territory but also from the Transvaal and Orange Free-State. In all these questions he was ably supported by his staff and on the 28th September, O'Meara made a hazardous expedition by bicycle to Boshof in the Free State, about thirty-six miles east of Kimberley. What he saw there convinced him that the Boers were concentrating for an attack on Kimberley and on his return *via* Windsorton Station he sent telegrams to Kimberley and Cape Town. The unrest became so evident that the police posts on the railway were drawn in to Mafeking and Kimberley, and on the 5th October an alarm caused all the defence posts around Kimberley to be manned. It was not, however, until the 11th October that an ultimatum sent by President Kruger expired and a state of war was declared.

Meanwhile, Kekewich, at the request of the Mayor and Council of Beaconsfield, a township just south of Kimberley, had included this town within the perimeter of the defences, which was thus increased to nearly 13½ miles. There was no long distance telephone system in the country but communication was maintained with Cape Town and with Mafeking by an interchange of telegrams, until the lines were cut by the Boers on the 14th, and from this time Kimberley was isolated. O'Meara, however, managed to establish a system of native runners who were able to pass through the Boer lines, and the De Beers Company had a similar organization, by which they kept communication with the directors of the Company at Cape Town. There were two small telephone systems in the town and O'Meara was appointed Director of Telegraphs to control these systems, in addition to his other duties.

The increase in the number of mounted men, who totalled over 600, made it necessary to establish a better organization and Major Scott-Turner at his own request was placed in command. O'Meara was then appointed Chief Staff Officer and continued to function in this capacity during the siege. At the same time Lieut. MacInnes was brought to headquarters as the Staff Officer for personnel and discipline. Many administrative difficulties had to be faced as the Boers closed round the town; the water supply was interfered with and the De Beers' private supply had to be connected with the Kimberley Waterworks; the local prices for commodities had to be fixed to prevent profiteering; and later, the supply of food had to be rationed and the population taught to eat horseflesh!

On many of these questions the military received valuable help from Mr. George Labram, an American employed as the Engineer of the De Beers Company, who arranged the connection of the water systems, and later, as the siege was drawn out, succeeded in manufacturing ammunition for the 7-pdr. guns, including workable fuzes and cartridges, using explosives obtained locally. Later, Labram, helped by the advice of the R.A. and R.E. officers, was successful in manufacturing a gun of 4·1-in. bore, throwing a 28-lb. shell; this was mounted on a wheeled carriage and proved very useful during the later part of the siege. Labram also constructed a conning tower on the highest point of Kimberley, which was manned night and day, and Kekewich, accompanied by O'Meara, made a point of mounting to this tower every morning an hour before sunrise, so as to be ready to meet any attack which might develop during the night.

Kekewich's tactics were devoted to keeping the enemy out of rifle-shot of the town, partly by the system of redoubts, and partly by sorties by small parties against any of the attackers who became troublesome. With the small garrison available it was important not to push such attacks too far. On the 27th November, the little garrison began to get communication by searchlight with Methuen's relief column, and in order to keep the Boers occupied, Kekewich organized a rather larger sortie of infantry and the mounted troops. Unfortunately, the latter pushed in too far and were heavily engaged, losing two officers and twenty other ranks killed, including their Commander—Scott-Turner. Despatch riders were sent out to Lord Methuen with details of the enemy's dispositions, and a few days later, communication was established by heliograph. On the 12th December the relieving force was "checked" at Magersfontein, and Kekewich was then told that the garrison must hold out for a further two months. In January, Labram's gun "Long Cecil" was brought into action and in reply the Boers brought up one of their "Long Toms," a 6-in. gun from Ladysmith. It was in charge of a party of Frenchmen who had accepted military service under the Boer republics, and opened fire early in February. Its shells caused considerable alarm in the town and on the 9th an unlucky shell struck the hotel in which Mr. Labram was stopping and he was killed by the falling masonry. Kekewich partly countered the effect of this gunfire by his own gun "Long Cecil" and by pushing out a party of snipers, who kept the detachment working the Boer gun under continuous rifle fire. By this time the garrison was in communication with Lord Roberts from Modder River and were told a relief force was on the way, and Kekewich had sent out a strong party to the southward to hold the water supply at Alexandersfontein. On the 15th, a message was received from this party that a large body of mounted troops was approaching and these proved to be the advance body of the Cavalry Division commanded by Sir John French. With relief at hand, Kekewich at once assumed the offensive and initiated an attack against the Boers on the north front, in the hope of capturing Long Tom and of holding the Boers in position until they could be dealt with by the relieving force. The next day French marched into the town and the siege, which had lasted just four months, was over.

The following day, French moved north about 12 miles against the Boers, but there was no water for the horses and the force had to retire. The next day the Cavalry Division was recalled by Lord Roberts to assist in the rounding up of Cronje. In 1926, after the death of Major-General Kekewich, O'Meara was asked by the Buffs, Kekewich's old regiment, and by his family, to write an account of the siege, which was published in book form under the title of *Kekewich in Kimberley*. The above account is taken from this book, in which O'Meara, in addition to military operations, goes in considerable detail into the position of Mr. Cecil Rhodes during the siege. This distinguished statesman was on his way to Rhodesia when hostilities were imminent, but was stopped at Kimberley by the closing of the railway, and remained there during the siege. While he and the De Beers Company, which was under his control, rendered valuable service in many ways, Rhodes himself frequently tried to intervene in military operations and was throughout in direct communication with the High Commissioner in Cape Town and with the Director of the De Beers Company. These communications often gave an inaccurate account of the military position and were not submitted for censorship. This placed O'Meara, who was the military censor, in a very awkward position and he had considerable trouble in restricting the efforts of the local press, which was mainly controlled by Rhodes. There can be no doubt that the defence of Kimberley was a striking success as a military operation. The small group of regular officers who bore the main responsibility for this siege deserved the greatest credit for the operations. At the time this success was obscured by the inaccurate accounts in the press, though later, when fuller enquiry had been made, the value of the serious check given to the Boer attack on Cape Colony was better realized.

In his despatch on the siege which was published in *The London Gazette* of 8th May, 1900, Lieut.-Colonel Kekewich thus refers to O'Meara :—

> " Captain (local Major) W. A. J. O'Meara, Royal Engineers, my Intelligence Officer, carried out his many duties to my entire satisfaction and was of the greatest assistance to me. He has professional acquirements and ability of a high order, and is, I consider, a most hard-working and capable Staff Officer. The arrangements connected with despatch riders, the careful watching of spies, the censorship of telegrams and the press, and the collection of information under most difficult circumstances were most carefully and intelligently arranged by him. He also successfully carried out the duties of Director of Army Telegraphs in Kimberley. I cannot praise his good work too highly."

When Kimberley was relieved, O'Meara joined the staff of the Director of Military Intelligence at Army Headquarters and was present at Paardeburg at the final assault on the Boer position, witnessing the surrender of Cronje. He was then attached to the staff of the Cavalry Division and was present at the actions of Poplar Grove, Dreifontein and that south of Bloemfontein, and accompanied Lord Roberts into that town. He was then posted to the staff of the newly-appointed Military Governor of Bloemfontein, Major-General Pretyman, and had to devote himself to civil administration. Early in April he was posted as D.A.A.G. for Intelligence with the 7th Division, but Pretyman obtained permission to retain his services. He was promoted Major in the Corps on the 21st April, 1900.

Among other duties at Bloemfontein, he raised and commanded the Provisional Mounted Police of the Orange River Colony. He thus took no part in Lord Roberts' advance to Pretoria, but in June, 1900, he was ordered to proceed to Johannesburg. On his way, on arrival at Kroonstadt, the Boers were blocking the road, and O'Meara acted for ten days as Brigade-Major of a Provisional Cavalry Brigade, consisting of Cavalry details, Yeomanry and Mounted Infantry, which was employed reconnoitring round Kroonstadt. On the road being cleared, he continued his journey and on arrival at Johannesburg on the 21st June, 1900, he was detailed by the Military Governor, Colonel Colin Mackenzie, to take charge of all municipal matters in Johannesburg. The Dutch Burgomaster, the town Councillors and the Town Clerk had been removed from office and O'Meara, single-handed, carried out the duties of all these authorities for a period of eleven months. The municipality owned electricity and gas works and a cemetery and also carried out the sanitary services of the city. O'Meara had to administer all these services and obtain sufficient revenue from them to pay the staff. He was also Chairman of the Johannesburg Hospital Board. When Civil Government was again introduced, O'Meara was appointed by Lord Milner as Government Commissioner for Johannesburg and District and *ex-officio* Chairman of the first Town Council. While he had been acting as Assistant to the Military Governor, O'Meara had made a close study of the Transvaal laws governing municipalities and compared them with similar laws in other countries, and had drafted a law for the future municipal government in the Transvaal. He had also noted that, though the business area of the City was under the Burgomaster, there were surrounding this centre large residential estates administered by their owners. He therefore prepared a scheme of town planning under which these estates could come under the control of the municipality, and also suggested the removal of the Asiatic quarter from the heart of the city to a more sanitary locality. On his appointment as Government Commissioner, all these outlying areas were placed under his control and his draft law was accepted by Sir Richard Solomon, the legal adviser to Lord Milner, as the basis of the new law for the control of municipalities in the Transvaal. Military law was then still in force, but he was able to act as a buffer between the military and civil authorities and the tact and skill he displayed soon earned him the full confidence of Lord Milner and of all the authorities with whom he was working.

On the 8th May, 1901, Lord Milner wrote to Mr. Chamberlain that :—

> " The most important matter which I had to consider in making these arrangements was the provision of some machinery for carrying on municipal work. This had hitherto been done by Major O'Meara and I am of opinion that he carried out the work in a very able manner."

In a later communication from Lord Milner to Mr. Chamberlain, he says :—

> " The Council owes a good deal to the sympathetic and tactful chairmanship of the Government Commissioner, Major O'Meara."

