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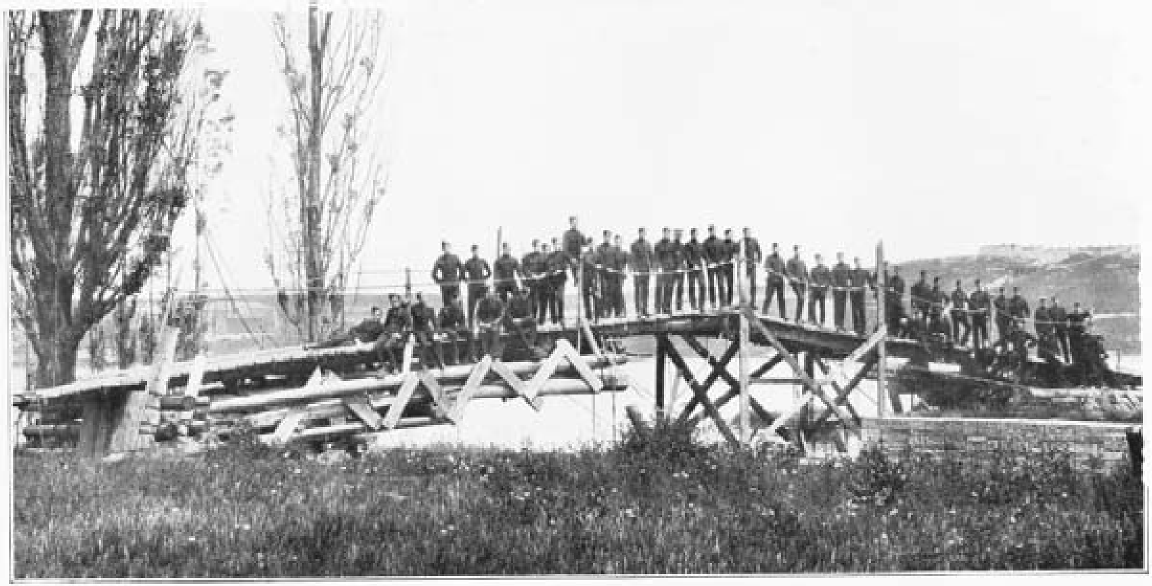
CANTILEVER BRIDGE, 80 FT. SPAN.

Constructed by Cadets at the R.M. College, Kingston, Canada.



(1). The left anchorage consisted of a tree and posts in the ground, as described in para. [illegible], "Details of Construction."
(2). The bottom of the central girder (para. [illegible]) is hidden in the photo by the foreground.
(3). Owing to different levels of banks the highest point of the bridge is to the left of the central girder.

CANTILEVER BRIDGE

CANTILEVER BRIDGES.

A COMPARISON WITH OTHER SINGLE-SPAN TYPES, WITH NOTES ON CONSTRUCTION AND CALCULATION.

By CAPT. E. N. MOZLEY, R.E.

ENGINEERS who study economy of construction in time and material know well that bridge spans should be as short as possible down to a certain limit; in other words, wherever two points have to be connected with a bridge it is generally advisable to have many intermediate points of support. This applies especially to military engineering, where the materials and means of erection are of a somewhat improvised kind, and are usually unsuitable to any ambitious designs.

COMPARISON OF CANTILEVER BRIDGES WITH OTHER SINGLE-SPAN TYPES.

Let us take a brief survey of the types of military bridges; there are six of these, viz. :—

(1). Frame.
(2). Suspension.
(3). Girder.
(4). Trestle.
(5). Floating.
(6). Cantilever.

For the reasons we have stated the Trestle and Floating types supply a large majority of the bridges actually built both in war and peace. The other bridges, being single-span, may be looked upon as necessary evils, and, interesting as they are to construct, military engineers should beware of spending overmuch time on their practice to the exclusion of the more usual kinds.

But single-span bridges have not infrequently to be built, and therefore the respective merits of the four general types of these bridges should be studied and compared.

Frame Bridges.

To take the Frame Bridge first. These ingenious devices have for a very long time occupied an honoured place in our text-books and the writer therefore feels a certain reluctance in attempting to dethrone them. Iconoclasm, however, has its use in the world if progress is to be made; and at the risk of meeting with considerable dissent the objections to the "engineer's substitute for an arch" will be arrayed.

The example most usually quoted of the use of lock bridges is in the case of a broken arch of a viaduct. Very few engineer officers at present serving can have had experience of this case, although instances are quoted in Douglas's *Military Bridges* as having been met with in the Peninsula.

The difficulties of such a work must be great. The arch will have been destroyed by explosives, resulting in an irregular section with probably extremely friable faces. The footings will very likely have to be at different levels, even on the same side, and the probability of an irregular lock will be much enhanced. Moreover, as will be

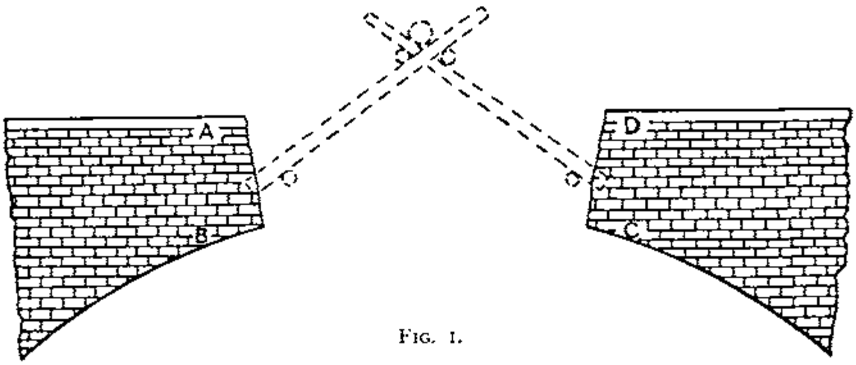


FIG. 1.

seen in *Fig.* 1 (the parapet wall being omitted), unless the depth from A to B is considerable compared with the span BC, the lock will be high above the level of the roadway AD. This will involve a ramp up in the case of single and double-lock bridges; and even in the case of sling bridges the transoms supported on the frame legs are likely to be inconveniently high.

But the chief objection to this form of construction is the probable difficulty and time involved in cutting out the footings. If the broken section AB is nearly vertical, the bricklayers or masons may well be dangling in front of the broken faces for hours, while the rest of the army looks on.

It will be remembered that the great bridge over the Tagus at Alcantara, where the gap was of this kind, was spanned by a ramp suspension bridge. The span was 100 feet, and this method could therefore be used wherever frame bridges are possible. Probably, however, for any ordinary broken arch either long beams (scarfed if necessary) laid across small gaps, or a cantilever bridge for longer spans, would be the quickest and by far the simplest method. If, however, a cantilever bridge were built in such a position it would be necessary to place the shore transom far enough back from the edge of the gap to prevent any possibility of the great pressure on that transom breaking down the arch again.

Under what other circumstances would lock bridges be used? Scarcely any that can be imagined. Small gaps with vertical sides occur rarely in nature. The sides will probably slope, and rarely at a steeper angle than 45°. Nor will they run together in the form of a **V**, but the bottom will probably be horizontal for a fair proportion of the span. The depth, therefore, below shore transom level will rarely exceed 15 feet for a 45 feet span. In such cases a trestle bridge will almost always be preferable to a single or double-lock. No very rapid stream is likely to run through such a gap, and the other obstacle to trestle bridges, viz., mud, can be overcome with ease.

The case against lock bridges has been considered. It rests mainly on the contention that, for all gaps except broken arches, trestle bridges could be and would be used; and that in the case of broken arches the difficulty of the footings for the frames will probably be so great that a simple span of road-bearers or a cantilever bridge would be quicker and easier to build.

The case against sling bridges rests on three points. Firstly the excessive time taken to construct them, secondly the necessity of careful workmanship, and thirdly the exceptional length of spars necessary compared with the span.

As regards time. The text-book, which employs workmen whose skill is the admiration of every practical student of the art of bridging, requires

160 man-hours to construct a 50-ft. frame bridge.							
240	,,	,,	,,	,, 60	,,	,,	,,
336	,,	,,	,,	,, 70	,,	,,	,,

Each 10 feet extra span therefore adds apparently 50% to the time.

The writer has constructed with Cadet labour an 80-ft. cantilever bridge in 625 man-hours. With Sapper labour this could be reduced by one-third, to 417 man-hours. Will a Field Company R.E. put up a treble sling bridge over an 80-ft. gap of ordinary difficulty in this time? No doubt, if the eyes of the Corps were on them, they would achieve as abnormal results as did the Spectator Experimental Company when every illustrated paper contained its portrait. But we can scarcely hope for such results on an ordinary fieldworks course. Moreover we must allow for the fact that these bridges not infrequently refuse to lock. The risk is undoubted, and accuracy of measurement and careful workmanship are accordingly essential. These are the very qualities which might almost be termed unimportant in cantilever bridges.

Length of spars too is a serious drawback. 50-ft. logs, 13½ inches at the centre if unselected, are needed for a 70-ft. span. A cantilever bridge of the same length, with a 20-ft. central gap and the anchorages 10 ft. back from the shore, could be constructed with 37-ft. spars, which need not be especially stout if enough of them are to be had. It is true no doubt that cantilever bridges require a great many logs; but where four such big logs as those required for the treble sling bridge are obtainable, it is pretty certain that a great many smaller ones could also be procured.

Suspension Bridges.

Such are the reasons for considering frame bridges as of small practical use. No engineer would make such an accusation against Suspension Bridges. These alone supply to the military engineer the means of spanning big gaps. The civil engineer, who has at his disposal every resource of machinery, with which the field engineer has scarcely any acquaintance, can utilize steel. He can erect girder and arch bridges of no mean span and cantilever bridges which continue to hold the world's record. *Our* only means of employing steel, however, is in the form of chains and cables, though with what excellent results has been shown in Chitral and Gilgit.

While however it is acknowledged that for long spans suspension bridges have neither an equal nor a second, yet for smaller types, between 50 ft. and 120 ft., they not only take rather longer time than might be expected but are also distinctly unsteady. It is only when the weight of a bridge is large compared with that of the usual traffic that this unsteadiness begins to disappear.

Suspension bridges moreover require cables (or else time and wire to make them) and also careful workmanship. Their principal rôle is undoubtedly to span big gaps.

Girder Bridges.

The question of Girder Bridges has scarcely received from the Corps the attention it deserves. These bridges have one great merit, which no other, save perhaps floating bridges when swung out, can claim; they can be constructed in secrecy and then launched with great speed. This quality alone should give them a place in every text-book. They are also very stiff. Their chief disadvantage is the necessity of careful construction.

As regards time the following information will be of use:—An 80-ft. girder bridge (both girders being braced together before launching) was built by Cadet labour in 296 man-hours. It was launched under circumstances of exceptional difficulty,* which could scarcely have occurred on service, in 400 man-hours, and the bracing and roadway completed in 90 man-hours. On ordinary occasions the time required for launching could easily be halved, and such a bridge could be completed from start to finish in 600 man-hours of Cadet labour, which is about equivalent to 400 man-hours of Sapper labour. The actual work done under the eyes of a possible enemy, viz., the

* The whole girder had to be lifted lengthways over an old cantilever anchorage, protruding 2′ 6″ above ground, which it was not desirable to remove.

launching and completion of the roadway, would probably not take more than 3 hours, if Sappers were employed: this point might of course be of vital importance.

It is not proposed to discuss further in this article the suitability of girder bridges. Their details and the arrangements for launching call for a professional paper. The conclusion arrived at by the writer is that, except where secrecy is of great importance, the type would rarely be chosen, but that for secrecy they are unequalled.*

Cantilever Bridges.

Having briefly surveyed the characteristics of its rivals we will consider those of the Cantilever Bridge. This type is pre-eminent in certain respects. Nor can it be said to have any decided disadvantages for the spans for which it is adapted.

The great merit of cantilever bridges is their simplicity. They are simple in material, simple in construction, simple in adjustment. If the necessary timber is to hand they can be built quickly; and their strength need never be called in question. In no other bridge is it so easy to insure against failure. It is but a question of adding more logs, or more wire to the anchorage, or of digging the anchor trench deeper. In cantilever bridges the strength depends scarcely at all on workmanship. In trestle and suspension bridges it depends on it very greatly, in frame and girder bridges absolutely.

The chief disadvantage urged against the cantilever bridge is its shakiness in long spans. This defect is very evident if the bridge is built in its simplest form. But if a little extra material in the shape of nails and wire can be got, it is easy to make cantilever bridges practically as stiff as those of frame or girder construction for equal spans. These means will be investigated later.

To sum up. Of the four main requirements for a military bridge, viz.,

Strength (including stiffness),
Speed of construction,
Simplicity—(i.) of material, (ii.) of workmanship,
Secrecy,

the cantilever excels the other three single-span types in all but secrecy; in secrecy the girder is pre-eminent. It is probable therefore that the cantilever bridge is generally the best for spans between 40 ft. and 120 ft., unless secrecy is essential. For longer spans than 120 ft., no other type except the suspension is available for military engineers.

* A girder bridge might be the only possible one for a single span, if the only material available consisted of the small scantlings of a builder's yard.

CONSTRUCTION OF CANTILEVER BRIDGES.

DETAILS OF CONSTRUCTION.

1. *Centre Line.*

Accurate longitudinal alignment of the layers of cantilevers is important, and will give trouble if not attended to. Lay out the centre line of the bridge with marks clear of all construction, *i.e.* beyond the anchorages on each side, and refer to them constantly.

2. *Levels.*

(*a*). In long cantilever bridges several layers of stout logs are necessary. These give considerable depth to the bridge at the abutments. It is necessary, therefore, either to excavate deep seatings for the cantilevers at the abutments, if the roadway level is to be kept flush with the ground; or to keep all the cantilever logs above ground on shore, and build up an earth or trestle ramp to the bridge at each end. The latter method is generally preferable as it takes less time and can be carried on concurrently with the construction of the bridge.

(*b*). A steep camber is desirable for four reasons :—

- (i.). The usual one, *i.e.* to check traffic coming on to the bridge and facilitate its landing on the far side.
- (ii.). Because cantilevers dip a good deal at their ends under a load.
- (iii.). Because shore transoms are liable to sink unless the ground at the abutments is hard; and if the shore transom sinks a little the centre of the bridge will drop a good deal.*
- (iv.). In order to reduce vertical oscillation in the centre. This is explained below under the heading of "Stiffness."

(*c*.). No great accuracy of levels is required, as any discrepancy can always be adjusted by adding extra transoms or blocks between the layers. Treble transoms, made up of two logs side by side with one above them, have been used on occasions between the layers of logs.

(*d*). While the anchorages are being prepared and the logs brought up, parties should be employed in scarping the ground between the anchorages and the shore transoms to the proper slope, to give camber to the lowest layer of logs.

* A cantilever footbridge of 60 ft. span was built by the writer with the shore transoms on marshy banks. After two years this bridge was found to have sunk till it resembled a ramp suspension bridge. Its camber was restored by bestriding the centre of the bridge with a pair of sheers, raising it with heavy tackle, and packing up under the shore transom. With a deep gap this of course would not be practicable.

A crib platform should be built under the shore transom, if the ground is soft.

3. *Methods of Anchoring the Shore Ends of the Cantilevers.*

There are three ways of doing this :—

(*a*). As practised on the Indian frontier, *i.e.* by piling earth or stones on the shore ends as a counterweight. This method is rather primitive, as is indeed to be expected since no tools nor manufactured materials are used. Boards may be laid or nailed across the tops of each layer to give additional area for the material to bear upon.

(*b*). By excavating an anchor trench vertically below the shore ends of the cantilevers, and anchoring them down with wire to a sunken log at the bottom of the trench, which is afterwards filled in. This as a rule is the best way. The following points in connection with it call for notice :—

(i.). Make the bottom of the trench horizontal for a sufficient length and width, so that the anchor log may lie on the bottom and the whole depth of the trench be utilized.

(ii.). The holding-down ties may be from four to six in number, built up on the 'Aylmer' system* with composite wires. They should be made long enough to be secured with a round turn to the crosspiece above the shore ends of the *top* layer of cantilevers. But since in this case they cannot be made fast till all the cantilevers are in position, it is necessary to have in addition light 'construction ties,' made fast from the anchor log to a crosspiece below the shore ends of the lowest layer. Each crosspiece at the shore end, when placed, can then be secured by a few turns of wire to the crosspiece below it. The whole will thus be held down securely during construction, and the possibility of a slight rise of the shore ends and the consequent necessity for a readjustment of levels will be averted. When the top layer of cantilevers has been placed, the main anchor ties can be fastened to a crosspiece above them and tightly windlassed up.

(iii.). In filling in the anchor trench keep all the ties clear of earth and quite straight, or they will straighten later when the stress comes on them and the shore ends of the cantilevers will rise.

(*c*). The third method of anchoring down the shore ends is chiefly suitable for soft ground. It is as follows :—

Drive a series of piles into the ground on a line at right angles to the axis of the bridge, where the shore ends of the cantilevers will be.

* See "Notes on Bridging in Gilgit," by Major F. J. Aylmer, V.C., R.E., in the *R.E. Professional Papers*, Vol. XX., 1894.

Secure horizontal crosspieces to these piles, and let the shore ends of each layer of cantilevers rest underneath a crosspiece as in *Fig. 2.*

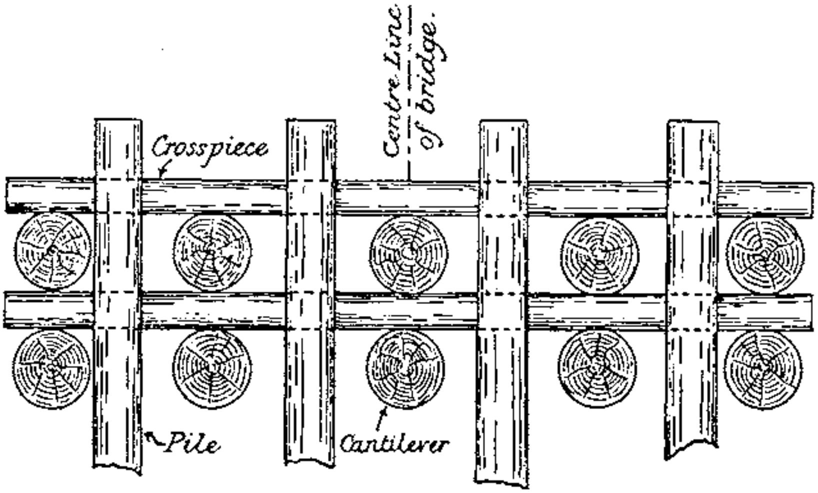


FIG. 2.
End view of bridge at anchorage.

The crosspieces may be fixed to the piles by halving or shouldering and spiking the crosspiece to the pile with dogs (which must be placed as nearly vertical as possible) or with wire lashings well frapped or windlassed up with nails.*

If there is a convenient tree on the site some of the piles on that side may be dispensed with. In such cases the crosspieces must be stout as they are subjected to a considerable upward cross-breaking stress.

An additional precaution to strengthen the connection between the crosspiece and the pile or tree is to spike a stout cleat above the former to the upright.

4. *Strength.*

(*a*). Avoid cedar or other poor woods for cantilevers.

(*b*). Paradoxical as it may seem it is generally correct to place the butts of the cantilevers outwards. The reason is that this usually gives a greater cross section where the maximum bending moment comes on the cantilever. The extra stress brought on the parts of the bridge by shifting the centres of gravity of the cantilever logs outwards is small compared to the increase of strength thus gained.

* The best way to tighten a wire lashing is with 6-in. wire nails, which are used to twist the returns of the square lashing at each corner where they pass from one log to the other. Frapping turns may be dispensed with if this is carefully done.

(*c*). Do not allow the cantilevers to extend more than a few inches beyond the outer crosspiece above them.

(*d*). Wedge up cantilevers where necessary at the anchorage or at the outer crosspiece on which they are supported. Also, where required, insert blocks between the cantilevers and the outer crosspieces above them. These wedges and blocks will insure crosspieces touching every cantilever and therefore that every cantilever takes a share of the weight. These wedges should be constantly examined while the bridge is in use.

(*e*). Cantilevers rest generally on two crosspieces, one at the anchorage and one at the outer end of the layer below them. Between these points there is, when the bridge is loaded, a tendency to reverse, *i.e.* upward, flexure. This may be met by inserting cross logs between these two points *above* the cantilever, thus bringing the stress on the layer above. The method of vertical diagonal bracing described below under the heading of "Stiffness" will more scientifically meet this tendency to upward flexure.

(*f*). Remember that there are three methods of adjusting the strength of a layer of cantilevers.

(i.). By adjusting the number of logs in the layer.
(ii.). " size of the logs.
(iii.). " overlap.

5. *Stiffness.*

The following methods have been adopted with great success in an 80-ft. bridge. The bridge when completed was as stiff under marching troops as a frame or girder bridge could be.

(*a*). Short pieces of boards were nailed in a diagonal position, but as nearly as possible in a vertical plane, from the cantilevers of each layer to those of the layers above and below. They were not only nailed to the outer cantilevers but to those in the middle as well. It is necessary therefore to fix these boards (or braces as they practically are) while the cantilevers are being placed, as it is difficult to get at the centre cantilevers when the roadway is on. (The photograph explains this bracing).

It is suggested that these boards serve to some extent the same purpose as does the bracing of a lattice girder bridge, namely that they tend to give the bridge the strength and stiffness of a single cantilever whose depth is equal to the total depth of the combined layers.

(*b*). Any play or slackness due to the stretching of the anchor-log ties can be removed by wedging up tightly underneath the lowest crosspiece above the anchor trench in order to keep these ties stretched. Such play is occasionally met with in small cantilever bridges, where the weight of the traffic is considerable compared to the weight of the bridge.

(*c*). The top layer of cantilevers, on which the roadway runs, is normally unsupported for a very considerable length. A large amount of direct and reverse flexure will therefore be experienced as the load crosses the bridge, unless this layer is

(i.). Supported by the layer below by means of crosspieces wedged between the two layers.

and (ii.). Held down by wire ties at intervals to prevent reverse flexure and oscillation when the central girder is loaded.

(*d*). The outer ends of the top layer of cantilevers on one side of the bridge may be connected to those on the other side with boards or logs securely fastened to them; by this means a most noticeable decrease of vertical oscillation is obtained. For this reason it is important to give a somewhat excessive camber to a cantilever bridge (the ramp may be as much as 1 in 12). It will then have some of the properties of an arch, and the timbers connecting the outer ends of the opposite top layers will act with greater effect in restraining oscillation, somewhat as does a keystone.

These connecting boards may easily form part of the central girder of the bridge, and will then rest on the crosspieces underneath the outer ends of the top cantilevers, in addition to being nailed to the latter.

(*e*). A truss under the central girder as in *Fig.* 3 has been tried. It should theoretically assist in preventing oscillation, but to what extent it does so is uncertain.

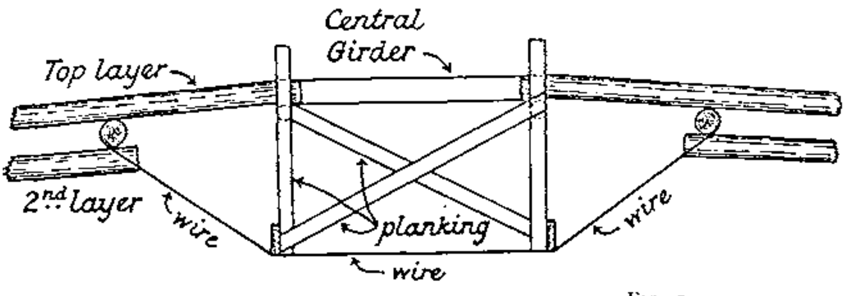


FIG. 3.

Of the methods described it was found that (*a*), (*d*), and (*c*) appeared to be most effective in the order named.

6. *The Central Girder.*

Roadbearers alone may be used to connect the opposite sides of the bridge at the centre; but it is better, if materials are available, to build up a couple of small braced girders of 20 ft. or 25 ft. span. These girders will not only decrease vertical oscillation by being firmly secured to the cantilevers at each end, but will also somewhat diminish horizontal sway by the use of horizontal cross-bracing.

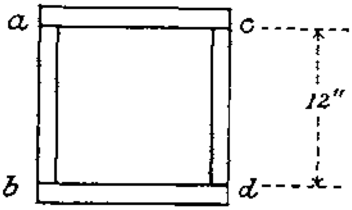


FIG. 4.

The girders may be of the section shown in *Fig.* 4, where *ab* and *cd* are two vertical planks connected at intervals by transverse vertical stiffeners and also by horizontal diagonal bracing above and below as *ac* and *bd* (see also *Fig.* 5). Composite planks may be used if necessary. The two girders themselves should be connected together with horizontal diagonal bracing.

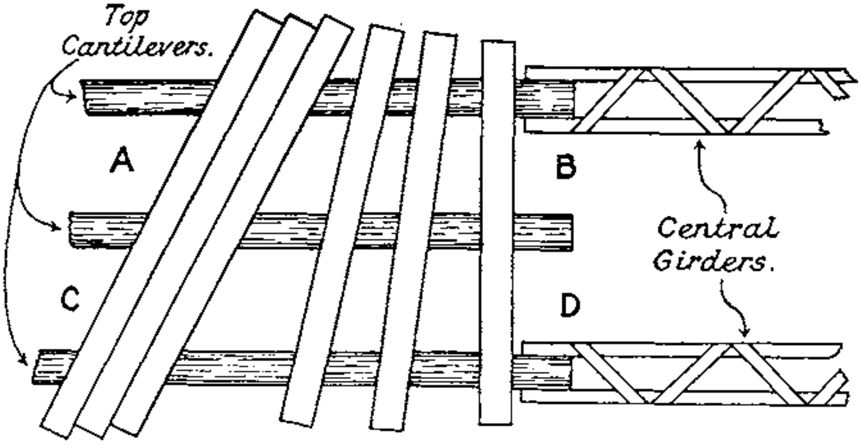


FIG. 5.

The girders, which play the double part of roadbearers and preventers of oscillation, should rest on the crosspiece underneath the outer ends of the cantilevers and be nailed to the adzed sides of the latter.

7. *Roadway.*

If the roadway is laid directly on the top cantilevers these must not be further apart than 2 ft. 6 in. centre to centre. They must be adzed smooth to get a level bearing for the chesses. The butts must also be adzed to get an even slope without a step on to the central girder.

If the roadway is a six-foot one and long planks are used diagonally, there will be difficulty where the camber changes, *i.e.* where the cantilevers meet the central girder. Perhaps the best way of arranging the chesses in this case is as in *Fig.* 5. Another layer of planks must be laid in the direction AB and CD to cover the spaces.

If the chesses are fastened down to the cantilevers without ribands, use wire, for wheeled traffic will cut cordage.

CALCULATIONS.

Very little is said in the text-books on the subject of calculations for cantilever bridges. The investigation necessary to ascertain the stresses is given below.

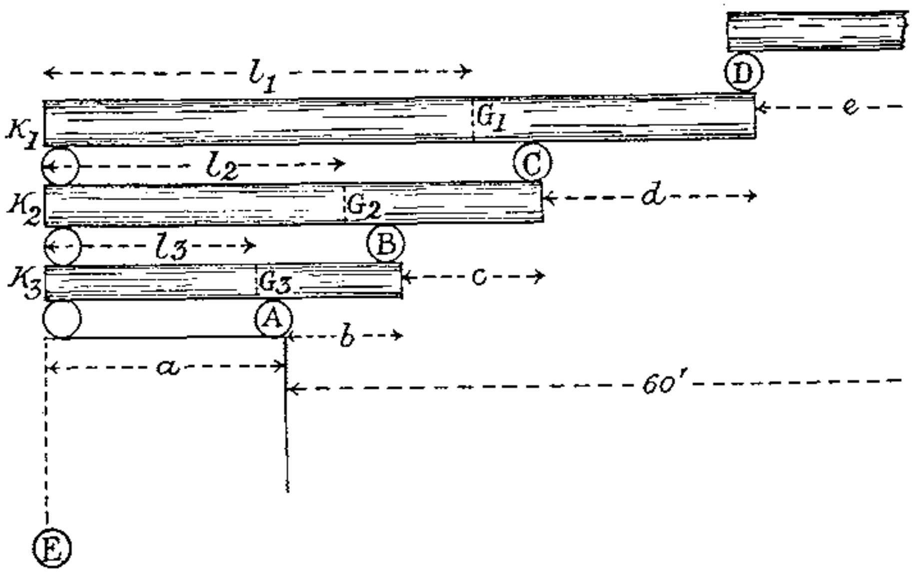


FIG. 6.

Elevation of one half of bridge.

$a = 10$ feet. $b = 5$ feet. $c = 6$ feet. $d = 9$ feet. $e = 20$ feet.
$l_1 = 18$ feet. $l_2 = 13$ feet. $l_3 = 9$ feet.

W = total weight (dead) of central girder = 1540 lbs.
W_1 = ,, top row of cantilevers = 3072 ,,
W_2 = ,, second ,, ,, = 2070 ,,
W_3 = ,, bottom ,, ,, = 2040 ,,
w = max. dead load per foot run which bridge is intended to carry $= \frac{3}{2} \times 560 + 50 = 890$ lbs.

Fig. 6 shows half a bridge, span 60 ft., in which

a is the horizontal distance between the anchorage E and shore transom A.

b, c, and d are the respective overlaps of the 3 layers of cantilevers shown.

e is the span of the central girder.

l_1, l_2, l_3 are the horizontal distances from the anchorage to the centres of gravity of the 3 layers, assumed at $\frac{2}{3}$ from the butts (butts out).