When O'Meara finally left this appointment, the Town Council passed a resolution of regret at the loss of his services and passed with acclamation a vote of thanks, which was duly communicated to him through the Secretary of State for the Colonies. The Town Council also showed their appreciation by having his portrait painted, which they presented to the town. In the final despatch of the war, O'Meara was again mentioned in despatches and awarded the Queen's Medal with five clasps. He was also given the C.M.G.

In November, 1901, O'Meara obtained leave of absence to join his family in England, from whom he had been separated for two and a half years. But in April, 1902, on the eve of his return to duty, he met Sir William Preece, then Consulting Engineer to the Post Office, who told him that they wished to introduce new blood into the Post Office Engineering staff, and the next day Sir William took O'Meara to see the Secretary of the Post Office, who offered him the appointment of Assistant Engineer-in-Chief and said that, if he accepted, his release from his appointment at Johannesburg had been arranged. Up to this time the staff of the Post Office Telegraphs had been a closed body, and although the O.C. of the 2nd Division Telegraph Battalion, had always worked in close co-operation with the heads of the civil staff, no officer of the Royal Engineers had joined the permanent staff. This was especially noteworthy, as in nearly all other branches of the public service, the Foreign Office, Colonial Office, Home Office and in the Prisons, Railways and Local Government branches, senior officers of the R.E. had done distinguished service. The intrusion of an R.E. officer into the Post Office Telegraph Department was resented by some of the senior permanent officials, especially those who had claims for the succession to the senior appointments.

O'Meara commenced duty as Assistant Engineer-in-Chief on the 28th April, 1902, and a year later retired from the active list of the

Corps. This was necessary under the regulations for the Civil Service. He held this appointment until 1907, when he was made Engineer-in-Chief, which he held until 1912. During this period he threw himself into his work with his usual thoroughness and efficiency and was able to improve the working of his department in many ways, both tech-nical and administrative. Among other details, he was said to have saved the Government a capital expenditure on airline of nearly a million pounds by reviewing the arrangements for telegraph communication at race meetings. Up to then, each race-course was provided with permanent branch line connections, even if only one meeting was held yearly. O'Meara introduced a system of mobile telegraph offices which could be sent to places as required, tapping by cable on to main lines. Among other changes, one affected the Corps. With the development of telegraphy the work of K. Coy. R.E. (formerly 2nd Division Telegraphs) in the South of England was gradually getting more complicated ; also the railway branch of the War Office was asking that some of the personnel should receive instruction in the maintenance of apparatus for the control of railway traffic. In England, all such apparatus was in the hands of the railway companies, but in Ireland, all such apparatus was erected, installed and maintained by the branch of the Post Office Telegraph Department in Ireland. He therefore arranged to transfer K. Coy. as a whole to Ireland, placing the R.E. headquarters in Dublin, and this change was carried out in 1909.

After the appointment of O'Meara as Engineer-in-Chief, the agitation against what was called the " militarization " of the Post Office continued, and his efforts to improve the routine and organization were misrepresented and obstructed. This caused O'Meara much strain and annoyance and affected his health ; also he felt that friction of this sort was not good for the service. He therefore asked the permission of the Postmaster-General to retire from the appointment ; but in view of the good work he was doing, this was refused, until a report by his doctor brought matters to a head, and he resigned in 1912, when he had completed ten years' service with the Post Office. It was then found that, under the Civil Service regulations, the first year of this service, while he was still on the active list of the Army, did not count for the minimum period of ten years required for a civil pension. Later, in 1912, O'Meara was appointed a special Engineering Commissioner to report on the telephone systems of other countries and spent a whole year visiting the United States and the Scandinavian countries of Europe which had efficient telephone systems. His reports, which were prepared with his customary clearness, were freely used in the organization of the British service. He finally left the Post Office in the autumn of 1913.

He was then in his 51st year, at an age when his contemporaries in the Army were being selected for senior appointments and this termination of his Post Office appointment was a great blow to him. He turned to the law for consolation and, after study and the consumption of the necessary dinners, qualified as a Barrister-at-law. But he was still on the reserve of officers as a Major and on the outbreak of the war in 1914 he was employed in that rank at Chatham in charge of the 3rd Billetting Company. He remained at Chatham until August, 1915, when he was appointed G.S.O., 2nd Grade, with the Northern Army of the Central Force, first at Dunmow and then in Norfolk. He remained in this appointment for the remainder of the war, receiving the brevet of Lieutenant-Colonel in 1917.

He was a member of the Council of the Institution of Electrical Engineers from 1908 to 1911 and was a Vice-President from 1911 to 1913, and while Engineer-in-Chief in the Post Office was chairman of the Institution of Post Office Engineers.

Immediately after the Great War, O'Meara was asked by the Council of the Institution of Electrical Engineers to edit a Roll of Honour, containing a biographical notice of the 162 members of the Institution who lost their lives during the Great War. This work occupied him for five years, during which he meticulously checked all the information supplied to him, with a result that the Volume is a monument of accuracy as well as a very valuable record of the services rendered by Electrical Engineers during the Great War.

Soon after joining the Post Office, O'Meara had been appointed one of the three Trustees of the Corps Funds and he continued to interest himself in Corps matters. After the war he placed his legal knowledge freely at the disposal of the Corps in the preparation of the Charters for the Institution of Royal Engineers and the R.E. Charitable Association ; he also interested himself in our Kitchener Scholarships and served on the Councils of the Institution and of the R.E. Widows Society, becoming Vice-Chairman of both bodies. He also contributed to *The R.E. Journal* and was a prolific writer on many subjects. From 1924 to 1926 he was Chairman of the Board of Studies in Electrical Engineering at the University of London.

He married, in 1892, the second daughter of Colonel W. Graves, R.A.M.C., of Coleraine, who survives him. His only son received a Commission in the East Lancashire Regiment but was killed while on duty in the trenches in France, in February, 1917.

The above summary of his career hardly does justice to the kindly disposition and charming personality which O'Meara showed to all with whom he came into contact, or his absolute lack of self-interest, though it may perhaps show something of the zeal which he displayed in everything he undertook and the hard work and determination with which he tackled every job which was placed on his shoulders.

W.B.B.

All Reviews of Books on military subjects are included in the provisions of K.R. 535c (*1935*).

BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library at Brompton Barracks, Chatham.)

THE HISTORY OF THE INSTITUTION OF ELECTRICAL ENGINEERS. 1871–1931.

By ROLLO APPLEYARD.

Illustrated by 37 Plates.

(Institution of Electrical Engineers. Price, 18s. 6d.)

The book was prepared at the official request of the Institution of Electrical Engineers and deals chiefly with the sixty years from 1871, when the Society of Telegraph Engineers was founded, to 1931 that marked the centenary of the discovery by Michael Faraday of " the evolution of electricity from magnetism."

The Introduction.

In 1871, a voluntary association called " The Society of Telegraph Engineers " was formed. This title was broadened in 1880 to " The Society of Telegraph Engineers and Electricians " and in 1888 became " The Institution of Electrical Engineers " under which title a Royal Charter of Incorporation was granted in 1921.

The idea for establishing the Society originated in Lord Lindsay's laboratory in " Eaton Place," which was the centre where men from all parts of Europe assembled " in an informal and informative fashion."

The history of the development of Magnetism and Electricity is dealt with briefly, commencing in 1600, when William Gilbert of Colchester published his work entitled *De Magnite*.

In May, 1837, the Electrical Society of London held its first meeting. Sturgeon was the first President. At the time of founding there were " no telegraphs, no electrotyping, no electric plating, no electric gilding, nothing electric upon a commercial scale."

Sturgeon started life as a cobbler and subsequently enlisted into the Royal Artillery at Woolwich in 1804. He picked up enough mathematics, Latin and Greek at Woolwich to get a grip of scientific terms. In 1825 he produced the first iron electro magnet and, in 1832, an electro-magnetic rotary engine of considerable power.

This Society collapsed in 1843, just when electricity was making itself felt in the practical realization of the telegraph.

By 1871 there was in England about £40,000,000 invested in telegraph companies, and experience, not always happy, had shown that boundless opportunities existed for investigation.

Army Estimates for this year showed the addition of a " Telegraph Troop " to the Royal Engineers.

The Founders.

A meeting was held on 17th May, 1871, " To consider the expediency of forming a Society of Telegraph Engineers, having for its object the general advancement of Electrical and Telegraphic Science, and more particularly the exchange of information and ideas among its members."

The following were present and therefore may be designated the founders of the Society :

William Whitehouse, Esq. (*Chairman*).
Captain P. H. Colomb, R.N.
Major R. H. Stotherd, R.E.
Louis Loffler, Esq.
Captain C. E. Webber, R.E.
Captain E. D. Malcolm, R.E.
Robert Sabine, Esq.
Major Frank (Francis) Bolton (*Secretary*).

It is significant that of the eight founders, five were service officers and three were civilians.

Colomb introduced to the Navy " Colomb's Flashing Signals " and was lent to the Royal Engineers in 1867 to assist in improving military signalling. He was part author of Colomb and Bolton's book *The System of Flashing Signals in Her Majesty's Army and Navy*."

Webber was at this time assisting the Post Office in constructing and organizing the telegraph service.

Malcolm was Inspector of Submarine Defences at the War Office.

Bolton was lent to the R.E. from the East Suffolk Regiment and had been Deputy Assistant Quartermaster General and Assistant Instructor in Visual Signalling.

The first President was Charles William Siemens, C.E., F.R.S., and among the council were three Royal Engineer Officers.

There is a short description of the early telegraph work in the Army and illustrations showing the ploughing in of cables and a telegraph wagon in the Crimean War are given.

The First Decade.

The first list of members, dated 1872, shows that of the 268 members 41 were officers of the fighting services.

The offices were rented at 2 Westminster Chambers. In 1872, Major F. Bolton found the work of Honorary Secretary too heavy and " a duly qualified " secretary at £100 p.a. was appointed. In 1873 Serjeant Tyler, R.E., was appointed Treasurer's Clerk at £5 p.a.

The first paper was read before the Society in March, 1872, by Mr. R. S. Culley, Engineer-in-Chief of Post Office Telegraphs, on " Automatic Telegraphs." A few weeks later, papers were read by Captain P. H. Colomb, R.N., on " Progress of Sea Telegraphy " and Captain E. D. Malcolm, R.E., on " Army Telegraphs."