Let the bridge be to carry infantry in fours. Assume the timber used to be spruce, and the weight of roadway 50 lbs. per ft. run (if the chesses rest on the top layer of cantilevers).

Weights.

The weights of the various parts of the bridge are first estimated as follows :—

Central Girder.—This will not exceed the weight of simple roadbearers required to carry the load across this span. By the usual formula five $8\frac{3}{4}$-in. circular roadbearers are found to be sufficient. The weight of these (22 ft. long) will be 1,540 lbs. (W).

Top Layer of Cantilevers.—There are assumed to be 4 logs, 8 in. at tip, 14 in. at butt, full length 32 ft. Their total weight will be 3,072 lbs. (W_1).

Second Layer.—There are assumed to be 6 logs, 6 in. at tip, 12 in. at butt, length 23 ft. Their total weight will be 2,070 lbs. (W_2).

Bottom Layer.—There are assumed to be 10 logs, 6 in. at tip, 10 in. at butt, length 17 ft. Their total weight will be 2,040 lbs. (W_3).

With the butts out the centres of gravity (G_1, G_2, G_3) of the layers will be respectively 18 ft., 13 ft., and 9 ft. horizontally from the anchorage.

Let w = weight of traffic and superstructure per ft. run, reduced to dead load, $=\frac{3}{2}\times 560+50=890$ lbs.

Investigation of Stresses.

Central Girder.—This is assumed to be strong enough to transfer its loads to the tips of the top layers of cantilevers.

Top Layer of Cantilevers.—The forces acting are :—

$\frac{W}{2}+w\frac{e}{2}$ at D,

$w(a+b+c+d)$, at a point distant $\frac{a+b+c+d}{2}$ from K_1

W_1 at G_1

R_1 at K_1 (stress on anchorage, assumed to be of a lifting nature on the anchorage and causing a downward pull on the shore ends of the cantilevers).

F_1 at C (pressure on tips of layer below).

Resolving vertically,

$$\left(\frac{W}{2}+w\,\frac{e}{2}\right)+w\,(a+b+c+d)+W_1+R_1=F_1 \quad \text{.............(i.)}$$

Taking moments about K_1,

$$\left(\frac{W}{2}+w\frac{e}{2}\right)(a+b+c+d)+w\frac{(a+b+c+d)^2}{2}+W_1 l_1=F_1\,(a+b+c) \quad \text{...(ii.)}$$

Substituting values in both equations,

(i.) becomes

$$770+8,900+26,700+3,072+R_1=F_1, \text{ or } F_1=R_1+39,442$$

(ii.) becomes

$$290,100+400,500+55,296=F_1, \text{ or } F_1=35,519$$

Hence $R_1=-3,923$ lbs., *i.e.* the shore ends of the top layer of cantilevers exert a downward pressure of this amount.

Second Layer of Cantilevers.—The forces acting are :—

F_1 at C; R_2 at K_2; W_2 at G_2; F_2 at B.

Resolving vertically,

$$F_1+W_2+R_2=F_2 \quad \text{..........................(iii.)}$$

Taking moments about K_2,

$$F_1\ (a+b+c)+W_2l_2=F_2\ (a+b) \quad \text{.................(iv.)}$$

Substituting values,

(iii.) becomes $35,519+2,070+R_2=F_2$, whence $F_2=R_2+37,589$

(iv.) becomes $745,896+26,910=F_2\times 15$, whence $F_2=51,520$.

$R_2=13,931$ lbs.

Bottom Layer of Cantilevers.—The forces acting are :—

F_2 at B; W_3 at G_3; R_3 at K_3; F_3 at A.

Resolving vertically,

$$F_2+W_3+R_3=F_3 \quad \text{..........................(v.)}$$

Taking moments about K_3,

$$F_2\ (a+b)+W_3l_3=F_3\times a \text{.......................(vi.)}$$

Substituting values,

(v.) becomes $51,520+2,040+R_3=F_3$, whence $F_3=R_3+53,560$

(vi.) becomes $772,806+18,360=F_3\times 10$, whence $F_3=79,117$.

$R_3=25,557$ lbs.

Therefore total upward pull on anchor log

$$=R_1+R_2+R_3=-3,923+13,931+25,557=35,565 \text{ lbs.},$$

and the necessary depth of anchorage for a log 12 ft. long and 12 in. diameter in ordinary soil is found in the usual way to be 4 ft. 6 in. (at centre of log), using a factor of safety of 3.

If there is no live load on the portion of the bridge vertically above the horizontal length a (*Fig* 6), *i.e.* between anchorage and shore transom, then the stress on the anchorage will be increased to 40,219 lbs.

To find the number (n) of cantilevers required in each layer.

Take a factor of safety $=4$, and the modulus of rupture for spruce $=f_0=8{,}680$.*

Bottom Layer.—The diameter of the logs at A is about 9 in.

$$M_{ff}=F_2\times b=51{,}520\times 60 \text{ inch-pounds.}$$

$$M_r=n\times f_0\times\frac{I}{y_0}^{*}=n\times f_0\times\frac{\pi r^3}{4}^{*}=n\times 8{,}680\times\frac{91}{4}=620{,}620\,n.$$

Equating M_{ff} and M_r and introducing the factor of safety,

$$51{,}520\times 60\times 4=620{,}620\,n,$$

whence $$n=20 \text{ nearly.}$$

Our original estimate was for 10 logs. It will not be necessary to re-calculate, as the weight of the layer bears but a small proportion to the weight it carries. Another log may be added to the layer to cover the inaccuracy, making 21.

Second Layer.—The diameter of the logs at B is about 10 in.

$$M_{ff}=F_1\times c=35{,}519\times 72 \text{ inch-pounds.}$$

$$M_r=n\times f_0\times\frac{\pi r^3}{4}=n\times 8{,}680\times\frac{22}{7}\times\frac{125}{4}=852{,}500\,n.$$

Equating as before,

$$35{,}519\times 72\times 4=852{,}500\,n, \text{ whence } n=12.$$

The original estimate was 6. The same remarks apply as before.

Top Layer.—The diameter of the logs at C is 12 in.

$$M_{ff}=\left(\frac{W}{2}+w\,\frac{e}{2}\right)d+wd\,\frac{d}{2}=1{,}044{,}360+432{,}540 \text{ inch-pounds.}$$

$$M_r=n\times f_0\times\frac{\pi r^3}{4}=n\times 8{,}680\times\frac{22}{7}\times\frac{216}{4}=1{,}473{,}120\,n.$$

Equating as before,

$$1{,}476{,}900\times 4=1{,}473{,}120\,n, \text{ whence } n=4,$$

as originally estimated.

Pressure on Shore Transom.

This is F_3, *i.e.* 79,117 lbs. For a shore transom 20 ft. long $\times$ 12 in. in diameter the pressure will be $\frac{79{,}117}{20}=3{,}956$ lbs. per sq. ft. (The great stress here should be noticed).

The number of wires in the anchor ties is calculated from the total pull on the anchor log, viz. 35,565 lbs.

* See *Instruction in Military Engineering*, Part III.

ROAD CONSTRUCTION AND MAINTENANCE IN TROPICAL AFRICA.

By LIEUT. G. W. DENISON, R.E.

THE road engineer in Tropical Africa is confronted with three great difficulties,—the absence of skilled labour, the presence of white ants, and the very heavy cost of transport. The rules laid down by European authorities for road construction in Europe therefore do not apply to the construction of roads in these uncivilized countries, and the engineer has to learn by experience the best way of carrying out the work assigned to him.

The scarcity of funds and the heavy expense of construction, owing principally to the cost of transport, prohibit large steel or brick structures, and most of the work has to be carried out with only unskilled native labour and with the materials which can be obtained locally.

The destructive effects of white ants upon timber makes this abundant material almost useless, as there are only two kinds of timber which they will not attack. These are mahogany and "masuka"; the first is very valuable, and the other is only a small tree seldom found of a greater diameter than eight or nine inches. Practically the only materials available for use are earth and stones.

In these uncivilized and unsurveyed countries, the surveying and construction of new roads is of far greater importance than the repairing of existing ones, which can usually be done in a couple of months at the beginning of the dry season, the rest of the year being available for constructing new ones. The engineer is frequently asked to construct a road between two places, perhaps hundreds of miles apart, through an absolutely unknown and often hostile country; and is given a very short time in which to complete the work.

ROAD SURVEY.

As the existing maps of this part of Africa are very inaccurate and incomplete, the first thing to do is to make a rough survey of the country between the two places which it is proposed to connect by the new road. This is done by first sketching the native path between the two places, taking in as much of the country on each side of the path as possible, and especially noting the size and direction of flow of all rivers and streams crossed. The following information should also be noted :—

(*a*). The position of marshy and low ground.
(*b*). The position of the water sheds.
(*c*). The position and extent of all isolated hills and ranges of hills.
(*d*). The position of all passes in mountain ranges and the gradients of both sides of the passes.
(*e*). The nature of the soil whether dry or damp, rocky or sandy.
(*f*). The places or streams where water can be found all the year round.
(*g*). Whether the natives of the district are friendly or hostile; whether they can be employed on the construction of the road, or whether imported labour will have to be used.

On the return journey it may be necessary to sketch a new route; but in most cases it is only necessary to stop for a day or two at doubtful places and to sketch these places with greater care.

An experienced engineer will very quickly pick out the general alignment, and especially the ruling points. Most of this he can do on the first journey, and after completing the rough survey he can draw on the map the general direction of the line.

An inexperienced engineer will have to make a more careful survey before deciding upon the general alignment.

New roads are required to connect one European station or cantonment with another, and the native towns, even if large, are of very little importance. It is better, in fact, to keep the road a little distance away from a town, and then build a rest house at the side of the road at the nearest place to the town where water can be obtained. The natives of the town form a small market near the rest house, and thus prevent "carriers" and other natives using the road from going into the town itself.

The above system is largely used in British Central Africa and North Eastern Rhodesia, and to a lesser extent on the West Coast, and works very satisfactorily.

After the general alignment has been decided upon, a more careful survey of the ground is made. This is sometimes done by running trial lines with a theodolite; but as this takes considerably more time than is usually available, the line is often "pegged out" by eye, and this can be done fairly accurately after a little practice. In doubtful places two or more lines may have to be run, and the advantages of each compared before the best line can be obtained.

It is advisable that the engineer who has to construct the road should also survey it, as he will then decide how each constructional obstacle is to be overcome, and may find it advisable to change the alignment. There is seldom time to make accurate surveys and drawings, and the engineer must therefore keep in his own head a deal of information which would be difficult to write down or show on drawings unless they were accurate.

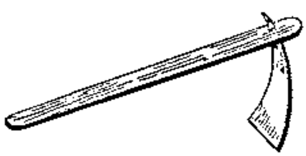
The survey and the construction is very often carried on simultaneously, the construction commencing when the survey has advanced a few miles. The engineer in charge will personally superintend the laying out of the lines, leaving a European assistant to superintend the construction; and as the survey is quicker work, the engineer can devote some of his time to the road making.

GRADIENTS.

A maximum gradient of 1 in 15 should, if possible, be kept to, but gradients of 1 in 12 are permissible if very short, such as slopes down to "drifts" or on the straight. Gradients as steep as 1 in 10 are to be found on the existing roads, but should be reduced whenever possible. On curves the gradient must be reduced and very sharp bends should be on the level.

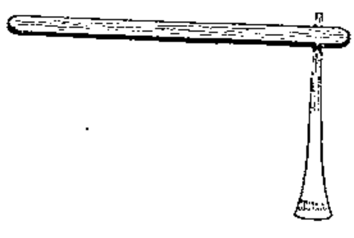
LABOUR FOR CONSTRUCTION.

The only labour available for constructing the roads comes from the natives of the country, who are only accustomed to the use of a hoe (*Fig.* 1) and an axe (*Fig.* 2). Such tools as spades, shovels, picks, etc., are of very little use in their hands; and the way they use a wheelbarrow is to carry it on their heads, so a light basket or wooden box is used for removing earth.



Native Hoe

FIG. 1.

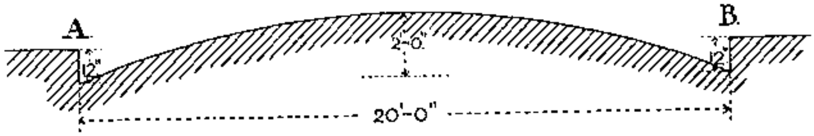


Native Axe

FIG. 2.

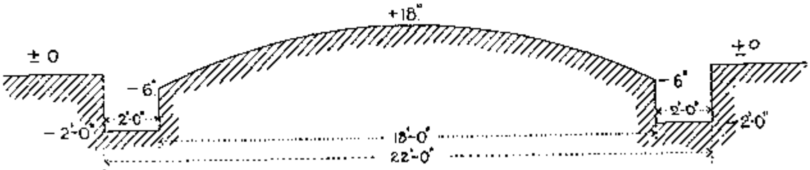
The natives are organized into gangs under their own head men. The number in a gang varies from 10 to 40, but 20 is the most suitable number. Each head man is responsible for the work carried out by his gang.

Whenever possible task work, and not time work, should be used, as the natives work much harder and better when given a task.



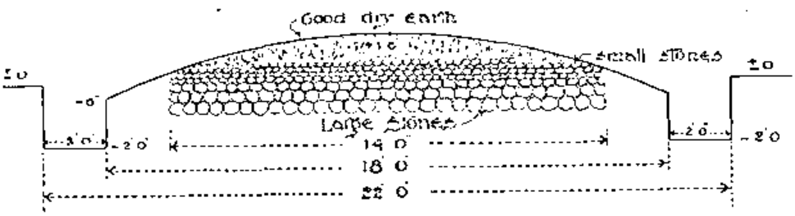
Cross Section on Level Ground.
FIG. 3.

Fig. 4 shows the best cross section over a marshy place; the deep ditches collect the water and keep the surface of the road dry.



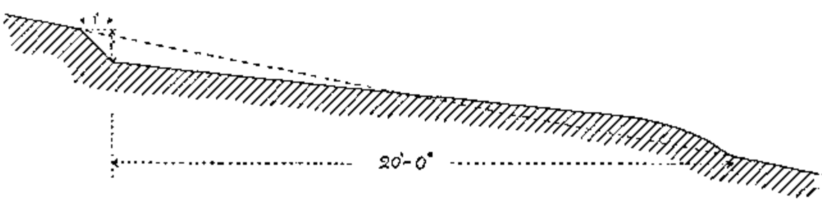
Cross Section on Marshy Ground.
FIG. 4.

Sometimes it is necessary, if the earth is very soft, to form the road as shown in *Fig.* 5.



Cross Section on very Marshy Ground
FIG. 5.

Fig. 6 shows the cross section for slightly sloping grounds; *Fig.* 7 on the side of a steep hill; and *Fig.* 8 on a heavy gradient but with a horizontal cross section, such as the approaches to a straight "drift."