In 1879, Lieut.-Colonel J. U. Bateman-Champain, R.E., was elected President. In this year there was an agitation to quicken the advance of electric lighting in this country and he was able to report that trials of numerous systems were at last being made at four places in London.

In 1880, the President, Sir W. H. Preece, stated " gas is not going to be affected by electric light. The proper function of gas is to generate heat. Ninety-four per cent of the ingredients of gas are consumed in generating heat and only six per cent in producing light. It is remarkable that so amenable and tractable an agent for heating purposes has not been utilized : but the fact is that the public is ignorant of its properties, careless of its employment and callous of its defect."

Attention is drawn to the fact that *The Military Telegraph Bulletin*, published by the Royal Engineers " for private circulation only," contained valuable details of equipment and methods employed in the field and in telegraph offices and particulars of organization and personnel, sketched lightly, but with complete knowledge and abundance of humour by the officers and men on the spot. The first number is dated 15th March, 1884.

The Transition.

In this period the Society gained influence and became universally acknowledged as authoritative in electrical affairs—revision of units, application of theory to design of plant and equipment and the reform of technical education.

The First Wiring Rules were drawn up and published in 1882, during the year of office as President of Lieut.-Colonel C. E. Webber, R.E.

Colonel R. E. Crompton, R.E. (T), who was a member of this committee, and whose recent death is so deeply regretted, was a director of Crompton Parkinson.

The Institution in Being.

In this section the more important developments in the electrical industry and extracts of some of the papers read before the Institution are dealt with briefly. The period 1889–1900 marks a great development in the growth of electric lighting. In 1897, there were 121 electric power stations as compared with 14 in 1889.

In 1896, the Institution offered to the War Office a scheme to render available for purposes of National Defence the technical skill of Electrical Engineers, and a committee was appointed at the War Office to investigate the matter. As a result of this committee's findings in 1897, a corps of Electrical Engineers, R.E. (Volunteers) was formed. The first Commanding Officer was Dr. J. Hopkinson, F.R.S., who was killed in an Alpine accident on 30th August, 1898, and Lieut.-Colonel R. E. Crompton succeeded him.

On 18th October, 1898, upon the motion of General C. E. Webber (late R.E.), it was resolved,

> "That a Volunteer Corps Endowment Fund be formed, with the object of assisting the Corps of Electrical Engineers, R.E. (Volunteers) to obtain instructional plant and instruments for the training of the Corps; that a subscription list should be opened amongst the members of the Institution for that object and that a committee be appointed to confer with Lieut.-Colonel Crompton on the subject."

In March, 1900, a portion of this unit under Lieut.-Colonel Crompton volunteered and embarked for service in S. Africa.

It is noted that nearly every volume of the Journal of this period records the friendly relationship that existed between the Institution and the fighting services.

In March, 1899, Mrs. W. E. Ayrton was elected the first lady member of the Institution for her work on Carbon Arc Lamps.

The Pre-War Period.

The Institution was instrumental in the formation of a standardization committee on Electrical Machinery and made a grant of £250 for this work, and has since from year to year continued to provide grants. This committee is now the British Standards Institution.

An extract from the Presidential Address in 1903 includes among the noteworthy events of the year, the construction of four turbo-generators of the Parsons type and also the completion of the world telegraphic girdle by the laying of the trans-Pacific cable between Canada and Australia.

In 1908, the Institution acquired its present buildings and The Kelvin Lecture was first given in this year. The developments in electric transmission, electric lamp design, telephones, and applications of the use of electricity in ships, are among the extracts of papers read during this period.

The War Period.

The Institution offered on 7th August, 1914, "to assist the Authorities, to place at the War Office's disposal, free of charge, the available space in the Institution building, to place the organization at the disposal of the Admiralty and the War Office to select men trained in electrical engineering for any purpose that might be required."

These offers were accepted and the use made of the Institution during the war is dealt with shortly.

One thousand six hundred and seventy-one members (approx. one quarter) joined the fighting services. A roll of honour of the 162 members who gave their lives is included.

The Restoration and Advance.

This period is marked by the large increase in membership, which had risen from 110 in 1871 to 7,045 in 1914 and to 18,252 in 1938.

The Institution was approached in 1923 by the Board of Education to encourage instruction, especially by part-time day and evening classes, in electrical engineering and devised a scheme which has done much to further technical education.

In 1923, The British Broadcasting Co. rented some of the Institution buildings and up to 1932, when the B.B.C. moved to Portland Place, the Institution was the centre of Broadcasting in this country. The work of the B.B.C. in this period is dealt with shortly.

Amongst the important papers of special service interest read during this period were:

"The Fullerphone and its application to Military and Civil Telegraphy," by Major A. C. Fuller, R.E.

"Direction and Position Finding," by Captain H. J. Round, R.N.

"Short-Wave Directional Wireless," by C. S. Franklin.

"Applications of Electricity in Warships," by W. McClelland.

The Precincts.

The Institution buildings are built upon a plot of land once described as "the fairest manor in England" with its palace "unto which there was none in the realm to be compared in beauty and stateliness." The story of the ancient manor is of general interest.

The Presidents.

In this section short biographies and photographs of the Presidents from 1871–1938 are given.

Appendices include the Royal Charter, Medals, Scholarships, Premiums, which include the Webber (value £10) for Papers on Military and Naval applications of Electricity, First Wiring Rules.

A.W.S.

BATTLE TRAINING IN WORD AND PICTURE.

(George Newnes, Ltd. Price 6d.)

This magazine is laid out on the lines of many of the modern semi-technical or scientific publications. It skilfully blends historic stories with tactical exercises and supplies light relief by humorous pictures.

This method of presentation should appeal particularly to the present civilian army and is far in advance of the normal dull and uninspiring official text-books. Many parts of the magazine cannot fail to be of universal interest and the technical matters are presented in such a manner that they can be absorbed with the minimum of concentration.

The section showing pictorially the right and wrong way of carrying out various operations is most instructive and impresses the facts on the mind much more clearly than pages of print.

Perhaps additional articles on the causes of the present war, the aims for which we fight and kindred subjects would be of value. It must be remembered that in this modern age the rank and file of the army is an educated and practical man who forms his own opinions and conclusions.

E.C.P.

TRACK STRESS RESEARCH.

(Government of India—Railway Dept. Price Rs. 10, or 16s.)

Railways have been in existence for well over a hundred years, during which the weight and speed of trains has enormously increased. Corresponding increases in the strength of the permanent way have been required, yet so complicated are the stresses in track, that until recently, there has been little accurate scientific knowledge on which to base design of track, methods of maintenance and safe speeds. The practical experience of generations has produced the track and methods in use to-day which have, on the whole, met requirements, though possibly not with the maximum economy, but exact measurements, on which to base improvements in detailed design, resulting in a well balanced whole, have been lacking. Moreover, the question of safe maximum speeds, now assuming an increased importance in view of the tendency to speed up heavy trains, has been largely determined by the judgment of those concerned, depending mainly on personal experience.

The Central Standards Office of the Railway Board of the Government of India have been engaged on this investigation for the past four years. Previous to this, they had carried out extensive research into the strains in large girder bridges on the same lines as investigations at home, resulting in a considerable increase in knowledge and more accurate formulæ for their design. The Fereday-Palmer stress recorder has been the principal instrument used in both these investigations and a full description of all instruments used, with illustrations, is included in this report.

The report deals with the following points :

(i) Working stresses in rails and fishplates.
(ii) Static stresses and deflections in solid rail.
(iii) Dynamic deflections in solid rail.
(iv) Dynamic stresses in solid rail.
(v) Fishplate stresses and joint deflections under static conditions.
(vi) Dynamic stresses and deflections in fishplates for well-packed joints.
(vii) Dynamic stresses and deflections in fishplates for low joints.
(viii) Stability of sleepers in ballast under vertical and lateral loads.
(ix) Description of field testing equipment and its use.
(x) Experiments to determine lateral strength and stiffness of permanent way and the lateral loads applied to it.
(xi) Safe working loads and speeds.
(xii) Summary of conclusions.

Many of the points investigated have a direct bearing on the design of metal sleepers. This is a matter which has been under investigation by the Central Standards Office for some time. Metal sleepers have been largely used in India for many years and there are many different patterns of varying efficiency. But, though it has been known how they differed, these investigations have thrown a good deal of new light as to why they differed.

Item x is chiefly due to the serious derailment at Bihta in 1937, which appears to have been due to distortion of track under a heavy engine.

The report is in two volumes. Volume 1 is the actual report and Volume 2 contains detailed results of the tests made. It is highly technical and will mainly interest those who have specialized in railway track matters. The information gathered will no doubt influence new designs of track, locomotives and maintenance methods on main lines carrying heavy high speed traffic, but is unlikely to have any great effect on military railway practice.

H.L.W.

"EXPERIMENTAL WORK ON ROADS."

The Report for the year ended 31st March, 1939, of the experimental work on Highways (Technical) Committee is a Ministry of Transport publication of particular interest to members of the Corps, to whom fall duties connected with the construction and maintenance of roads and the like.

The report begins with an introduction, which is in effect the covering memorandum addressed to the Minister by the Committee, submitting the report. Except for reference to experiments in progress, but not yet ripe for report, and to experiments to be undertaken in the future, the introduction contains nothing of note.

The chief value of the report lies in the introductory paragraphs to the chapters that follow, dealing with concrete, cement-bound macadam, tar and other bituminous surfacings, thin surfacing coats, surface dressing, footpaths, and cycle tracks. In the introductions to these chapters will be found summarized results of the experiments, and from these some lessons can be learnt.

Dealing with *Concrete*, the report shows that comparatively cheap aggregates of suitable grading can give satisfactory results. As regards thickness, 6 in. with proper construction and suitably reinforced has proved adequate, while in few cases can there be any justification for a more expensive construction than 8 in. thick, 4 : 2 : 1 mix, doubly reinforced. The importance of the subsoil in this connection is referred to, but while subsoil research is evidently being pursued by the Road Research Laboratory and by the Ministry on a number of roads under construction, no details are available, and there is no hint of the examination of subsoils where failures have occurred. Some more information on this subject would have been welcome.