Cross Section on Slightly Sloping Ground.
FIG. 6.

With task work, supervision is much easier, and more work can be got out of the men. Task work also sets up rivalry between the different gangs, and the poor workers are weeded out because a head man will discharge a lazy native and take on another in his place.

Work commences about 6.30 a.m. and continues without any interval until about 2 p.m. Each gang is dismissed by the European in charge when they have completed the task given them.

There should be an European assistant for every 500 men, and he should have a native overseer to assist him, who should be able to talk English.

The tools issued to each gang are :—

(*a*). A native hoe to each man of gang.
(*b*). 2 or 3 spades.
(*c*). 2 or 3 axes.
(*d*). One crowbar.
(*e*). One line (about 100 feet).

BLASTING.

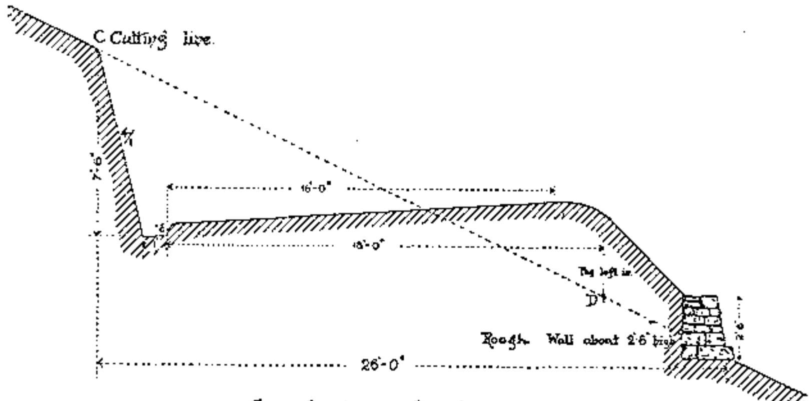
A few of the best men are picked out and taught to drill holes for blasting; they work in pairs, each pair being provided with a drill and sledge hammer. The task for each pair is usually four holes, which takes about seven hours to complete. The number of men required on this kind of work depends upon the nature of the country, but 8 to 10 men should be trained to it.

Though the boring is done by the natives, the charge must be fixed and fired by an European, as the natives do not understand the danger of dynamite.

Dynamite is better than guncotton for blasting, as it can be rammed with a wooden rammer into any size hole, and can be fired with the ordinary commercial cap. All that is required is to break the stones in order that they can be moved. Before firing the charge it is necessary to see that the earth has been removed from around the stone; if this is not done only the portion of the stone which is above ground will be broken, and probably another blasting will have to be carried out before the whole stone is removed.

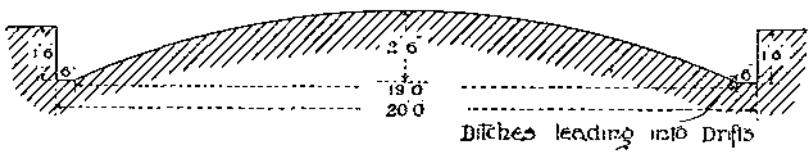
CROSS SECTION.

It is very difficult to say what is the best cross section to adopt, but the cross sections used in Europe can never be obtained. Through level dry country the cross section shown in *Fig.* 3 is the best ; it is cheap and easily constructed, and the surface gets very hard from the heat of the sun during the dry season. The surface water should be conducted away from the sides of the road to lower ground whenever possible.



Cross Section on Steep Hill Side.

FIG. 7.



Cross Section on Approaches to Drifts

FIG. 8.

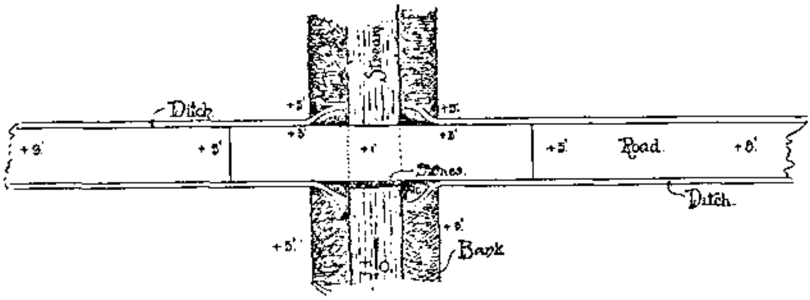
SURFACE OF ROAD.

As steam rollers are so expensive good metalled roads are never seen in Tropical Africa. The only form of metalling used is broken stone placed on the surface of the road, but of course this gets very bad during the rainy season. Most of the roads are therefore plain earth roads, the surface of which gets very hard from the heat of the sun and from the traffic of thousands of natives passing over it in their bare feet.

DRIFTS AND SMALL BRIDGES.

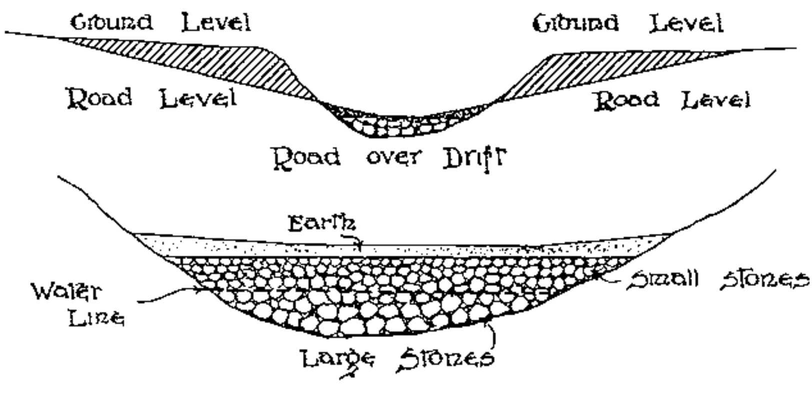
Streams are best crossed by means of "drifts," as wood is destroyed by white ants and iron and steel are very expensive. Drifts are made as follows :—

Several layers of stones are placed in the river bed where the road crosses it, the biggest stones being placed on the down stream side; on top of these are placed smaller stones; and on the top of all about six inches of earth. The banks of the stream are cut away and left at a gradient of 1 in 10, if the stream is crossed on the straight; if not, the gradient of the slopes on each side of the "drift" must be reduced (see *Figs.* 9 and 10).



Plan of Drift.

FIG. 9.



Cross Section of Drift (Enlarged)

FIG. 10.

Drifts are cheaper and last longer than small bridges; but sometimes it is necessary to build small bridges in order to save elevation or in places where it is impossible to cut away the banks on each side of the stream.

In building small bridges stone is a better material to use than bricks, as the local bricks are very soft and will not stand well when exposed to the action of running water. If timber is used to bridge the span, it must be either mahogany or "masuka" as already explained; other kinds of timber will not stand more than a few months.

CONSTRUCTION.

For constructional purposes it is advisable, when choosing the alignment, to keep on the driest ground possible, and in places it will pay to obtain this at the expense of length or elevation. If the alignment can be kept along a water shed, it may be long and difficult to construct, but it will be dry and the cost of maintenance will be small. Traffic is hindered less by an extra mile of good road than by a few hundred yards of bad. A good example of this is on the Blantyre-Zomba road in British Central Africa. The road purposely rises about fifty feet to the top of a small plateau, goes across the top, and then down again on the other side, thus getting on good dry level ground for about four miles, with no streams whatever to cross. To have gone round the base of the plateau would have gained a little in length and elevation, but the construction would have been very heavy, with several streams to cross; also the maintenance of this piece of road would have been very costly, whereas the four miles along the top of the plateau cost practically nothing for repairs, and the rise of fifty feet at a gradient of 1 in 15 is no obstacle to an ox team.

After the centre line has been pegged out by the survey party the two side lines are laid out before the construction party commences work. When the country is flat these two lines mark the two cutting lines of the sides of the road as shown at A and B in *Fig.* 3, and they will each be 10 feet from the centre line of pegs.

If the road is on the side of a hill, the upper line will be the cutting line, and the lower one the outside edge of the road when completed, as shown at C and D in *Fig.* 7. The line on the lower side is taken up shortly after the work commences, and only the pegs the line was fastened to are left in. In this case the upper line will be 11 to 15 feet away from the centre line, according to the steepness of the ground.

The cutting lines are laid out at least one day before work commences, and are kept at least a day in advance of the construction. This saves a good deal of time, as there is sure to be some confusion in the morning if the cutting lines are not down before the men commence work.

The tasks are set as follows:—each head man is given a certain number of yards run along the road, according to the number of natives in his gang. The number of yards per man will vary from one on very steep or hard ground to eight or ten on very easy level ground. The engineer soon learns how many yards to take off, or add on, if the work is harder, or easier, than that given to the other gangs. Thus on the same day one gang may have three yards per man, another four, and another five. For the construction of "drifts," put one or two gangs on to complete the work, but do not split up a gang.

Each gang has to complete the section of the road given to them before being dismissed for the day. All trees, stumps, and other obstacles have to be removed, also small stones. Rocks which are too large to move are left, after the earth is removed from around them for some distance below the surface of the road, and are blown up with dynamite afterwards, a special gang being kept for this kind of work.

The natives in British Central Africa are very good at constructing "drifts," and need very little supervision; but the natives in Northern Nigeria and other parts of West Africa do not understand this work, and it takes a long time to teach them.

No native has any eye for a straight line. Therefore never allow any work which requires to be straight, such as ditches, to be commenced unless a line has already been put down by an European.

If the surface of the road is at all damp cut away the trees on each side of the road, and the hot sun will help largely towards keeping the road good. If the ground is dry and sound, it is not advisable to cut down the trees at the sides.

As there is very little wheeled traffic footpaths are not necessary, and the usual width of the road is 20 feet on the level and 18 on embankments and hillsides. Roads of widths between 30 and 40 feet were tried in Zomba, British Central Africa; but they were very expensive and difficult to maintain, and had no advantages whatever over the narrower ones.

Avoid marshy ground as much as possible. But if it is necessary, as it often will be, to cross a marsh, get the surface of the road as dry and hard as possible. First cut deep ditches on each side, and if this is not sufficient, put in a foundation of stone as shown in *Fig.* 5. "Corduroy" roads, like those in America, cannot be used except for very temporary work.

As far as possible "drifts" should be constructed during the dry weather, for then they will have several months to settle before the heavy floods come on. If constructed during the rainy season the work is very likely to be carried away in a flood before it is completed. The above also applies to bridges; in Northern Nigeria the piers of a large railway bridge were carried away by a heavy flood before they had time to set.

As the chief form of transport is ox wagons, which take up a large length of road, sharp curves or bends are very difficult to get round. If they come on a steep incline they must be made as flat as possible and also very broad.

TRAFFIC.

The nature of the transport varies in different parts of Africa. In some parts horses will not live, while in others they can be obtained in large numbers, but they are never used by the natives for wheeled transport.

In British Central Africa, Cape carts (wagons) drawn by eight span of oxen are largely used. Each wagon carries from 2 to 2½ tons, and will cover about 15 miles in a day. They travel up and down the roads in convoys of several wagons under an European.

Traction engines are also used, varying in weight from 7 to 16 tons, so all bridges, culverts, etc., must be constructed to take this weight.

In Lagos and Northern Nigeria horses can be obtained, but up to the present have only been used for pack purposes. Mules and donkeys are also largely used as pack animals by the natives. In Somaliland and other desert parts camels are largely used, but usually only as pack animals.

Light mule carts have been tried in different parts of Africa; they are not as economical as the ox wagons, they do not appear to be able to stand the rough roads, and in most places have not been a success.

In all parts of Tropical Africa the native "carrier" (coolie) is largely employed, but roads are being constructed in order to avoid this form of transport as much as possible.

MAINTENANCE.

The rainfall during the wet season of the year is in most parts of Tropical Africa very heavy, and as much as 15 inches in a week is common. This heavy rain is very destructive to the surface of the roads, forming great ruts, especially when the road is on a hillside. The water also washes away the earth and leaves the road covered with loose stones, which renders it almost impassable until repaired. The drifts also suffer to a great extent and some get carried away each year.

During the rainy season the natives will not work, and consequently repairs cannot be carried out until the beginning of the dry season. It is therefore necessary to go along all the roads, as soon after the rains as possible, with large working parties, and put the roads in repair. This can be done at the rate of two or three miles a day with 500 or 600 men. In British Central Africa over 100 miles of road were repaired within a month with 3 Europeans and about 1,500 natives; the roads then remained in good condition during the whole of the dry season. The repairing of this 100 miles cost approx. £400 or £4 per mile.

A few natives can be kept during the rainy season by paying them very high wages; they are used for repairing drifts and removing landslides and other obstacles, thus keeping the roads open for the small traffic which uses them.

MATERIALS.

Earth is good in most parts and easily worked.

Bricks can be made locally, but are very soft and do not weather well.

Stone is fairly plentiful and easily obtained.

Wood is very abundant, but cannot be used (except mahogany and "masuka").

Cement is very expensive indeed.

Dynamite is also very expensive, but very useful.

Steel and *Iron* are hardly ever used.

LAND.

Land has practically no value in Tropical Africa, except inside the cantonments. In most of the British Crown Colonies and Protectorates the land is entirely in the hands of the Government, and there is no difficulty in running an alignment in any required direction. In British Central Africa $\frac{1}{20}$th part of any estate may be taken by the Government for roads or railways without any compensation to the owners. Compensation must, however, be given for damage done to crops (coffee); but this is very small.

ESTIMATE OF COST.

As the chief item in the cost of roads in Africa is the labour, it may be well to state here the pay of the native in the different parts.

In West Africa the pay of a native labourer is 5/- a week; 2/- of this is paid at the end of each week, and the remaining 3/- when the native is discharged.

In British Central Africa and Rhodesia the pay is 3/- a month and 6d. a week food money; as on the West Coast, the pay is held over until the native has completed his engagement, which is usually three months.

The tools and materials required, such as dynamite, hoes, etc., will cost about £500 a year, and the pay of the European staff will be extra.

100 men working for one month cost £100 (approx.) in West Africa and only £25 in British Central Africa. In ordinary country 100 men will in one month complete about 3 miles of road. Thus in British Central Africa construction cost £10 per mile (approx.) and in Northern Nigeria and other parts of the West Coast £40 (approx.), including cost of tools and material.

In easy country it would be less and in difficult country it would be more. If any steel bridges have to be constructed the cost of them would of course have to be added to the above estimate.

The methods employed in Tropical Africa appear very primitive; but it must be remembered that the distances are long, labour unskilled, materials scarce, funds hard to get, and the time available for survey and construction often insufficient.

*THE THIN END OF THE WEDGE.**

By CAPT. L. H. CLOSE, R.E.

IN the discussion of schemes for organization for Home Defence it seems to be generally accepted that there is no *via media* between conscription and voluntary enrolment (whether in the Militia, the Volunteers, or local bodies such as rifle clubs). The best authorities recognize that the strength of our defensive cadres is inadequate to meet the possibility of an attack on us by one of the Western Continental nations, so they advocate conscription; while the opportunists content themselves by suggesting modifications directed towards the strengthening of our existing system.