As regards reinforcement, the conclusions are drawn that the total length of cracking which ultimately develops in a concrete road is independent of the presence or otherwise of reinforcement, and that the presence of reinforcement does, however, influence the distribution and extent of individual cracks.

The risk of cracking in concrete may, it is concluded, be minimized, whether reinforcement is used or not, by attention to the following :—

(1) The presence of a good subsoil and an even sub-base.
(2) The provision of waterproof paper between the sub-base and the concrete.
(3) The use of suitable cement.
(4) Careful grading and proportioning of the fine and coarse aggregates.
(5) Accurate batching of the materials.
(6) Adoption of a low water-cement ratio, facilitated by (7).
(7) The use of mechanical methods of consolidation and finishing.
(8) The use of short slab lengths.
(9) Efficient curing.

The cost and inconvenience of two-course work is not justified.

Some interesting notes are made about joints, and joint-filling materials, and on jointless concrete.

Effective control of the water-cement ratio, the importance of which has long been recognized, must depend on an accurate knowledge of the water content of the aggregates, especially of the sand. Of five methods investigated, only the specific gravity method, suggested by Dunagan, appears to have given really good results ; even by this method it is observed that the supplies of aggregate on the site should be as large as is practicable and that they should be stored in adequately drained and protected stock piles, to avoid variations in the water content of the aggregates. The use of the sand inundator and vibrator is referred to also, but in its present form this method is not suitable for machine-compacted work.

An interesting experiment was carried out on the London-Southend Road to compare the results of curing a concrete surfacing with bitumen emulsion with the normal method of curing. In a previous report the statement had been made that curing with bitumen emulsion had resulted in a slippery surface. It was pointed out to the Ministry that this statement was possibly due to the inefficient method adopted in the experiment quoted, since an excessive quantity of emulsion had been used and it had not been " blinded." In the experiment now under report, two types of bitumen, three rates of application of emulsion and two types of blinding grit were used. The interim conclusions drawn show that any differences in strength, resulting from the use of different methods of curing, were masked by the inherent variations in the strength of the concrete. The estimated cost of curing with bitumen emulsion, including grit, is slightly higher than that of the normal method, but it is clear that, where difficulties exist in regard to the supply of water for curing or in any other factor affecting the normal method, the difference in cost may be in favour of emulsion curing. The chief object of the experiment, *i.e.*, to test the alleged slipperiness, is not yet disclosed, as the skidding tests are not completed. Those carried out up to May, 1938, do not indicate low sideway force coefficients.

On *Cement-bound macadam* the conclusions show that compressed concrete has proved better than the sandwich and cement penetration systems, while successful construction demands the development of a special technique.

The chapter on *Tar and other Bituminous Surfacings* deals with two main experiments of general interest—undertaken on the Kingston and Kirkham by-passes—and with others of mainly local interest. Of the ten general conclusions from the two main experiments the following are of particular interest :—

> Several types of surfacing constructed to various B.S. specifications have given excellent service for at least eight years, on a road carrying fast and heavy traffic, without needing any appreciable expense for repairs.
>
> Careful attention to the selection of suitable aggregates and to the processes of manufacture and laying are essential to success.
>
> " Noticeably good results have been obtained in one instance with a cheap two-coat cold bituminous macadam."
>
> Materials which conform with B.S. specifications, carefully manufactured and laid, do not depreciate in riding qualities under traffic.

The importance of *Thin Surfacing Coats* in modern road maintenance is emphasized by this subject being treated in a separate chapter, dealing with the eight experiments undertaken. While the cost of the thin surfacing is appreciably higher than that of a surface dressing, this may be more than counter-balanced by the greatly improved riding qualities and longer life obtained in a thin surfacing and the tendency of repeated surface dressings becoming too rich in binder. Those sections which contained aggregate of max. gauge of $\frac{5}{8}$ to $\frac{3}{8}$ in. showed the most consistent good resistance to skidding, while with two exceptions the " sand-paper " textured surfacings were less satisfactory in this respect. In each of the experiments undertaken in 1934, a carpet into which pre-coated chippings had been rolled proved one of the most durable.

Accurate control during manufacture is again emphasized.

The use of gravel as aggregate presents special difficulties with this type of surfacing if an open textured surface is to be maintained.

The experiments in *Surface Dressing*, from which conclusions are mainly drawn, were carried out in 1931, 1932 and 1933. Those in 1931 and 1932 had shown the importance of the state of the chipping used, *i.e.*, whether wet, warm or dry. The work in 1933 demonstrated that in certain conditions the final results could be excellent ; the sections in the Oxfordshire experiment of that year, which were blinded with gravel, lasted five years before requiring re-treatment, while those blinded with granite have not yet reached the end of their useful life The binders used for this experiment were a tar and a proprietary dressing. The value to successful results of doing the work during dry weather is brought out. As the success of this type of work can be so marked, and the cost is so low, it is remarkable that more care and attention is not usually given to selecting the best conditions, and to ensuring that traffic is not allowed to use the newly treated surface until the set of the binder is effectively holding the blinding material.

The next chapter deals with *Footpaths in Rural Areas*, and it is observed that ordinary concrete has proved satisfactory, requiring no maintenance so far. Compressed, grouted or rolled concrete has proved inferior to ordinary concrete, and usually more expensive. The fact that other materials used have required surface dressing is not very surprising, and as they are usually appreciably cheaper it would not appear to constitute a drawback. In the final chapter on *Cycle Tracks* it is observed that these require riding qualities at least as good as those of the usual carriage way ; the experiments have not been done long enough to enable conclusions to be drawn.

While the report as a whole is of considerable interest and instructive, it is to be regretted that more details are not given of the gradings of aggregates used in the case of tar and bituminous surfacings and thin surfacing coats. It should also be noted that where cost per square yard of the surfacing is given, this refers to the actual cost of the test length and is not necessarily a correct indication of the cost of similar work in a contract of reasonable size.

E.G.W.

A HANDBOOK OF HOME GROWN TIMBERS.

(Price, 1s. 6d.)

A HANDBOOK OF EMPIRE TIMBERS.

(Price, 3s. 6d.)

Edited by H. A. Cox, M.A., Dept. of Scientific and Industrial Research (Forest Products Branch). H.M.S.O.

These two works between them give statistics of some 120 timbers and their varieties.

The information given, representing an enormous amount of work at the Forest Products Research Laboratory at Princes Risborough, Aylesbury, Bucks, goes far beyond the meagre information to be found in most engineering text-books. Under each species, a list of the trade names in use is given, followed by a brief description of the size and habitat of the trees. A general description of the timber comes next, detailing its weight per cu. ft., and its seasoning properties, accompanied by the kiln schedule recommended, particulars of which are given in an appendix to the second volume. Bending properties follow, in the shape of a formula giving the safe radius to which a specimen can be bent. The paragraph on mechanical properties includes such useful items as resistance to suddenly applied loads, to indentation and splitting. The natural durability, *i.e.*, resistance to decay, and liability or otherwise to insect attack, are detailed, its permeability or otherwise to preservative, a brief description of its working qualities, including saws recommended, come next, and then its uses and, in the case of imported species, some indication of the supplies available.

Each species, it may be added, is allotted from 1½ to 3 pages, of a size comparable with those of the *R.E. Journal*.

The only criticism that can be levelled is that the table of mechanical properties is omitted from the home-grown timbers volume, the introduction to which is also much shorter than the very valuable one in the other book. It should be added, however, that the mechanical qualities of many of the home-grown species are added for comparison to the table in the Empire volume. And, of course, there are obvious reasons why it is necessary to keep both books as works of reference.

Of Indian and Burma timbers, only those imported into this country are given, eleven in all. An interesting comparison can be made between the qualities of certain Empire species, *e.g.*, Douglas Fir and Sitka Spruce, as grown in their native lands, and the same trees as grown in the U.K.

These two works should find a place in the reference shelves of every R.E. workshop and park.

F.C.M.

THE PHYSICS OF THE DIVINING ROD.

By J. CECIL MABY, B.SC., A.R.C.S., F.R.A.S., and T. B. FRANKLIN, M.A., F.R.S.E.
(Bell. Price 21s.)

The sub-title of this book describes it as an account of an experimental investigation of water and mineral divining, but it goes much further than this. It is divided into three Parts—Part I, consisting of three chapters, deals with previous investigations and theories of dowsing; Part II describes in the next five chapters the Authors' own investigations and experiments, while Part III deals with the theoretical and mathematico-physical aspect of dowsing.

Chapter I gives a brief historical sketch of the dowser's art and concludes with the ten initial principles of the British Society of Dowsers. Chapter II considers the problem of mineral and vital radiations, whilst Chapter III deals with the physical investigations in relation to dowsing, including not only the possible sources of error in dowsing but also recent physical investigations, both abroad and in England.

The account of the Authors' experimental dowsing investigations opens in Chapter IV with proofs of a physical basis of dowsing. Chapter V deals with the details of dowsing fields and reactions, and contains much information, not only of great interest but also probably new to the majority of readers. Geophysical and physiological factors are considered in the next chapter and the Authors' remarks on solar activity and sun spots are of particular interest.—In Chapter VII is considered the application of the new knowledge.—Suitable conditions for dowsing are studied and advice on the more useful forms of indicators and other apparatus is given.

Chapter VIII, the concluding one of Part II, is probably of much wider interest than other chapters of the book and should be studied by all those responsible for the siting and construction of buildings and for the health of the inhabitants thereof. The subject of the Chapter is "Electrical radiations relative to growth and disease," and it includes a study of earth rays in relation to disease, ionisation relative to plant growth (of considerable interest to horticulturists), and the medical aspect of dowsing research. In this connection the Authors raise some interesting questions as to whether the increase in cancer, tuberculosis, and rheumatic disorders may not be accounted for, partially at least, by the increase in the use of metal in the construction of modern buildings, etc., and by the increase in recent years in the number of bungalow dwellers.

In Part III the Authors deal with the theoretical and mathematical side of dowsing. This is followed by a useful select bibliography, an excellent twelve-page glossary of technical terms, and a comprehensive index. The book contains half a dozen clear plates and many diagrams in the text.

The Authors' investigations have been conducted under the auspices of the Investigation Committee of the British Society of Dowsers, and it is of interest to the Corps to note that Colonel A. H. Bell, D.S.O., O.B.E., late R.E., as President of the B.S.D., was responsible for the formation of this Committee.

J.H.D.B.

OLD TIMES UNDER ARMS:
A MILITARY GARNER.

Compiled and Edited by Colonel C. FIELD, R.M.
(William Hodge & Co., Ltd. 10s. net.)

This is a volume of military lore which must represent the result of many years' search in out-of-the-way corners. It brings together a great variety of detail and anecdote, classified under nineteen headings. Here is matter for almost any military student; here are the pieces, of which the reader can make what picture he chooses of old times under arms.

Most of us have smiled at the curious words of command in the old musket exercises, or the quaint woodcuts showing men in action in chimney-pot hats or periwigs; but here we can picture them as human beings, not very different from ourselves; suffering indeed under grievous penalties and inflictions, but having hearts and feelings, and courage in the face of all kinds of dangers.

Colonel Field has grouped his fragments under suitable headings, and he appends the source of every one of them. He begins with National Characteristics. An old commentator of 1617 has some pithy comparisons of Spanish, French, English, German and Italian soldiers.

"It was an old observation of Philip de Comines concerning us Englishmen "'That we have lost by our Heads what we have gained by our Hands, and have "always given up by Treaty what we have won by the Sword.'

"Doctor Johnson considered that the special characteristic of the British "soldier is a species of 'plebeian magnanimity.' His greatness of heart is exhibited "not only in his bravery, but in the quality which he expects in his officers. He "relies on them to lead him, and they, on their part, are quite satisfied that he "will follow them."

In a chapter on the British Soldier, there is an interesting account of the soldiers of Cromwell's Army at the Battle of Dunkirk in 1658. Cromwell sent an expeditionary force of 6,000 men under Sir John Reynolds to fight with the French, led by Turenne, against the Spaniards in Flanders. Reynolds commanded, but Sir Thomas Morgan was the Brigadier, and to him the successful attack on Dunkirk was due.

There are several extracts from James' *Military Dictionary* published in 1802, and a curious misquotation has been allowed to pass on p. 39.

"There are three regiments of Fusileers in the English service; the Royal "regiment of Scotch Fusileers, raised in 1678; the royal regiment of Welch "Fusileers raised in 1685: and the royal regiment of Welch Fusileers raised in "1688–9."

The second of these should be, of course, the 7th or Royal Fusileers, as indeed the second edition of James' *Dictionary* has it.

The ill-treatment of soldiers by their officers in the eighteenth century is illustrated by three examples from "Cautions and Advice to officers of the Army, by an Old Officer, 1760."

In a chapter on Impressment, Recruiting and Deserters, there are some amusing examples of recruiting serjeants' posters.

In Drill, Training and Exercises, we have the whole detail of the Grenadier Exercises in 1690: here are some of the commands:—

"Handle your Primer. Shut your Pan. Blow off your loose corns. Cast about "to charge. Handle your Cartridge. Open it with your teeth. Charge with "Powder and Ball. Draw forth your Scowrer. Shorten it to an inch. Ram down "Powder Ball. Withdraw your Scowrer. Shorten it to a Handfull. Return your "Scowrer. Poize your Fire-lock."

In 1759, an advertisement appeared in the *British Chronicle* of a Military Academy in Bloomsbury Square, kept by Thomas Marquois. This is probably our old friend of the Marquois scales, for their invention dates from that period, and at his Academy he favoured the art of drawing Plans of Places.

The Duke of York's reforms in the Army are given a due amount of notice, extracted from the *United Service Journal* of 1833.

The chapter on Uniform and Dress has some interesting details of cost and complexity. What a time of it our ancestors had in those thick uniforms, in which they had to serve in whatever climate fate took them to.

Among Guns, Gunners and Gunnery, the author gives a list of some notable cannon and their pet names. The earliest is "Salamonica," dated 1132. This is a very early reference to cannon, and should have some further authenticity. Under the date 1914–15 appears "Granny," as a gun used at Gallipoli by the British. I have always understood that the name applied to the early 15-inch howitzers, which first appeared in France about March, 1915; these monsters were certainly known in Flanders by that name. Leather guns, wooden guns, and even gold guns were noted. Machine-guns may be said to have had an origin in Flanders in 1367, but these early attempts were confined to arrangements for firing a number of barrels simultaneously.

An extract from Smith's *Military Dictionary* (1779) shows the total annual cost of Edward VI's Artillery to have been £1,547 9s. 2d.

The origin of Woolwich Arsenal is referred to in the following interesting item :—

"The original Ordnance Foundry was situated in Upper Moorfields, London. It "had been determined to re-cast into English guns some old cannon, the trophies "of victories obtained by the English Army, under the Duke of Marlborough, over "the French; and the circumstances being known, awakened the curiosity of a "great number of persons. Among a great concourse of persons assembled was a "young man named Andrew Schalch, a native of Schaffhausen in Switzerland, "who being intimately acquainted with mechanics, discovered a defect which "involved in it serious consequences. The moulds in which the cannon were to "be cast had not been sufficiently dried, and a glance at the laws by which the "dispersion of water is governed, convinced the young Swiss that if not remedied "the result might be terrible. He immediately informed Colonel Armstrong, the "Surveyor-General of the Ordnance, of the threatened danger, who determined "to follow his advice and quit the foundry. It does not appear, however, that "any steps were taken to apprise the public of the impending peril, nor any extra "precautions used to prevent accidents; but the prediction of Schalch was fully "and awfully verified; the instantaneous conversion of the damp into steam on "the application of the tremendous heat of the metal caused a horrible explosion, "the heated metal flew about in all directions, and the concussion of air attendant "on so great an explosion dashed down the galleries and tore down a great part "of the roof. Many persons perished, others were dreadfully mutilated, and the "scene, so pleasantly begun, terminated in sorrow and confusion.

"Schalch was afterwards commissioned by the Government to seek out some "spot within twelve miles of the metropolis, to which the whole manufacture of "the ordnance might be transferred, and he fixed upon Woolwich, to which it was "immediately removed, and where suitable buildings were erected. The young "Swiss was appointed superintendent of the whole concern, which office he "continued to hold for sixty years; during which time, so admirable were the "arrangements made, and so extensive the knowledge displayed, that not one "single accident occurred. He died at the advanced age of 90 years in 1770, and "was buried in Woolwich churchyard."

There is a good chapter on mines, from which the following anecdote is taken :—

"During the siege of Bologna by the Viceroy of Naples in 1512, Count Peter "Navarro finished a mine, and having set fire to it, part of the wall of the city "was lifted up, so that they without saw those in the town, and the townsmen "those in the field under the wall; yet it fell again in the same place, and settled "as fast as at first."

Those of us who were commissioned at 5s. 7d. a day will be interested in the details given of the pay of Cromwell's Army in 1654. The daily rates varied from £13 for Oliver himself to 3s. for an Ensign. The Commissary was paid £3 a day, but the Adjutant General had only 15s. The daily expenses of an Ensign in 1780 ran up to 2s. 6d., out of which he paid 6d. for breakfast, 1s. for dinner, and 6d. for wine and beer, and 1d. to the man who shaved him. "In short, the pay from the "Colonel down is by much too little, when we consider that the present pay was "established above a century ago, and at that time was worth thrice its present "value."

A "handsome" increase of pay was made in 1797; the private soldier was given

1¼d. a day more, costing the public 1s. 1½d. For this modest sum, England obtained the services of the men who fought under Wellington.

In 1857, the Duke of Cambridge, the Commander-in-Chief, issued an "order for "the rigid limitation of the charges for the dinners, and the exclusion from the Mess "table of such expensive wines as claret and champagne. Two shillings *per diem* is "to be the maximum price for each officer's dinner: and in consideration of the "means of subalterns, the Prince Regent's Allowance for wine, of which only a "portion of the officers were accustomed to partake, is to be appropriated to the "common use in reducing the actual expense of each officer to 1s. 6d. Thus each "infantry subaltern will have 3s. 9d. *per diem* for the other necessaries of life." This was a brave effort, but like many of those attempts, it was left to the individual Corps to put into practice or not as they fancied.

The officers of those days lived at a high standard; they could not live on their pay; but were there many who regretted the good things they had? We hear those men spoken of as gilded popinjays, but they left their mark on our history. They handed on the traditions of the British Army; and they served under very severe conditions, as the next chapter on Crime and Punishment shows.

There are some tragic stories of the terrible punishments meted out in old times; among them the story of Colonel Campbell of the Marines, who at an execution parade, intending to produce the white paper of reprieve, pulled out his handkerchief with it, which was the signal to the firing party, who instantly acted on it.

Turning from grave to gay, there is this story of a Volunteer parade.

"A serjeant drilling a Volunteer Corps a few days ago was peculiarly severe on a "gentleman, whom he did not fail to tax as amazingly stupid and awkward. The "recruit grumbled, and was beginning to reply when Kite stopped him by exclaim-"ing, "Hold your tongue, sir; a soldier is only allowed to open his mouth twice "in the ranks; once when his name is called, and again to bite off the end of his "cartridge."

Of military mutinies there were scores of instances; the last example quoted being a disturbance at Chatham in 1834, when some Connaught Rangers broke out into riot.

A chapter on Foreign Armies gives a variety of information about most of the European armies.

The last two chapters are on Woman Warriors, and Anecdotes; the former includes practically all the known cases of individual women who escaped detection during their remarkable service in the ranks.

This is a book of rare entertainment. The compiler deserves our gratitude.

W.H.K.

MAGAZINES.

MILITÄR WOCHENBLATT.