In the face of the opinion of experts it is only reasonable to disregard the theories of the latter school, and to accept the view that numerically the Home Defence forces of the Crown are far below the proper standard. But at the same time, while we accept the standard of the experts as to numbers, we are not obliged to believe (as they, or the majority of them, do) that conscription or the Militia ballot presents the only solution of the problem.

The opposition to conscription lies mainly in disinclination to compulsion—in the feeling that the liberty of the Briton is being encroached upon—and to some extent also in the belief that the cost of the experiment would be as prohibitive as its effect upon trade would be disastrous.

Of these two objections, however, the argument as to cost is invalid. It arises mainly from the popular idea that conscription means that *all* able-bodied men must bear arms; whereas the number actually required to serve can be exactly adjusted to requirements by the percentage of exemptions allowed when the ballot is taken. Requirements must be met in any case, and there is no *a priori* reason for supposing that the cost of enrolment under conscription would exceed the cost under any other system.

The second objection, however,—that the liberty of the subject is being interfered with—is far more reasonable, and is wholly true to the extent that a compulsion to serve, if the recruit is unwilling, must weaken the whole fibre of the Army. To argue that the pressed men of the Napoleonic wars were excellent fighters is beside the point. At that time the condition of labour was so far less favourable than it is now that service in the Navy must have proved to many men a

* This article was written before the publication of Mr. Haldane's proposals for a reorganization of the Auxiliary Forces.—EDR.

more desirable life in all essentials than they could ever hope to command at home. The fact remains that at the present day one volunteer is worth ten pressed men.

The preamble of this argument is now concluded, and we are left with the *residuum*—Can the State by any means compel to volunteering? Put thus bluntly the question seems paradoxical, but is not as paradoxical as it seems.

In the opinion of the writer the whole problem is capable of solution by means of compulsion on *employers* of labour, instead of on labour itself; so that the pressure, instead of being direct, becomes indirect, and there is no interference with the liberty of any particular individual. For him it will be simply a balance of advantages; whether to accept greater security for the tenure of his employment, with probably higher wages, and the possibility of having to help defend his native land; or to keep out of the defensive forces with the knowledge that, other things being equal, his value in the labour market will be always less than that of his fellow who is enrolled in some defensive corps.

Such a result as here outlined can be attained unquestionably by means of a State edict to the effect that every employer of labour must maintain at all times on his establishment a certain minimum percentage of labour enrolled in one or other of the defensive corps, under a monetary penalty for every unit of labour deficient from his proper percentage. It would not be a difficult matter to assess the pecuniary value to the State of every citizen soldier, and this value would be recoverable from every firm whose books and muster-rolls, when checked periodically by properly accredited Government officials, showed an average defect of one citizen soldier during the year, and for greater deficiencies in proportion.

What would then happen would be an effort on the part of employers to induce their employés to enlist up to the percentage laid down by the State. To achieve this end they would either offer higher wages to individual men willing to enlist, or take on new men. In either case the desired result would be attained:—The pressure exercised by the State on the employer would lead to the voluntary enrolment of as many men liable to be called out for Service as was deemed expedient by the State.

In order to adjust this scheme of recruiting to the case of small firms, shops, private establishments, etc., the Home Defence army would be organized in different corps, which would become liable for service in succession and in which the period of service would be successively reduced. Thus, if 5 corps of 150,000 men each were determined on, the period of service in the 1st Corps might be fixed at 10 years, that in the 2nd 8 years, and so on down to a service of 2 years only in the 5th Corps. But it would be only in the gravest national emergency that the 5th Corps would ever be called out; so that an obligation on a firm having only 2 employés to have one of them in the 5th Corps could not be considered a pressing burden. Moreover training itself would be varied in its effectiveness and duration on a descending scale corresponding to the probability of any corps being called out for service. The men of the 5th Corps might only be asked to muster at intervals, and to belong to a Rifle Club; while the men of the 1st Corps should be given the most thorough training that was financially possible.

Of course we do not need to be told that training is a matter of expense. That is so under every imaginable scheme. But, in the opinion of the author, what differentiates this scheme from all others yet propounded is its elasticity. Does the Government want to be able to lay its hand on men in large numbers who will come forward at once under arms although their training is sketchy? It can have them, and make sure of getting them at a minimum of expense and without in any way exacerbating public opinion. This is one extreme of the scale. Again, does the Government require a highly trained Home Defence Army of 150,000 men, ready to go anywhere and do anything, and to back them up by other corps whose somewhat inferior training can be improved while they are waiting to feed the First Line? This can also be done, and done as cheaply as by conscription, and with infinitely less dislocation of labour.

The highest authorities argue for a 3 months' universal training. As regards the individual this is to take place once for all; but to keep cadres up to strength it is obvious that at some centre or another there will have to be facilities for giving such training yearly. The inevitable result will be heavy expense in conveyance and housing. But if for this we substitute local corps which come up for a larger or shorter period yearly, or which simply parade or muster on stated days, all this source of expense is avoided.

Let us keep the main argument clear, however. A 3 months' training, if it is essential, is just as easily effected by means of the scheme here advocated as under conscription. But the point is, if we have 150,000 well-trained men to meet the first shock of an emergency, can we not afford to risk bringing the training of the 2nd Corps up to the three months standard after the emergency is upon us? It has to be remembered that the difference between the two corps in fighting efficiency is not represented by 3 months but probably by 1 month of training, since, on our hypothesis, the efficiency of the training increases progressively from the 5th Corps up to the 1st.

Again, is it not the modern tendency to look on the cohesion of the body as a whole as of equal importance with the training of the individual? and where is the cohesion of the battalion, regiment, or battery to come from, if the individuals who are to form them go off after one period of training to their own homes and only re-appear when their services are required for war?

But by means of compulsion on employers to maintain Home Defence soldiers it is known *ab initio* that the numbers of the latter will vary directly as the population of any district. Consequently within a radius of a few miles a battalion or other unit can be formed the members of which will always be found living in or about the same villages or streets, since the localities of the firms by whom they are employed do not change. Hence cohesion is at once attainable, an intimate knowledge between officers and men, and that continuity of regimental feeling which is of the highest value.

Moreover, is there not a world of difference between the security given by dependence upon the willingness of citizens to enlist in a hurry and at the last moment and the security of having absolutely in hand 750,000 men sworn to serve whenever called upon by the State? The first case spells chaos, and the delay of every detail of organization when delay is fatal; the second case eliminates every danger due to faulty organization, since what is known beforehand can be prepared for beforehand. And, since half a loaf is better than no bread, the cohesion resulting even from only an occasional muster of the unit, which can be provided for in the second case, is an immense step in advance of the entire absence of previous association between men who have to be taken from any quarter where they may offer themselves.

It is to be concluded, therefore, that, even if the training is of the slightest, the organization in war-units of bodies of men known to each other is a most important step. Having taken the numbers considered by experts to be required for all the emergencies of a war between two first-class powers, divide this total into distinct armies, and each army into local battalions or other war-units according to the proper proportions of each arm. Then decide how best to spend the money available for the training of the whole:—whether by giving the first line of defence a very high proportion of the total expenditure, while leaving the other armies more to local and voluntary effort; or by assigning allotments to each army roughly in proportion to the period of service for enlistment in each.

It may be asked—Why should anyone enlist for the long service of one of the first lines? Obviously because the State is pleased to assess his value higher when he thus serves; and the State value becomes the market value. If the relative inconvenience to the employer resulting from maintaining a man belonging to the 1st Army, for instance, is made somewhat less than in the case of his maintenance of men of the less highly trained corps, through a high value being placed on the man in the scale of equivalents in pounds sterling per annum which the firm must maintain or be fined, then a demand will arise in the labour market for men willing to enlist in the 1st Army, since the employer has to engage fewer of them in proportion and so will lose less over the enhanced rates he must pay for labour.

The adjustment of these different equivalents will necessarily be largely experimental, but there is no reason to suppose that the experiment would be attended by risk. There can be no doubt that 700,000 recruits would be forthcoming at once if the Government were to enact that all employers of labour must maintain ten per cent. of Home Defence soldiers on their establishments, under an average penalty per man of £100. This hypothetical average value of £100 per man might then be raised to £150 for men of the 1st Corps, and lowered to £20 for men of the 5th Corps. Thus, if a 10 per cent. levy is decided to be sufficient for the defence of the country, an employer of 100 men must maintain in his establishment the defensive equivalent of $\frac{100}{10} \times 100 = £1{,}000$: this would be given by 7 men of the 1st Corps, for $7 \times 150 = £1{,}050$. On the other hand an employer of only 2 men would be required to maintain the defensive equivalent of only $\frac{2}{10} \times 100 = £20$. This he could accordingly do by drawing one of his two employés from the 5th Corps.

It is clear that on these lines the system is easily adjustable to the conditions of every description of employment, whether in the town or country. Now, if it is decided to have a minimum training of 10 days for the 5th Corps and a maximum of 50 days for the 1st Corps (in both cases yearly), it is evidently advantageous to the employer to maintain men of the 1st Corps rather than those of the 5th; for the value of each man in the former corps is £150 to him, and the relative cost 50 days of absence from employment; that is 5×10 days, the equivalent absence of 5 men of the 5th Corps, whose maintenance would only lower his indebtedness to the State by $5 \times 20 = £100$. Thus, by increasing the value of units in the most highly trained lines of defence out of due proportion, a premium is clearly put upon their engagement by employers.

We come lastly to the question—Would such a scheme work? As to this it is only possible to say that it mitigates every irksomeness inherent to conscription; and if the latter, which is a system of direct compulsion on the individual, is feasible, a system of indirect compulsion on the employer is *a fortiori* so. Would the men enlist? Yes, because the employer makes it worth their while to do so, and those employers who fail to offer attractive terms must pay in hard cash to the State. These payments enable the State to add to its regular, *i.e.* Imperial, forces.

As to the employer we need waste no pity on him. The commercial operations by which he grows rich are only possible because there is a general feeling of confidence in the adequacy of the national defence. Directly this feeling begins to vanish rates of interest go up and trade suffers. Since national confidence is based upon the views of experts, as soon as these views become unfavourable it is the duty of the State to add to its defences until the requirements of the experts are met; and to do so it is clearly justifiable to tax both capital and labour, for both are profit-sharers. But labour is only taxed indirectly owing to the slight rise in the cost of living that increased national expenditure must entail.

While conscription can *only* be introduced against the active opposition of both Capital and Labour, recruiting by means of State compulsion on employers would only have to encounter the opposition of Capital. But capitalists are not devoid of reason; and it is probable that they would welcome a satisfactory organization for Home Defence, even if they had to pay more for it, provided it could be shown both that it is essential and that it will give an economical equivalent for the money spent.

It has to be recognized that against the introduction of this scheme many might raise the cry of State interference with private concerns. It does not seem certain, however, that there need be much more interference than now takes place under the Factory Acts. From the Government point of view all that is required to be known is the average daily strength of labour employed by a firm, averaged on the working days of 1 year. These figures for each firm would form the basis on which to compute the numbers of Home Defence soldiers that should be included within the firm's establishment for the next year.

Medical inspection of would-be recruits would be necessary, but the standard would be made less rigorous for the less highly-trained corps.

In order to keep the war units of the different armies up to strength during a war provision would have to be made for maintaining reservists for each army. Probably the simplest way of effecting such provision would be to treat certain units of one Army as depôt units for the supply of the Army next above. Thus, of the 150,000 men in the 2nd Corps 50,000 might be organized as depôt units to feed the 1st Corps during war. The independent strength of the 2nd Corps would thus be only 100,000 men, for which the 3rd Corps would maintain 30,000 reservists, its independent strength also being 100,000, and its full strength, including its reserves for the 2nd Corps, 130,000.

The scheme could be introduced gradually by raising the percentage of Home Defence soldiers to be maintained by employers of labour from an original levy of 4 per cent. by 1 per cent. increase per annum up to 10 per cent., which percentage would probably suffice to give the gross total required.

The officering of units of the different Corps would be carried out by local Boards of officers of the Regular forces appointed for the purpose by the War Office. The salary drawn by any gentleman, being the market value of his labour, would roughly indicate the relative rank he should hold as officer, if, in other respects, he is found to be fitted for the post. A monetary equivalent could be found for the value of an officer's services, increasing with rank; so that any member or partner of a firm, serving as an officer, would largely reduce the statutory strength in Home Defence soldiers to be maintained by the firm.

It is probable that in working out the scheme existing Militia battalions could, by means of certain adjustments, be made to form the 1st Army here outlined, the 2nd Army being composed of existing Volunteer battalions. The 1st Army would be held liable for foreign service, and also those men of the 2nd Army who had enlisted as reservists for the 1st.

All that any firm stood to lose under this scheme would be the absence of 10 per cent. of its employés for about 5 weeks every year, plus the slight rise of wages to be offered to the same 10 per cent. to induce them to enlist. The only monetary loss that would occur is indicated by the latter loss. Now, if a set time were fixed for the annual training of each army, employers could make arrangements for bringing in temporary men to fill the places of their Home Defence soldiers while out for training. This they would do, not by obtaining men from other Corps whose training were over or not commenced, for such men are already employed *ex hypothese*, but by bringing in unskilled labour and moving up their un-enrolled artizans into higher paid billets, which they would hold so long as the enrolled men were away.

If, then, training takes place during the winter months, we have in this scheme probably a complete solution of the unemployed problem, for throughout 4 or 5 of the winter months there will always be 150,000 places that can be filled by unskilled labour. This method of finding work for the unemployed would seem to be in every way preferable to the expenditure of large sums on unproductive public works. By utilising the unemployed in this manner the State has it in its power to thoroughly perfect the training of all the soldiers it requires for internal defence.

To recapitulate the advantages offered by the scheme here put forward:—

(1). It meets the views of the highest experts both as to the number of men required for Home Defence and their training.

(2). It can be carried out without any compulsion on individuals.

(3). Its compulsion on employers is nominal, if the scale of penalties is carefully framed to meet the conditions of poor districts such as Ireland and the East End of London.

(4). It is absolutely elastic, and can be adjusted to meet the circumstances of the largest manufacturing firms and the smallest shops.

(5). It contains within itself the stimulus required for obtaining a sufficiency of officers.

(6). It is completely adjustable to the circumstances of individuals, for room can be found in the various lines of defence for the young and the old, for athletes and those suffering from some non-incapacitating physical infirmity, for the adventurous and for the citizen who is tied down by family circumstances.

(7). It is wholly adjustable to the money that can be spent on it, and training can be carried out to any small or great extent in any one or all of the lines of defence.

(8). Where money is not forthcoming for training, organized bodies properly officered can nevertheless be formed, whose training in peace time will devolve on local effort, by means of rifle clubs, etc., maintained by private firms; and in war time the whole body can be called upon to serve without the fatal delay that occurs when volunteers are called for. Such bodies, being the last lines of defence, could probably be given a training of some value after the incidence of a national emergency.