(*December*, 1939.)—*The German Engineers in Poland*. This number contains a short article on "The problems and work of the German field engineers in the German-Polish campaign, 1939." Its essence is that "without the decisive engage-"ment of the engineers the rapid execution of the German operations would have "been impossible." The theatre of war was full of rivers which hampered movement: the San, the Warthe, the Vistula, the Narew and the Bug, and their affluents. In their retreat the Poles destroyed all the railway and road bridges over the rivers—fourteen over the Vistula alone—and nearly all those over the small streams.

The principal task therefore was bridging. Passages for the light motorized troops were made by the divisional and corps engineers; and heavy bridges, later, by special bridging units under the superintendence of fortress engineer staffs. Rapid bridging enabled sections of river lines held by the Poles to be turned, sometimes to be attacked frontally by surprise.

In the attack of blockhouse lines " the old engineer methods were employed: wire " cutters, hand grenades, high-explosive charges, smoke candles and flame " projectors." The engineers fought alongside the infantry and " in the final assault " on Westerplatte, near Danzig, an engineer storm company led the way."

The repairs of the railways had also to be done quickly. Until the railway administration could take them in hand, the engineer railway troops had to construct temporary bridges and make diversions; *e.g.*, at Dirschau, on the Vistula, a diversion and temporary bridge were made clear of the destroyed girder bridge.

Nothing is said about all the rivers being very low—the Vistula fordable near Warsaw—and others quite dry, so that tanks could cross them, nor that ample supplies of timber were available in the forests close at hand.

J.E.E.

JOURNAL OF THE INSTITUTION OF MECHANICAL ENGINEERS.

(*November*, 1939.) *Motor Transport.* By E. C. Ottaway. This is an up-to-date and informative review of Road Passenger Transport, but most of it is also applicable to goods vehicles, to which brief reference is made.

The paper is divided into two parts:—

1. *Control by National Authority*, in which the legal, technical and other requirements are fully dealt with.

2. *Engineering Design.* In this part a short review of the present *fuel* situation is given and the characteristics and advantages of the *compression-ignition engine* with various types of combustion chamber are clearly explained from the practical point of view with regard to fuel and lubricating-oil consumption and to maintenance.

With reference to *transmission*, the characteristics and possibilities of fluid couplings and torque converters as alternatives to the ordinary friction clutch and gear box are also fully considered.

The writer of this paper is Technical Officer ('Buses and Coaches), London Passenger Transport Board.

He has presented the subject in a very clear and readable manner and the paper is a most useful addition to the literature on the subject.

H.L.L.

THE INDIAN FORESTER.

(*September*, 1939.)—The Editorial is deeply concerned with the future of the magazine. The expense incurred by recent enlargement and increase in the number of illustrations has not been defrayed by a larger circulation. The Editor appeals for a wider public, without which the journal will have to curtail its activities. It is certainly deserving of a place in every R.E. Mess in India, and might be included among the professional papers sent round periodically by the M.E.S. The annual subscription in India, if paid in advance, is Rs. 15.

Mr. Bor contributes a poem on " The Indispensable Pair." It will delight the heart of old *koi hais* to learn that the pair are the hurricane *batti* and the kerosene oil tin, and that they are as indispensable now as they were a generation ago.

An extract from the *Scientific American* on valuable products from lignin introduces some chemical terms which fairly make one stagger. Here are two of them—paraprophylcyclohexanol and 4-propyl, 1, 2—dihydroxycyclohexane.

(*October*, 1939.)—*Sopa* is the vernacular name for several kinds of tree growing in the plains of Assam. Some of the species are said to be largely used in building construction as well as in cabinet making, and one at least makes an excellent roadside tree.

Anogeissus pendula (*kardhai*) hold the world's record for toughness. One specimen, 30 in. by 2 in. by 2 in., resting on supports 28 in. apart, just failed to stand up to a blow from a 100-lb. hammer dropped from a height of 66 in. Its value for handles, spokes, poles, etc., is therefore evident. It grows in the drier tracts of the Punjab, Rajputana, the C.P. and U.P. Its disadvantages are that it splits badly and is liable to fine surface cracks. It seldom grows to large enough sizes to make a good building timber.

From an extract we learn that *lantana*, a garden escape, which in North Queensland has become a pest, is being exterminated by the introduction of a bug from Hawaii. It is well known in India; "a flowering shrub with small yellow, orange or purple flowers," describes it well enough to those who know it, but not its name.

Another interesting topic discussed is that of the "viability" of seed. The *Scientific American*, while discrediting the tales of the germination of mummified wheat from Egypt, quotes the growing of lotuses from seed covered in a peat bed for 300–500 years.

Mr. Tara Singh gives a list of 31 words and phrases used by *mahouts* and understood by their elephants. Many of them are Hindustani but some seem to be peculiar to drivers of elephants.

Lastly, comes a brief account of a fight between a tiger and a wild boar, in which the latter was killed. The victor was in turn vanquished by a second tiger which had meanwhile come on to the scene. Both combats were witnessed by two villagers, who had thoughtfully occupied gallery seats in a neighbouring tree.

(*November*, 1939).—"Can Bengal claim compensation for her floods?" is the title of an article by Mr. Y. S. Ahmad. Of recent years the Gangetic plain has been devastated by terrific floods, which not only render the Bengal Government liable to the expenditure of vast sums in relief, but add an increasing layer of barren detritus to once fertile soil. The cause, the author argues with reason, is the improvident means of cultivation in the foothills of the Himalayas, which leads in the course of a very few years to barren hillsides, which will not retain moisture, but allow it to rush off headlong to the plains. The remedy, as all will agree, is legislation to stop this wasteful destruction of soil. But it must be remembered that for the most part the foothills lie in independent or semi-independent States, such as Nepal and Bhutan, and it is probably very difficult for the Government of India to obtain effective co-operation from the rulers of those countries.

"Markal" is a paint in stick form, an American invention, described as a useful way of marking trees, etc., avoiding the use of pots and brushes.

There is little in text-books on the strength of bamboo. Here are some figures quoted from the *Engineer*, based on experiments in China. A hollow section, 1 ft. long, 2½ in. diameter, with walls ¾ in. thick, supported a weight of 15,050 lb. Ultimate stresses are given as follows:—

Compression	5,500 lb. per sq. in.
Tension	13,000 lb. per sq. in.
Shearing	450 lb. per sq. in.

Bamboo ropes 250 ft. long and 21 in. in circumference have been used in Western China for the construction of a suspension bridge 9 ft. wide; not a single nail or piece of iron was used in its construction.

(*December*, 1939).—The dryage of timber, *i.e.*, loss of weight during storage, sometimes comes up in a sapper's experience. The results of experiments carried out on the drying of *sal* are as follows:—

	Loss of weight per cent. billets	Loss of weight per cent. split wood
Felled in winter	44.8	39.7
Felled in summer	23.9	24.7

Some similar figures relating to *alder* are given in *The R.E. Journal* for September, 1935, reviewing an article in the *Indian Forester* of May of that year.

"Forests and Rural Welfare," and "Oil from Meconopsis Seeds" are articles worth reading.

We learn also that lectures on German forests are given to students and others by taking them in aeroplanes above the subjects of the lectures, an example which we well might copy from the enemy.

F.C.M.

THE MILITARY ENGINEER.

(*November–December,* 1939.)—*The Coast and Geodetic Survey. Its Part in the National Defence.*

Rear-Admiral Colbert describes the work carried out by the United States Coast and Geodetic Survey. Its activities in preparations for national defence are many and varied. In peace time, the Bureau supplies the Navy Department with over 100,000 nautical charts every year, while the Air Services of the Army and Navy utilized over 200,000 aeronautical charts.

Close relations exist between the Coast and Geodetic Survey and the Corps of Engineers in the Army. Its personnel, in its peace time activities, perform a field service which enables them readily to transfer to emergency duties in time of war.

Engineers in First Army Manœuvres at Plattsburg.

Colonel R. T. Ward gives an account of some of the work carried out by the Engineers in the First Army Manœuvres. Preparatory work started in February, 1939, and consisted of such work as roads and bridges, water supply, both for drinking and bathing, and the construction of ramps for railheads. A complete set of maps was printed.

The actual manœuvres took place in August. The Engineer strength was about 2,478, approximately 5% of the total strength of the entire force—too small for independent operations. The main engineering operations consisted of bridging, *i.e.*, a trestle bridge, a pontoon bridge, a foot- and assault-bridges across the Saranac River.

The manœuvres were held on a large scale; they involved hard work and proved very instructive.

Bridge Construction in the New England Hurricane Area. By Colonel L. E. Moore.

On September 21st and 22nd, 1938, New England was visited by a tropical hurricane, and at the same time floods took place in Massachusetts. Five hundred and fifty-two highway bridges were damaged or destroyed. The renewal of these structures was entrusted to six engineering organizations, of which the writer's firm was one.

The article describes some of the work carried out, in particular the construction of a new bridge over the Chicopee River, of four equal spans of deck plate girders of approximately 100 feet each, to replace a bridge that had been completely carried away. The new bridge was opened to traffic five months after the flood.

The Corps in the Days of the Revolution. By Major W. F. Heavey.

An account of the early days of the Corps of Engineers in the United States, with special reference to their services in fortifying West Point in 1777, and in the siege of Yorktown in 1781.

A District Looks at Safety.

Captain Matthews draws attention to a number of points that will ensure greater safety for workmen. He explains that the purport of his article is the cold-blooded one of preventing accidents which would otherwise increase Government costs. Put briefly, accidents may be avoided and safety achieved in an engineer district by a campaign having the following general features:—

1. Intensive and unremitting education of all personnel in safe working methods.
2. Ruthless elimination of unsafe personnel, practices, equipment and conditions.
3. Continual and efficient supervision to maintain safety.

General A. Uses Smoke.

Lieut.-Colonel J. A. Dorst describes a dream in which he had an interview with General A., who explained the value of smoke in warfare, if used at the right time and in the right way.

It is Time to Insure against War.

A leading article stressing the importance of insuring against war by having the necessary fighting strength to prevent it.

The writer states :—" England is at war with Germany; we have a Monroe " doctrine which forbids transfer of land in the Americas, and we will fight for it. " If Germany wins this war, she may conclude a peace which may ruin England, and, " unless our army is large enough to deter her, she may demand that England give " her Canada or the Bahamas or both, and that will mean war with us. So we " know just what are the requirements of our problem***In round numbers it appears " that the War Department has asked for an army of about 750,000 men."

War Notes.

A brief note on the first events of the war, dealing mainly with the campaign in Poland.

The Engineer R.O.T.C.

Captain D. A. Morris, a regular Engineer officer, points out that everything should be done to encourage the Reserve Officers' Training Corps, which is recruited from students in engineering colleges. He gives a schedule of the courses of instruction, and makes a variety of suggestions for making the Corps more popular. It is pointed out that membership of the R.O.T.C. will be of definite assistance professionally in after life.

Historic Panama. By R. Z. Kirkpatrick.

A brief history of Panama from its discovery by Columbus onwards. The history is divided into three periods :—

Period of Discovery and Conquest ...	1502–1550.
The Great Trade Period	1550–1855.
Modern and Transportation Period ...	1855–1939.

It is interesting to surmise what might have been the history of Panama if it had not been for a mistake in Ptolemy's map, which showed that China and Japan were about 1,500 miles from Europe. Would Columbus have ventured to try to reach China, if he had known that the distance *via* the Cape of Good Hope was 13,000 miles, and that *via* Cape Horn 17,000 miles?

Military Lessons from the Chinese-Japanese War. By Captain C. Rodney Smith.

From the very beginning China surprised Japan—and the rest of the world—by exhibiting a degree of unity never before achieved in her long history. The new unity had its origin when Dr. Sun Yat-sen founded the Nationalist Party. After his death in 1935, party control was soon gained by Chiang Kai-shek, a former protégé of his.

When the Japanese occupied Manchuria in 1932, the Chinese will to resist had been greatly encouraged by the sudden realization that the Japanese Army was not entirely the invincible force it had been reputed to be. Having dominated Manchukuo, Japan next turned her attention southwards. Chiang Kai-shek manœuvred to postpone direct resistance until China might have a better chance to win; in the meantime he prepared his people for the inevitable contest.

In 1937 Chiang Kai-shek and the Communists joined forces, and in July of that year, following a clash between sentries near Peiping, Japan began a systematic invasion of China. The subsequent operations are described in detail. Some interesting lessons emerge from them.

The Chinese engineers had prepared strong defences in the narrow Nankow defile. In August, 1937, the Japanese launched furious frontal attacks against these defences. The Chinese maintained a determined resistance until the Japanese turned their flank. The Chinese made the mistake of not providing sufficient depth, and not protecting adjacent flank approaches. This erroneous system of Chinese fortification appears again and again throughout the war. Their engineers knew details of fortification, but lacked knowledge of strategic defence.

To avoid capture, the Chinese abandoned the pass, dynamited the railway tunnels, and eluded capture by retreating to the south-west. Two weeks elapsed before the Japanese could utilize the railways running through the tunnels. It is interesting to note, by way of comparison, what might have happened in 1914 if the Belgian engineers had similarly wrecked the tunnels at Liège.

The Chinese were skilful in the use of inundations when opportunity offered. Although they repeatedly made the mistake of allowing the Japanese to outflank them, they never permitted the enemy to cut them off, but always succeeded in extricating their main body.

With all their superior equipment, training and organization, the Japanese failed to bring the war to a successful conclusion, and the issue still hangs in the balance.

The Military Geographic Institute of Colombia.

Dr. Wilches gives an account of the work done by the Military Geographic Institute of Colombia during the 2½ years of its existence. Survey work in that mountainous country is extremely difficult owing to lack of communications.

The Materials Corrosion Investigation at Eastport. By D. F. Horton.

Since 1936, tests have been made of ferrous and non-ferrous metals and alloys exposed to the action of sea water at Eastport (Maine). The results are carefully watched and tabulated. A certain chrome-nickel steel, designated No. 110, has yielded far better results than other types. Whereas some chrome-nickel steels showed heavy losses through pitting, No. 110 showed no evidence of pitting, and appeared, after two one-year periods of exposure, to be as good as new.

A.S.H.

ANNALI DEI LAVORI PUBBLICI.

The Assab–Addis Abeba Motor Road.

The issue for September, 1939, contains an interesting account of the construction of the Assab–Addis Abeba motor road, recently completed, connecting the port of Assab, on the Red Sea, with Addis Abeba, the capital of the Ethiopian Empire.

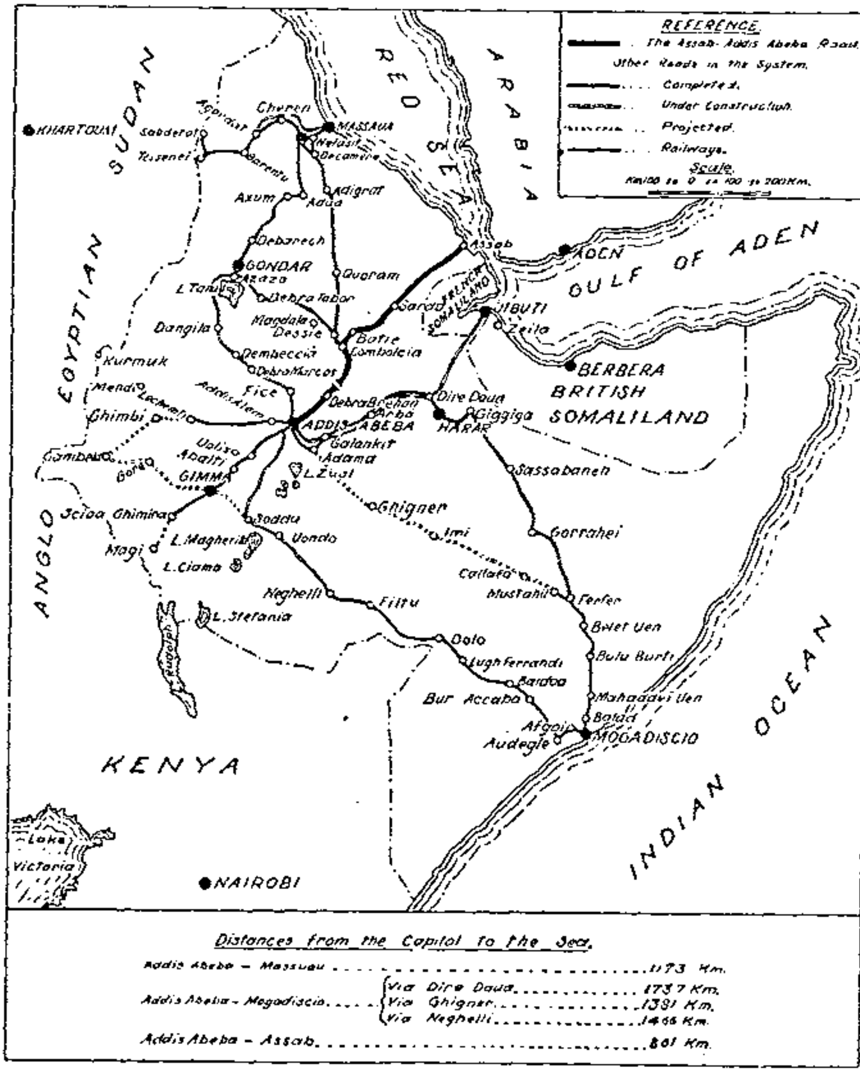
Signor Gigli, Minister for Public Works, has written a preface to the article, which has been compiled by Signor Giuseppe Pini, an experienced engineer, who supervised work on the road from the outset until its completion.

During the recent Abyssinian campaign the Italians used Massaua as their base, and constructed a road from there *via* Nefasit and Decamere to Addis Abeba, a distance of 1,173 km. The distance from Addis Abeba to Mogadiscio, on the Indian Ocean, is considerably greater than this. There are several advantages, both for strategic and other reasons, in having the main approach to the capital of Ethiopia from the Red Sea in preference to the Indian Ocean. The nearest suitable harbour on the Red Sea to Addis Abeba is Assab. The distance is only 861 km., a saving of 312 km. on that to Massaua, and the alignment across the Danakil (Italian: Danaclia) plateau avoids the steep gradients, rises and falls, and sharp curves on the Massaua road.

The new road from Assab to Addis Abeba, which was opened to traffic in July, 1939, has no gradients steeper than 7% (as against 10% on the Massaua road); the roadway is 9 metres wide, with a tarred width of 7 metres. Lorries with trailers can carry twice the load that it is possible to carry on the Massaua road. The cost of goods carried to Addis Abeba has been halved; the length of the journey for passengers has been reduced from 4 to 1½ days.

The Jibuti Railway, completed in 1917 by the French company in control at the present time, is now almost disused and cannot compete with the new motor road. It can only carry 300 tons a day, whereas the requirements during the first year of the war averaged 3,000 tons, and now amount to 1,500 tons daily. According to the writer, the railway has always been run on anti-Italian lines. It was used before and during the war to supply the Negus with arms and munitions in his struggle against Italy, and since then an obstructionist policy has been followed by neglecting

THE ASSAB-ADDIS ABEBA MOTOR ROAD IN THE SYSTEM OF MAIN COMMUNICATIONS OF THE ITALIAN EMPIRE.



essential improvements. Had Jibuti been in Italian hands, the port would have been extended and improved, the railway would have been put into a state of efficiency, and new rolling stock would have been provided.

Shortly after Marshal Badoglio's arrival at Addis Abeba in May, 1936, a plan of road construction was sanctioned by the Duce for the construction of nearly 3,000 km. of new roads and the improvement of 400 km. of existing roads. This plan, to be carried out in three years, included the new road from the capital to Assab. Signor Gigli, Minister for Public Works, took charge of the plan in October, 1936, as soon as the rainy season was over.

In selecting the alignment, the only obligatory point was the junction of the Danakil road (from Assab towards Dessiè) with the Road of Victory (Massaua-Addis Abeba). Dessiè is an important commercial centre on the eastern edge of the high Abyssinian table-land.