(9). It presents what is probably the best solution of the unemployed problem.

There remains one other point to be considered—the interests of the Imperial army and navy as affected by the scheme. In the first place there is nothing to indicate that recruiting for these forces would suffer under the scheme, since, except in the winter months, the number of places of employment remains as before. But the same principle can be applied for the benefit of these forces, viz.:—to make the employment of Regular reservists or of soldiers who have taken their discharge equivalent to the maintenance of Home Defence soldiers of the 1st Line; and similarly as regards the navy. This incentive to the employment of old soldiers might be added as one of the advantages of the scheme. It is high time that the present disgraceful neglect by the nation of those who have served it well should be made to cease; and in this way some compensation would be made them for inadequate pension or discharge without pension. Reservists of the Regular forces, and men who have passed out of the reserve, not being called out for training in peace time, would be more freely accepted for employment than Home Defence soldiers who have to train annually.

COAST DEFENCE ECONOMY.

By 'FORTS.'

ONE feels impelled—with all diffidence—to make some observations in reply to the article on "Economy in Coast Defence" which recently appeared in the *R.E. Journal:*

The views expressed in that article seem in fact a good deal opposed to the tendency of modern coast defence policy, so far as it can be discerned. A proposal which claims, like other projects, to attain an enhanced degree of economy in defence, should be deserving of close examination, and surely cannot be harmed by some criticism and, as it were, audit, if it be intrinsically sound.

A study, superficial enough perhaps, of the trend of the changes which have been taking place over a long series of years in the general scheme of defence of these islands seems to disclose an increasing tendency to concentrate our garrisoned strength round a few important points, reckoning that defence against raids at intermediate places would be provided in the main by mobile troops. I believe I am correct in saying that defence schemes usually take account of the possibility of landings. At the same time it is but fair to say that raid, invasion, bombardment are not the only acts of hostility which can be conceived.

The defence of a coast line has of course an analogy to that of a frontier, in that it is necessarily fitted, so to say, to a fixed line. The fleet may be compared to mobile and independent troops or armies on land, submarine boats to mobile troops attached to the fortresses, and the defended places themselves to the fortresses, *forts d'arret*, entrenched camps and so forth along the frontier line. Continental opinion, it may be remarked, has, if anything, veered away from the idea of a continuous line of defence along the frontier.

I am not very clear about the central idea of Colonel Hickson's scheme; but from the calculations he puts forward of the number of batteries he would propose, it seems to be that the coast line should be equally strong everywhere, that is to say, in other language, that the intensity of defence against attack should be equal all along the line. One cannot help thinking of affairs in the Peninsular War—many of us have perforce had to gain some cursory acquaintance with the Peninsular. There at least it was shown that attempts to hold a long line in equal or equivalent strength were apt to fail when a determined enemy made an attack in strength on one point before a concentration could be brought about.

Strong everywhere! So was the Great Wall of China. But has the Great Wall availed to prevent the barbarian getting in? A system of Coast Defence which relies on walls or their equivalent alone is foredoomed to failure. To aim at being equally strong everywhere under practical conditions inevitably means not being strong anywhere: that is the essence of Napoleon's advice to Massena to "concentrate on the decisive point!"

However, the extra armament is to be spread along the intervals between the defended ports, in batteries of single guns, or twos or threes: not the same thing as having guns mounted on railway trucks so as to allow of their coming into action at any point when the railway approaches sufficiently close to the coast. As a matter of fact at most of the places where the line runs near the shore the deep water is some distance out.

It is certainly a fascinating picture to imagine the enemy's fleet coasting down the channel in search of a "soft place" to land at, and being warned off every fifteen thousand yards by a policeman in the shape of a big gun. How about the chance of these isolated batteries being silenced in detail?

The time factor cannot be neglected. To produce much effect on a defended port, unless an absolute surprise is effected, demands a certain amount of time. Consequently an enemy may be expected to go at his objective as directly as he can once the objective is decided on, lest haply he should be interrupted before anything had been accomplished.

"Inducement," one may venture to think, must be a very strong factor in formulating any scheme of attack. The bigger the prize the bigger the risk an enemy would take. It is all very well to talk of a "fortress incubus," as some writers have done. This may be a convenient phrase. But fortresses have a way of hampering an enemy's movements to a serious degree; they cannot be swallowed up as he goes along; even with the best intelligence he is not likely to be able to tell with certainty what they have within them, either in the form of men, stores, or munitions, or what they guard: and the chronic problem besetting an invader is that of keeping up supplies of all kinds. In fact for an invader in the present day once the line of communications, whether over sea or land, is secure half the war is over. A raid with a force which is not capable of holding on until other pressure is brought to bear cannot hope to accomplish much, and would simply amount to the expenditure of so many men and so much matériel and, perhaps, prestige, a thing less tangible but more expensive it may be.

We have seen often enough, or at least we know from history, how the risk of attack from a hostile force near or far off has affected the course of war both on land and sea. It is not necessary to search out and quote particularly apposite examples, but the case of Nelson's fleet in the Mediterranean may be remembered.

Apparently we may assume that Colonel Hickson's scheme does not contemplate any diminution of existing fortress or harbour defences, and mainly provides for additional batteries along the coast. By the way, it may not be out of place to remark that the Royal Commission of 1859, which went the round of our coasts, recommended, if I remember right, the installation of a prodigious number of guns; but on broader strategical grounds it was decided to mount new armament at only some of the places considered.

The first cost of these new batteries is estimated certainly, but how about a system to command them and to supply them? The command of a long straggling line, even in these days of improved telegraphic apparatus, is a much more difficult affair than that of a compact fortress. Land, it may be remarked in parenthesis, is exceedingly expensive, particularly where it has to be bought in small lots.

A coast battery by itself is terribly exposed to attack. It sounds paradoxical, but everyone knows that field guns cannot be risked without escort of other troops; still less can heavy guns in permanent works be left unprotected by other arms, lest an enemy should attack the work and render it untenable or kill the gunners. Apart from raids, landings, and invasions it would be folly to neglect the possibilities of treachery. Why should not aliens in this country, at the outbreak of war or even before, turn themselves into franc-tireurs and so make it easy for the official enemy?

One may venture to express the opinion that the greatest danger coast defences have to provide against is land attack—another paradox, but defence matters are seamed with paradoxes. No one has really contested the view that ships have a very poor chance of effect against modern guns mounted in modern works. The chance of getting in an effective hit is too much in favour of the battery. Is it likely then that ships will themselves attempt to silence the batteries; surely rather they will give them a wide berth unless steps have been taken first to render them innocuous?

The new additional batteries will thus involve having attached to them a considerable number of coast defence troops. I have not attempted to make an estimate of numbers, but there would have to be a pretty solid deduction made from the army remaining after the Striking Force had sailed and the fortress garrisons were provided. Presumably it would be right to estimate on that basis, although, as indicated above, the main danger to our coast defences will be at or even before the Declaration of War.

It seems hardly fair to ascribe the Martello Towers and the monumental works of the Palmerstonian era wholly to a sudden fear of invasion. Was not the feeling of insecurity rather due to previous neglect of defence? Of recent years at all events our defence projects have been based on some sort of scientific consideration of the probabilities of war.

After all, it is strategy which determines all the preparations: in fact I fancy Peace Strategy has been recently defined as including *all* the measures, both military, social, and political which go towards preparedness. The worst of it is that the Army, as a body, has little opportunity of being acquainted with what the other side intends to do, but for that matter politicians are not always such augurs as to be able to foretell it either. As the sea runs between us and the invader it rests with our sailor men to do the prophesying in the first instance, and with us to believe them just as much or as little as prophets are wont to be believed.

Evidently, the author of "The Economy of Coast Defence" has not been tinged Ultramarine by the Blue Water School. That is clear, but it is *so* difficult to prophesy what will or will not happen in war that we may all be allowed a little liberty to theorise.

TRANSCRIPT.

WING TRENCHES.

Précis of an article by COLONEL S. A. TSABEL *in the September-October,* 1906, *number of the* EENZHENERNEE ZHOORNAL.

DURING the latter part of their war with the Japanese a distinct order was issued to the Russian troops by their new Commander-in-Chief, General Linovitch, directing that in the fortification of positions all redoubts, irrespective of local conditions, must be made to accommodate 2 (double) companies, and that wing trenches or "whiskers," each capable of holding 1 company, must be constructed on the flanks of each redoubt, so that in the redoubt and its wing trenches accommodation should be provided for a whole battalion. It may here be mentioned that, as far as the wing trenches are concerned, all arguments referring to redoubts apply with equal force to villages or any other local objects which may be put in a state of defence to form *points d'appui* in a fortified line.

The above-mentioned order led to frequent discussions among the Russian officers as to the efficacy and the correct form and use of these wing trenches. While obeying the order many Russian Engineers were not convinced as to their utility, and among these may be numbered the writer of this article, who is a man of wide experience, having superintended the defences of the 2nd Army at Mukden and subsequently had charge of the works on the Gunchuling and other positions.

The advocates of wing trenches may be divided into three groups. The first of these, which included General Linovitch himself, held that each redoubt and its wing trenches should be garrisoned with a full complement of 4 companies, thus bringing the fullest development of frontal fire to bear on an attacking enemy. In the later stages of the defence, however, the troops occupying the wings must be prepared to retire within the redoubt; and if, after this, the attack be repulsed, they must re-occupy the wings in time to fire on the retreating enemy.

The second group held that the intention of these trenches was twofold,—firstly to act as a place of retirement for the garrison of the redoubt during the artillery bombardment, and secondly to provide the unoccupied portion of this garrison (*i.e.* the men told off to occupy the gorge parapet, or the interior reserve) an opportunity of making use of their fire during the earlier stages of the defence. In this case, as before, the wing trenches had to be in direct communication with the redoubt, but they were manned with troops included in the garrison of the redoubt and were not allotted a separate garrison.

The third group considered that the trenches should be given independent garrisons, who would not be withdrawn into the redoubt at any period during its defence.

The following arguments are brought against the opinions of the first group:—

(i.). The garrison of a whole battalion is larger than can be usually spared for the defence of one *point d'appui* however important.

(ii.). If a whole battalion is allotted, surely it would be better to increase the size of the redoubt itself, rather than break the continuity of its front by making wing trenches.

(iii.). There would be considerable difficulty in transferring so many men from the wings into the redoubt and back again through narrow openings in the parapet during the later stages of the defence, and there would be danger of the enemy getting in on the heels of the defenders.

(iv.). There would be inconvenient overcrowding in the redoubt when four companies were drawn into a work intended only for two.

(v.). Would not the wing trenches form convenient lines of approach for the enemy up to the parapet of the redoubt? If special obstacles are prepared for closing the gaps caused by these trenches in the ring of obstacles surrounding the redoubt and in the parapet itself, could the men be trusted to close them thoroughly on retirement, and could they remove them equally quickly when re-occupying the trenches?

(vi.). The trenches, in order that they may not serve as cover for the enemy, must be perfectly straight, uninterrupted by traverses or blindages, and enfiladed from the flanks of the work. Under these conditions, in any but perfectly level ground, it would not be possible to get any field of fire from the trenches.

(vii.). Trenches forming part of a redoubt must remain, with the redoubt, silent until the enemy arrives within medium ranges of the work. Would not the extra troops be better posted in separate trenches, where they could bring long range fire to bear upon the advancing enemy without disclosing the position of the redoubt?

Against the use of wing trenches as cover for the garrison of the work during an artillery bombardment the following arguments are brought:—

It is doubtful if the cover obtained in these trenches is really better than that found within the redoubt. It is a mistake to consider the trench as a line and the redoubt as a space; for the redoubt is really nothing more than two lines, and, though certainly more vulnerable than a trench, it is not exceedingly so. Besides this, within the redoubt there can be made all kinds of splinter-proof cover, traverses, etc., while the trench, for fear of its giving cover to the enemy, must be made straight and without any such shelter.

From actual experience no definite decision was arrived at as to which was the safer; sometimes the wings suffered more than the redoubt and sometimes the reverse was the case. With the modern tendency towards careful masking and the difficulty in observing artillery fire there is no doubt that the wing trenches often received hits from shells which were aimed at the redoubt.

If the garrison is removed at all during the artillery bombardment it should be withdrawn to some shelter prepared for it in a fold of the ground in rear of and to a flank of the work, the communication with which must be carefully screened from the enemy's view. But many commanders consider that the risk of delay in re-occupying the work is too great to make it advisable for the garrison to be withdrawn under any conditions.

As to utilising the wing trenches to enable men from the gorge parapet and from the reserve to take part in the earlier phases of the defence, it is urged that, as these men have distinct duties to perform within the redoubt, they should be kept entirely for these duties; otherwise when they are required they may not be in their places. If they could be spared for the additional defence of the front face this face might be increased to accommodate them, but otherwise they should be kept carefully under cover in those parts of the redoubt which are most conveniently situated for their allotted tasks.

This tendency of bringing into the firing line even those troops which should be kept back as a reserve proved fatal on a large scale at Mukden, and it is surprising how quickly that expensive lesson was forgotten. At Sipingai the 3rd Army was at first placed in reserve in rear of the other two, but it was soon brought up to extend the right flank of the main line, which line attained the enormous length of 150 versts (100 miles).

The third party advocated a redoubt with wing trenches permanently occupied, the whole surrounded by a continuous belt of obstacles. But this is only effective against an attack from the front, as the wing trenches can offer no resistance towards the flanks and themselves would mask any flank defence from the work itself. They would therefore defeat the whole object of the closed work.

Even if it were arranged that the garrisons of the wings could be withdrawn to the rear in the later stages of the attack, the obstacles on the flanks would remain at too great a distance from the work for effective defence.

It therefore appears that, in the opinion of the writer, every form of wing trench is bad. But he suggests that, if it is considered necessary to reinforce the frontal fire of the redoubt by any exterior trenches, these trenches should be placed in rear and to the flanks of the redoubt and should be manned by troops not included in the garrison of the work. In fact the 'whisker' should not be a 'whisker' at all, but an 'adjacent' or 'neighbouring' trench to the redoubt.

These adjacent trenches should lie outside the redoubt's belt of obstacles and might be surrounded by obstacles of their own. In the position suggested there would be no objection to their being provided with traverses and splinter proofs.

They should have separate communications with the rear; and, if not provided with special garrisons, might be occupied by the troops who are driven back in the intervals between redoubts.

They might possibly be connected with the shelters, mentioned above, provided for the use of the garrison of the redoubt during bombardment;

so that, if the trenches are not otherwise occupied, the garrison could be transferred into them, moving to one side or the other to escape the concentrated searching fire of the enemy's guns.