Starting from Assab in the direction of Dessiè, there was an existing track that extended as far as Sardò across the basaltic formation of the Danakil plain, a distance of 315 km. Beyond Sardò, for a stretch of 227 km. there was no trace of any track, either in the plain or on the mountain slopes, until Batiè was reached, the first inhabited spot since leaving Assab. Caravans from French Somaliland follow the bed of the Auasac river.

The Danakil plain has been formed geologically by the settlement of the Ethiopian table-land to a depth of 2,000 metres. The edge of the table-land is marked by a deep geological fault.

The first reconnaissances of the route were carried out by air. Obligatory points were selected, and a rough track was cut on the approximate alignment.

For the execution of the work the route was divided into three sections, and each was allotted to a separate firm of contractors. The sections were (1) Assab-Sardò, (2) Sardò–As Comà, (3) As Comà–Combolcià-Addis Abeba. The central section was the most difficult from the point of view of access, supplies, and climatic conditions.

In organizing the work, it must be remembered that all material, other than stone, had to be imported from Italy, and that transport presented enormous difficulties. The Jibuti railway proved almost useless; for the inland sections it had to be abandoned in favour of transport by road from Massaua. Labour had to be recruited, but, in the intense heat of the Danakil plain neither Italians nor Abyssinians could work, and labourers had to be imported from Yemen and the Sudan. Italian masons were employed on bridge building in the highlands. All labour had to be specially housed and fed.

The time for completion of the road was cut down from 3 to 2½ years by the Duce's orders. This did not make things easier. Enough work to ensure through communication along the selected alignment was completed early in 1937.

Scarcity of water was one of the greatest difficulties that had to be contended with. Pipe lines and water-posts were established, but during the dry season there was only one water-post between Assab and Sardò, at a distance of 30 km. from the former and 285 km. from the latter place. Up to 260 tons of water had to be carried daily an average distance of 130 km.

The construction of the road across the Danakil plain was a source of friction with the French, who (it is stated) thought that the road was only a paper project designed to get more favourable tariffs on the Jibuti railway. They also maintained at one time that the road was being built on their own territory. The Italians, however, felt sure of their own ground and carried on.

One of the most important works on the road was the construction of the Termaber tunnel, 586 metres long. The tunnel is 8 metres wide, 7 metres high in the centre, and has a 2% upward gradient towards Addis Abeba.

By the end of July, 1939, the whole length 861 km. between Assab and Addis Abeba was open to traffic, and only a stretch of about 50 km. remained to be treated with bitumen. Extensive developments were made in the port of Assab.

The writer next gives a detailed description of the road. The text is illustrated by 68 excellent photographs. The first portion of the road across the Danakil plain presents no special engineering difficulties beyond those of crossing a region of basaltic rock without a scrap of vegetation, except for a few days after the rainy season, and almost entirely devoid of water. Curves and gradients are easy, and there are few bridges of any size. In this portion the heat was so intense that most of the work was done by imported Sudanese labour.

Sardò, 248 km. from Assab, was the headquarters of the first section. Here were grouped the contractors' work and repair shops.

Beyond Sardò a number of river-beds had to be crossed; some of the largest and finest bridges on the road are to be found here.

The Jeromè river (378 km. from Assab and 600 metres above sea-level) marks the end of the Danakil plain. From this point the rise begins that continues up to the highlands. As the road rises, vegetation increases, and the scenery becomes more imposing.

At Combolcià (km. 485 and an elevation of 1,922 metres) the road strikes the Massaua-Addis Abeba road, which it follows as far as the capital, 376 km. distant. About half-way between Combolcià and Addis Abeba the road passes through the Termaber tunnel, already mentioned. A short distance beyond the Termaber the road reaches its highest point, 3,178 metres (10,726 ft.) above sea-level. From this point there is a gentle downward gradient to Addis Abeba, 2,445 metres (8,252 ft.).

Significant figures are quoted to show the large scale on which the work was carried out. There were 76 store depots, with 270 masonry buildings, and 454 others of a temporary character. A length of 121,000 metres of tramway was used, with 50 locomotives, 2,040 trucks, 1,148 motor vehicles, 120 motor compressors, 222 stone crushers, 142 steam rollers, 45 concrete mixers and 49 tar sprayers.

One hundred and thirty-two major bridges were built with spans exceeding 10 metres; there were 2,851 minor bridges and four tunnels (one of them 739 metres long).

The cost amounted to 675 million lire for the Danakil road (Assab to Combolcià), and 580 million lire for the Victory road (Combolcià to Addis Abeba), 1,255 millions all told. The cost per km. works out to 1,392,000 lire for the Danakil road, and 1,540,000 lire for the Victory road, averaging 1,457,000 for the whole road.

The high speed at which vehicles can travel over the road dispels the feeling of the intense heat in the plains, while the change to the cooler regions of the highlands is so gradual that it produces no discomfort. At every 50 km. living accommodation is provided for Italian overseers, who supervise the native maintenance gangs. These houses also serve as rest-houses for travellers.

The construction of the road will be of the greatest value in the development of the country. Encouragement is given to Italian settlers by granting them concessions in the highlands. Water courses have been regulated, swamps have been drained, and the reclaimed soil is used for the cultivation of cotton. A great future is anticipated for Italian colonists in years to come.

A.S.H.

RASSEGNA DI CULTURA MILITARE.

(*October*, 1939.)—*Le risorse economiche dei paesi mediterranei.*

General Deambrosis concludes his study with this instalment. He has worked out a graph showing what he calls the "demographic rhythm" of four European powers: Britain, France, Italy and Germany. In recent years the excess of births over deaths is given as follows:—Italy 9%, Germany 7%, Britain 3%, France −0.5%. From this we are led to infer that Britain and France are, more or less, at a standstill with regard to their development, and that the younger nations: Germany and Italy (and he would also include Spain) are at the beginning of a period of expansion.

Conrad von Hötzendorf e l'Italia.

Lieut.-Colonel Tosti gives a short account of the career of Field-Marshal Conrad von Hötzendorf. After a distinguished service, both on the staff and in command of troops, Conrad became Chief of the General Staff of the Austro-Hungarian forces in 1906. Except for a break of about a year in 1911–12, he continued to hold the post of

Chief of Staff until 1916, but, after the death of the Emperor Francis Joseph, he was replaced by General von Arz, and appointed to the command of the Tyrol Army Group.

The writer maintains that Conrad was actuated throughout his career by an intense hatred of Italy, but was a loyal and devoted servant of the Habsburg dynasty. He holds him responsible for the failure of the Piave offensive in June, 1918, after which his active career came to an end.

La guerra in Europa. By Lieut.-Colonel Blatto.

This is the first instalment of an account of the European war. The writer describes the origin of the war, for which he lays much of the blame on the Versailles Treaty and on the failure of the League of Nations. Italy decided, on the 1st September, to take no initiative in military operations, and so partially restricted the zone of hostilities.

Colonel Blatto discusses the relative strengths of the four conflicting powers (the article was written in September) and concludes that:

The opposing land forces are numerically equal.

The Franco-British naval forces are superior to those of Germany, which has superiority in the air.

We next get a brief description of the operations in Poland, and of those on the western front during September, as well as of the naval operations. The Allies state that they are prepared for a three-years' war; the Germans say they can carry on for ten years!

Iacomo Fusti Castriotti. Architetto Militare e Inventore. (1501–1562.)

Professor Provasi concludes his article on this great master of fortification. Castriotti's greatest work was the fortification of Calais, but here he was not given the credit that he deserves. Foreigners, especially the French, have failed to acknowledge their debt to Italian military engineers for the great advances made in fortification during the sixteenth century. Vauban copied many of his works from those of Michelangelo. In the defences of Calais, Castriotti adopted a defensive plan which is known in modern text-books by the name of the second and third order of Vauban.

A.S.H.

REVISTA GENIULUI.

(October, 1939.)—*Instruction of helmsmen and rowers.* By Lieut. V. Hoara. The writer introduces the subject with the sentence:—"Instruction on the water is very pleasant, but also presents many difficulties."

He describes the following method of teaching beginners to handle boats, without making conditions too artificial.

1st day.—Boats moored to the bank. Men practise embarkation and disembarkation, and the handling of oars. Time required: 4 hours.

2nd–4th day.—Drive a picket on one bank of the river. Drive a second picket, 40 to 50 metres distant on the opposite bank. (If the river is too wide, anchor a boat at the requisite distance from the shore.)

Stretch a cable between the two pickets.

Attach the required number of boats to the cable by their painters. The painters should each be taken round a picket on the bank, so that the boats may be moored inshore and readily cast off when the men have embarked.

Three days should be spent in rowing the boats thus attached.

5th day.—Putting out and coming in to shore with unmoored boats.

6th day.—Rowing and steering in unmoored boats.

7th day.—Crossing the river.

J.V.D-H.

R.E. WAR COMFORTS FUND.

A War Comforts Fund has been formed for the provision of comforts for Warrant Officers, N.C.O's and men of the Corps who are serving with the British Expeditionary Force and for Prisoners of War; this Fund to be administered by the Royal Engineers Old Comrades' Association.

2. The wives and other relatives of all ranks are invited to assist the Fund and with that object a Ladies' Committee has been formed, under the Chairmanship of Mrs. R. P. Pakenham-Walsh, for the purpose of co-operation with the R.E.O.C.A.

3. Assistance may be rendered to the Fund as follows:—

(*a*) By the making up of woollen articles of which the troops are most urgently in need, or

(*b*) By the purchase of such articles ready made, or

(*c*) By subscriptions to a Cash Fund which has been instituted in order to cover the cost of postage, purchase of wool and other materials, and the purchase of tobacco, cigarettes and other comforts.

4. It is requested that the articles as in para. 3 above be sent to The Honorary Secretary, c/o R.E.O.C.A., 8A, Lower Belgrave Street, London, S.W.1., subscriptions being made either by cheque, money order, or postal order, payable to "The R.E. War Comforts Fund."