When the writer was fortifying the Gunchuling position at the end of the war, he devised a modification of the wing trench as a means of satisfying the order for the universal application of these trenches. In this, each trench consisted of two parts—(1) an inner or wing trench proper, about 40 paces in length, lying within the obstacle belt, and (2) an outer adjacent trench for one company, roughly in continuation with the former, but separated from it by the belt of obstacles and not connected with the redoubt in any way. The inner trench was straight; but the outer one was curved in order to secure a good field of fire, and was provided with traverses and splinter proofs.

F. E. G. SKEY.

REVIEWS.

DES PRINCIPES DE LA GUERRE.

By Colonel of Artillery F. Foch.—(8-vo., price 10frs. Berger-Levrault & Cie, Paris).

This book consists of a series of lectures to students at the French Staff College. It is impossible in a brief précis to do justice to the amount of solid food provided in these lectures, but the main points of the argument may be summarised.

As far as France was concerned there was no rational instruction in War before 1882; because our theories were false. First we had a school which ignored moral factors, whereas defeat is entirely the result of demoralisation produced by the combined and simultaneous application by the victor of moral and material factors. It sought to make War a mathematical science, ignoring the living factor—man. Then there arose another false school which taught:—"Only in War can War be learnt."

War is not a science but an art, "a terrible and passionate drama." In common with every branch of art it has a technique. This technique will not make a genius, but it is necessary even to such a man. To acquire it we must first study history in search of guiding principles. We must persevere in the study of applying these principles to cases, until from this study and experience we adopt the right course automatically and instinctively in any situation. "Il ne suffit pas de connaître les principes: il faut les appliquer, *savoir* et *pouvoir*." To this end we must always take the objective view of a situation, must always consider only "de quoi s'agit-il?"

We must then study the higher functions of war, always by the light of History.

Strategy, according to Moltke, requires the development of mind and character by means of military education and experience drawn from history or one's own life.

Genius creates: its pupils study and codify its work, and are indispensable to genius itself. For example, in 1870 the Prussian staff, unaided by genius, succeeded in manœuvring 3 or 4 armies, a task in which the unaided genius of Napoleon failed in 1812-3. We must grip truths, not accepting them as dogmas, but testing them by the sole criterion of reason, so that we may arrive on the field with a trained mind which applies principles automatically. This needs constant mental exercise. Then learn to think.

The type of War which we study must be one suited to the immediate military policy of the Nation. For France to-day this spells "the Nation in Arms"; the type of War which was born at Valmy, and made France great during the First Republic and the First Empire. We must abandon the old 17th and 18th century schools and study these later wars, not forgetting that War is subject to the law of evolution. There is always a tendency during prolonged periods of peace to hark back to the old style, because manœuvres of necessity emphasise the material factors. We had forgotten Napoleon's teachings and got back to the old style in 1870.

The National War as opposed to the dynastic type was fought first for freedom, then for admission to the comity of nations; now it is for commercial advantages. This war requisitions the whole intellectual and material resources of the nation: demands swift decision by force: its strategy has but one aim—battle. The National War brings in its train methods suited to the national temperament and armies: it abolishes imitative but aimless strategy: it recognises that methods suitable for a long service regular are not necessarily the best for the citizen soldier fighting under the influence of patriotism.*

The only correct strategy is that which aims at a tactical advantage, as opposed to that geographical strategy which considers an advance on the enemy's communications, for instance, as an end in itself. Success is the result of superior moral and material momentum, and demands attention to three points—preparation, concentration, impulse. Motion is the law of strategy. As regards concentration we are forced in practice to form detachments at first for purposes of reconnaissance, security, etc.; and to disperse for marches. The study of the economy of Forces teaches how to reconcile practice and theory.

Carnot first taught and Napoleon practised the right system—Concentrate your efforts against the enemy's main force: seek its annihilation in a decisive battle and relentless pursuit: "contain" him elsewhere with the *minimum* possible force. We must have covering detachments (generically, advance guards) to ensure free play for our main force.

Thus the system becomes that of dividing our forces into:—Advance guards exploiting the quality of resistance, and a main force exploiting the quality of shock.

The lecturer illustrates these principles by a lucid and detailed study of Napoleon's advance into Piedmont, 10th to 17th April, 1796.

In the fourth lecture Colonel Foch develops the study of how to obey. There is but *one man* directing the strategy of a war; his subordinates seek only to carry out the chief's intentions: but the subordinate on the spot (the higher his command the more is this applicable) must decide for himself what are the best means to adopt to this end under the circumstances.

But "discipline does not mean the execution of orders as far as may appear sound . . . or possible; but the free entry into the thoughts

* Colonel Foch doubts the possibility of successful attack by English "mercenaries"; but omits to notice that the English attack does not leave behind it hordes of skulkers, as has been noticed in the case of attacks by "patriotic" soldiers.

of the chief . . . ; the adoption of every means humanly practicable to give him satisfaction. Again discipline does not mean . . . the art of avoiding responsibility; but action in the sense of orders received, and, to that end, mental effort to discover the means; character to adopt the risks of execution . . .

Incapacity and ignorance are not extenuating circumstances; for knowledge is at the door of all who seek it."

To be in a position to execute orders (*a fortiori* to command-in-chief), it is essential to preserve liberty of action in the presence of the independent will of the enemy; "to attack without uncovering yourself, to threaten whilst parrying." This brings us to the study of the service of *sûreté*.* As an arm stretched out in the dark *feels* the way, *secures* from collision, *fastens* on a door handle: so covering detachments must:—

(1) acquire certain knowledge of the enemy's dispositions, on which alone may plans be based (vide letters of Napoleon to Prince Eugene, 1809)

(2) secure for the main body the time and space necessary for the preliminary manœuvres in execution of this plan (concentration on decisive point, deployment, etc.)

(3) *hold the enemy to the dispositions on which those plans have been based, until they can be developed.* This means piercing his covering detachments, and establishing contact with his main body; attacking it probably.

The principal *means* to this objective are long range fire: hence a preponderance, and free use, of artillery are essential.

These principles are well illustrated by a series of critical studies (descending frequently to the detail of the action of the companies) of advance and flank guard operations: including the "immobilisation" of Garibaldi's corps by von Kettler's brigade, January, 1871, and the battle of Nachod, 27th June, 1866.

The use of covering forces for strategic *sûreté* is also studied; the action of Ziethen's corps, covering the concentration of the Prussian army on 15th June, 1815, is considered in detail; the critical position of the IInd German army on the 16th August, 1870, is shown to be the result of a go-as-you-please order based on hypothesis not on *sûreté* obtained by a strategic flank guard.

Then in a critical study of Lannes' action at Saalfeld (10th October, 1806) Colonel Foch shows how this illustrates clearly all the fundamental principles of a decisive battle:—

(1) The six hours' *preparation* covered by the advance guard ($3\frac{1}{2}$ battalions, 9 squadrons, 2 guns), which drove in the hostile outposts and seized the *points d'appui* next the enemy on a front of 3,900 yards, whence it reconnoitred, contained, and held the enemy's main body. Screened and covered by this, the main

* This word is untranslatable in the sense given it by Colonel Foch, who at length and repeatedly explains that, as used by him, *sûreté* means the *material security* necessary for the free development of the plan of the chief, *plus* the *certain* knowledge (of the enemy's dispositions up to the moment of the decisive attack) on which alone such plan can be based.

body (9 battalions, 10 guns) manœuvred for the decisive attack; disposing 2 battalions in support of the frontal attack, 2 as a flank guard, and 5 on a front of 1,500 yards for a main attack. The direction chosen for this main attack was against the enemy's sensitive flank, and over ground with defiladed approaches, but free from obstacles and giving room for the attack.

(2) The attack was launched with speed and suddenly, and therefore as a surprise; the whole force (flank and frontal attack in close co-operation) except two guns was engaged in it.

(3) The victorious troops were at once reassembled, and a relentless pursuit undertaken.

From this Colonel Foch develops his theory of the modern battle, which, he considers, will take the form of a long preparation, consisting of a progressive series of actions for *points d'appui*, each such action being a miniature battle in itself, and involving the application of the same principles. The execution of the decisive attack will generally be against a flank.

There is nothing, of course, in all this which is not inculcated in our own *Combined Training*. But these lectures give, as a condensed Training Manual cannot give, the reasons for the principles; and so form as it were an introductory study to *Combined Training*. Colonel Foch's views on the rôle of artillery, given in the final lecture, will be found worthy of study.

J. W. S. SEWELL.

POCKET-BOOK OF AERONAUTICS.

By MAJOR H. W. L. MOEDEBECK; *translated by* W. M. VARLEY.—($6\frac{1}{2}'' \times 4\frac{1}{2}''$. 10s. 6d. Whittaker).

It is satisfactory to find that an English edition of this excellent pocket-book has at last been issued. It is a most useful work, giving a large amount of general information about Aeronautics, and may almost be considered an elementary treatise on the subject. The sixteen chapters into which it is divided are written by well-known authorities on the points dealt with, and the Appendix contains many useful tables, revised and adapted by the translator for the use of English readers.

One very satisfactory detail is the number of references given to books, papers, etc., on Aeronautics; and on this account, if for nothing else, the pocket-book will be found most useful, as almost every well-known author is referred to and the exact title of his writings given.

Taking the chapters in order:—

Chapter I., on Gases, describes their physical properties, characteristic equations, etc. In a technological section, the gases specially useful for balloons are discussed in detail, with the method of preparing them. Some useful notes on the inflation of balloons are included in this section.

Chapter II., Physics of the Atmosphere, is a general account of the properties of air, its pressure, temperature, general circulation, etc., and there is a brief note on weather forecasting.

Chapter III., Meteorological Observations, is chiefly devoted to the work done in manned balloons, and draws attention to the importance of having a definite system for recording the results obtained. Very little is said about the use of *ballons sondes*, kites, etc., but this subject is dealt with to a certain extent in other parts of the book.

Chapter IV., the Technique of Ballooning, is one of the best in the book, and, as far as the ordinary spherical balloon is concerned, goes into the subject most thoroughly. Formulæ useful to the designer are given, as also full details of the materials used, their strength, etc. The chapter is well illustrated, one of the most interesting diagrams being that of the Parseval-Sigsfeld kite balloon, used in the German and other armies.

Chapter V., on Kites and Parachutes, commences with a brief historical account of these machines, and then describes the details in connection with them. There are numerous diagrams showing different types of kites, such as the Lamson, Hargreaves box kites, etc., and much general useful information. The method of using kites in teams is described, and the chapter finishes with some details of parachute design.

Chapter VI., on the Theoretical Principles and Practice of Ballooning, is divided into two parts. In the first full details are given as to the lifting power, equilibrium, etc., of balloons; while in the second everything connected with the practical working of these machines, such as inflation, duties of conductors, landing, etc., is discussed. Even balloon sports are described, and rules for handicapping given.

Chapter VII., on Balloon Photography, describes in detail the style of camera, lens, etc., required, and there are useful hints as to the best method of using such apparatus.

Chapter VIII., on Photographic Surveying from Balloons, is a somewhat elaborate one, and gives a good deal of information about a very difficult subject.

Chapter IX., on Military Ballooning, describes the organization of the balloon service in the principal armies of the world, and gives a sort of brief diary of the development of military ballooning in each of them. In the section devoted to the British Army, the work done by the Balloon Sections in Egypt and S. Africa is described pretty fully, and the recent use of Cody's kites commented upon. In the French section there is a complete list of the balloons which succeeded in getting out of Paris in 1870–71, with full details as to the length of the voyages made by them. The "Lebaudy" is only briefly alluded to, as it is described more fully later on. It is interesting to find that the Japanese used kites in fortress warfare in 1869, the results as far as observation was concerned being very satisfactory.

The rest of this chapter is devoted to military applications of ballooning, and there are some notes on firing at balloons, throwing out shells from balloons in motion, etc.

Chapter X., on Animal Flight, is a brief one. Such an important subject cannot be adequately dealt with in four pages, and it is to be hoped that in future editions a much more detailed account of this interesting branch of Aeronautics will be given. There is a serious error on page 273. The formula, Section 3, para. 2, should read $\frac{F^{\frac{1}{2}}}{p^{\frac{1}{2}}} = \log \sigma$ (see *Le Vol des Oiseaux* by Marey, p. 82).

Chapter XI., on Artificial Flight, is divided into three parts. The first gives a brief account of the principal "Soaring Machines" up to the time of the Lilienthals; the well-known memorandum by Otto Lilienthal forms the second; while the third gives detailed information about the work of Pilcher, Chanute, the Brothers Wright, etc. The chapter is well illustrated, and the section on "Computations" gives some elementary ideas on the mathematics of Flight. The important question of the position of the "Centre of Pressure" is alluded to, and some few details of experiments on this branch of the subject are given; but future editions should contain more information, as this question is one of the first importance.

Chapter XII., on Flying Machines, is the most important in the book. It deals with the pressure of air on surfaces, and gives useful formulæ for calculating lift, etc. Hardly sufficient attention, however, is paid to the work done by Langley, whose remarkable and carefully conducted experiments do not seem to be quite appreciated. The results obtained by him do not, it is true, altogether coincide with those of von Loessel, quoted by the author, but they agree remarkably well with the work done by Duchemin and Kummer and are certainly deserving of more than a passing notice.

The chapter concludes with a brief account of the principal flying machines from Penaud to the present date, and some useful Aeronautical calculations.

Chapter XIV., on Motors, gives a great deal of valuable information; but tables giving details of fuel consumption, weight, floor space, etc., of different kinds of motors, likely to be used in aeronautical work, would be an improvement.

Chapter XV., on Air-screws, follows the conventional theory of screw propulsion. While a good deal of information is given about screws of different kinds, there are no diagrams showing the actual form of those referred to on pp. 432 and 434, and consequently it is very difficult to check the results given in the tables. An efficiency of only 34 per cent. seems to be extremely low for the flat-bladed propeller described on the latter page.

Chapter XVI. gives a list of the various Aeronautical Societies, and the fact that the Aeronautical Society of Great Britain is the oldest in the world is duly noted.

The *Appendix* contains a number of tables and other information useful to aeronauts

J. D. FULLERTON.

NOTICES OF MAGAZINES.

Revue du Génie Militaire.

February, 1907.

The Lebaudy Balloon of 1905.—The envelope of this dirigible balloon was made of two thicknesses of cotton with a layer of indiarubber between. A coating of rubber was also given to the interior to protect the cotton from the impurities in the hydrogen gas.

The balloon was 57·75 mètres long, and its greatest diameter was 10·3 mètres. It held 2,950 cubic mètres of gas. To prevent the balloon from pitching it was given a horizontal bilge keel round the stern, constructed of cotton stretched on a frame.

On the 3rd July the balloon started on a voyage. The first day it made 95 kilomètres in 2 hours 37 minutes. It was anchored in the open for the night, head to wind. The car was weighted and rested on a central pivot. In order to guard against any change of wind, it was necessary to provide anchorages all round the balloon to which the painter might be attached, if required. A party of about fifty men were employed in looking after the balloon while it lay at anchor. On the second day the balloon made very little progress owing to strong winds and frequent bursts of sunshine, which caused the balloon to lose gas. On the 6th July the balloon reached Chalons, but before it could be securely anchored a gust of wind drove it against some trees, and wrecked the envelope.

By the 8th October the balloon had been reconstructed. Various ascents were made at Toul and the neighbouring fortifications reconnoitred. The greatest height attained was 1,370 mètres above sea level.

The Artillery Barracks at Halle.—These barracks were built in 1902 and are considered to be the best in Prussia. They cost £120,000, and provide accommodation for three batteries of artillery including officers. Nine men occupy each room. The floor space works out to 48 square feet, and the air space to 550 cubic feet, per man. The beds are arranged in two tiers. The officers' mess consists of a dining room, with a gallery for the band (which plays during dinner on guest nights), a smoking room, and a library.

Photographic Reconnaissance.—The principle advocated by the author is that a special wide-angle instrument should be used in taking the photographs from which it is intended to locate the enemy's works. It will then be possible to include on one plate at least three known points, situated at a considerable angular distance apart, from which the position of the camera may be accurately fixed on the map, and the bearing of a large number of works ascertained. A second photograph taken from a new position will then give a cross bearing for each point that appears on both plates, and so fix its position.

The telephotographic camera, which has only a very limited field, should be reserved for the details of the works themselves. The article will be continued.

J. E. E. CRASTER.

RIVISTA DI ARTIGLIERIA E GENIO.

February, 1907.

NOTES ON IMPROVISED FORTIFICATIONS.—By Capt. Cardona, General Staff.—Of two instructional books on fortification, namely *Instruction in Field Fortification* (which forms part of the practical instruction of the engineers) and *Instruction in Work of the Sapper for the Infantry*, it is interesting to examine the last, which represents an unique guide to the infantry for the improvised fortifications which they may occupy.

We may refer to the following points:—

(*a*). The means necessary to-day to satisfy the requirements of improvised fortifications.

(*b*). The character of the works in relation to tactics.

(*c*). General rules for the execution of the works.

(*d*). Rules for the employment of sappers' tools.

(*e*). Methods for adapting natural shelters or defences.

(*f*). Some types of entrenchments which would fulfil the required conditions, methods for tracing them, and models for their construction.

(*g*). Rules for constructing hasty entrenchments and artificial obstacles, and for masking the works.

With regard to the first point, while twelve years ago it may have been admissible that entrenchments were only necessary for the defence, to-day we must hold that such works are equally required for the attack, and that the use of sapper entrenching tools should accompany the use of the rifle whenever the ground does not offer natural shelter.

The general rules of a tactical-technical nature for instruction should teach the necessity of the simplest works, hastily constructed, adapted to the ground, indiscernible from a distance, and always in accordance with the tactical idea.

The rules for instruction in the use of sappers' tools should tend to make known the best way of adapting them for the more difficult conditions of service—under fire from the enemy—so as to obtain the greatest advantage with the least expenditure of labour and with the least danger.

With regard to the adapting of natural shelter—improperly called obstacles in the instructional treatises—it is thought that precedence should be given to such adaptation of the ground (when possible) over works of shelter artificially constructed.

The types of trenches described in the instructional books are generally proscribed for the following reasons:—

1. The defender cannot fire conveniently. The internal slope of the parapet should be about 2/1 to allow the firer to rest conveniently against the parapet.
2. The parapet is too high for concealment from the enemy's view. It should not be more than $\frac{4}{6}$ths of a mètre—as in the recent Boer and Japanese wars—because a greater height renders it too visible from a distance.
3. The depth of the trench for a man standing should be about $\frac{4}{5}$ of a mètre.
4. The excavation of earth is usually excessive on account of the excessive size of the parapets and width of the trenches. For ordinary earth a height of about 1 mètre should be sufficient, and the width of the excavation at the foot of the trench should not be greater than 1 to 1·2 mètres.

The types adopted for the trenches should be few and simple, and the soldiers should have clear and practical ideas as to their construction with the least possible fatigue, and for adapting them to the various circumstances of time and of the ground. It may be noted that during the last war the Japanese made use of two kinds of shelter:—one type, for 1 or 2 men lying down, consisted of a simple isolated heap of earth, height 25 to 45 cm., sheltering the head and shoulders, the earth being taken from one or two little lateral trenches; the other type, for a firing line on foot, was a simple trench about $\frac{4}{5}$ths of a mètre deep, width at bottom $\frac{1}{2}$ mètre, with a parapet about $\frac{2}{5}$ths m.

With regard to the necessity of masking the works several measures may be adopted:—

Prevent the tracing or relief showing on the horizon;

Assimilate the appearance of the work with that of the surrounding ground, covering the parapets with clods, branches, leaves, etc., of the same colour as that of the ground;

Keep in front of the works rows of trees, hedges, cultivation, etc.;

Make use of concealed trenches in front of the masked works, at a distance of 100 to 200 m.

As to the progress and direction of the work, the rules should be framed with great simplicity, and should leave to the commander of the troops great latitude.

The following order of precedence may be allotted to works:—

1st, those that tend to increase the efficacy of our own fire,
2nd, those that are of value in protecting from the enemy's fire,
3rd, those that tend to facilitate our own advance,
4th, those that tend to offer obstacles to the advance of the enemy.

With regard to the employment of sappers it would be convenient that the commanders of the large units should consult and take the opinions of the commanders of the engineers, allotting to the sappers the works of a less simple character—demolitions, communications, etc.—for which works the engineer officers should, where possible, be in agreement with the commanders of the detachments of infantry directly interested. It may sometimes happen that detachments of engineers may be required to be employed on works depending upon the plans of the officers commanding the infantry troops, such as the strengthening of a position, etc., and it is not impossible that disagreements should occur between the engineer and infantry officers. It should not be difficult to prevent such disagreements, if it were left to the infantry officers to determine *where* and *when* to execute any work and to the engineer officers to settle *how* such work should be constructed. If, notwithstanding this definition, disagreement should arise between the tactical commander and the technical director regarding the progress and execution of the work, whatever may be the difference in rank between the two officers, the dispute should be referred to the superior officer in command of the operations whose duty would be to decide on the question.

To the end that the drill and training of the troops in constructing improvised fortifications should be as perfect as possible it is indispensable that they should have frequent opportunities for exercise and for becoming familiar with these duties.

EDWARD T. THACKERAY.

VOËNNYI SBÓRNIK.

August, 1906.

DESTRUCTION OF JAPANESE SEA MINES AT PORT ARTHUR. — Operations commenced immediately after the loss of the *Petropavlovsk* (13th April, 1904) and continued until September or October. The greatest depth of any battleship in Port Arthur did not exceed 30 feet.

The chief method employed was "sweeping." Ten weights (lead or cast iron) were fastened, at a depth of from 42 to 49 feet, by steel ropes to 10 small casks, which were spaced 70 feet apart and connected by a steel hawser. The two casks at the ends held $13\frac{1}{2}$ gallons (5 vedros) while the remainder were only 8·1-gallon (3 vedros) ones. The two outside weights were 144 lbs. (4 poods), and the inner ones 72 lbs. (2 poods). From the end weights two tow-ropes, 350 feet long, were led to two steam cutters, which steamed ahead at a distance apart of 700 feet, thus sweeping the water. When the trawl struck the anchoring cable of the mine, the mine exploded.

Frequently, however, the mine was not exploded, the trawl breaking the anchoring cable of the mine, and causing it to rise to the surface. The mine was then destroyed by gun-fire from the 37-mm. (about $1\frac{1}{2}$ inches) Hotchkiss guns on the steam cutters. Sometimes however the trawl slipped over the mine, and to prevent this four-fluked grapnels were fastened to the trawl rope.

Destroying mines by gun-fire was rather expensive, so in many cases they were towed to the shore and then destroyed by rifle fire. The bullet easily pierced the shell of the mine and set fire to the melinite, which commenced burning, emitting large volumes of black smoke, and finally exploded. This system prevented damage being caused to the trawl, and there was not an unlimited supply of rope in Port Arthur. Some mines blew up on touching the shore, so that great caution was required in dealing with them.

In view of the shortage of explosives many of the mines were emptied instead of being blown up. This was a task demanding much precision and coolness, and was always carried out by an officer, the rank and file being posted in as safe a place as possible. The danger was due to the ends of the trawl, being washed about by the surf and waves, striking the mine and sometimes causing the vibrator to close the circuit. In approaching the mine, therefore, it was necessary to choose a moment when the waves were receding from it. The first thing to do was to screw up the mechanism. While tightening up the spring, you had at the same time to turn the endless screw, thus separating the shackle from the splitted piece, by which means the conductor was disconnected and the mine rendered harmless. You could then take off the upper lid, and, cutting the lead, proceed to empty the mine. The anchoring cable of the mine was used for mending the trawl, which required constant repairing as every explosion of a mine through its agency damaged a quarter and even half of it.

At first only two pairs of steam cutters were employed in trawling, but eventually, as the number of mines increased, a whole fleet of trawlers, consisting of eight dredgers, long-boats, cutters, and rowing sloops was utilised. For protecting this fleet a gunboat and 2 or 3 torpedo-boats used to be sent out into the roads.

Two sorts of trawls were employed, in order to clear respectively the deeper and the shoal waters. The system was the same in both cases, the weights and sizes for the heavier being as above described; the dragging was done by dredgers, drawing 7 to 8 feet, and steam pinnaces. The lighter trawls were only 350 ft. wide, the weights at the extremities being 72 lbs. and in between 36 lbs. In taking the trawls out of the water, on completion of the work, it was necessary to exercise great care, as mines sometimes got entangled in the trawl and on knocking against the sides of the tugs were liable to explode. This actually happened in one case, and a dredger was sunk, being with great difficulty dragged just in time out of the fair way.

It was impossible of course to sweep the whole of the roads, and so only a strip 6 miles long and 470 yards wide approximately was cleared. The enemy was bluffed as much as possible regarding the position of this strip, by sending out the trawling parties in various directions, some of which did not actually do any work.

Trawling near the shore was rendered necessary occasionally owing to some of the Japanese mines breaking loose. This was rendered very difficult, as the trawls used to interfere with the observation mines laid by the subminers, who consequently did not regard the work of the sister service with a very friendly eye.

Counter-mines were tried, but proved a failure. Mines loaded with 180 lbs., 360, and finally 540 lbs. of pyroxiline were used, but gave no result to speak of. At a distance of from 50 to 100 feet from the site of the explosion, the trawl discovered at a depth of from 14 to 28 feet unharmed Japanese mines.

The work of trawling for mines was intensely exhausting, and the strain on the nerves much more tiring than that imposed on the men manning the defences or on the ships.

C. G. FULLER.

February, 1907.

NOTES ON THE ARTILLERY DEFENCE OF PORT ARTHUR.*—The writer of this article considers that too little attention has hitherto been paid to technical matters in connection with the siege, and, himself an artillery officer, proceeds to give the results of his observations.

On the sea front there were 22 batteries situated to the right and left of the harbour. Of these only 9 were really effective, namely: four batteries of 6" Kanet guns (Nos. 2, 9, 16, and 22), one 10" battery (No. 15), two 9" batteries (Nos. 5 and 17), and two batteries of 6" guns of 63 cwt. (Nos. 11 and 18).

No. 1 Battery was intended for 57-mm. coast defence guns, for firing on torpedo-boats and landing places, but actually contained two 47-mm. guns.

No. 2 contained five 6" Kanet guns.

No. 3, two 57-mm. guns, two others having been removed for the defence of the land front.

No. 4, eight 9" howitzers and one 57-mm. gun for ranging. Four howitzers were removed during the siege for the defence of the land front.

No. 5, four 9" guns of 1867 pattern.

No. 6, eight 9" howitzers.

No. 7, four 11" howitzers.

No. 8's two screw guns were removed during the siege for the defence of the land front.

No. 9 contained five 6" Kanet guns.

No. 10, called "Artillery Battery," contained six 6" guns of 63 cwt. and two 57-mm. coast defence guns for ranging. One 6" gun was removed during the siege and mounted near the lighthouse for firing on landing places; another 6" and the two 57-mm. guns were removed for the defence of the land front; towards the end of the siege only 2 guns were left.

No. 11 contained two 6" guns of 63 cwt. and two 120-mm. naval guns; it was called "Lighthouse Battery." The naval guns were served by sailors.

Between No. 10 and No. 11 Batteries two 2-screw guns had been

* Compare the account from the *Organ der Militärwissenschaftlichen Vereine* in the November, 1906, number of this Journal.—EDR.

placed near a projector, but they were removed at the beginning of the close investment.

No. 12 Battery was situated on the left side of the entrance to the harbour; it consisted of eight 57-mm. coast defence guns for firing on landing places. The guns were all removed at the beginning of the close investment for the defence of the land front.

No. 13, known as "Golden Hill," contained six 11" howitzers.

No. 14 had four 57-mm. coast defence guns for firing on landing places. All the guns were removed for the defence of the land front at the beginning of the close investment.

No. 15, called "Electric Crag," contained five 10" guns and two 57-mm. coast defence guns for ranging.

No. 16, "Camp Battery," contained five 6" Kanet guns.

No. 17, "Two-Horned Battery," contained eight 9" guns.

No. 18, "Flat Battery," had six 6" guns of 63 cwt. and two 57-mm. coast defence guns for ranging. In type it was similar to No. 10. By the end of the siege all its guns had been removed.

No. 19 contained no guns. It was built with its front facing the entrance to the harbour and almost at right angles to the fronts of all the other batteries; this was with the idea of its opposing torpedo boats and even larger craft endeavouring to force the entrance to the harbour.

No. 20, contained six 9" howitzers and two field guns of 1877 pattern. Later on all the howitzers were removed and a 24-cm. gun mounted instead.

No. 21 was armed with six 9" howitzers and two 57-mm. coast defence guns for ranging.

No. 22 had five 6" Kanet guns. This battery was constructed during the war and formed the extreme left flank of the defences.

As regards construction Nos. 2, 9, and 16 Batteries had concrete foundations, traverses, and magazines covered with earth. No. 13 was similar in construction, but without the earth covering and the concrete was thicker. No. 15 was of concrete with thick arches to the casemates. Numbers 19 and 21 were also of concrete. These are all the details given.

The only guns of any actual value for defence purposes were the Kanet guns, the 10" guns, and the 6" guns of 63 cwt.

The total nominal armament was therefore :—

10" guns...	5
9" guns	12
6" Kanet guns	20
6" guns of 63 cwt.	14
57-mm. (2·2") guns (for ranging)	8
57-mm. (2·2") guns (for use against landings)	12
Field guns	6
24-cm. (9·4") guns	1
12-cm. (4·7") guns	2
	79*

* The author appears to have made a mistake of 1 in his addition.—A. H. B.

Total guns:—heavy	... ...	18
medium	.. ..	35
light	... ...	26
		79
Add 11″ howitzers	... .	10
9″ howitzers	... ...	23
		33
Grand total armament	... ...	112 pieces.

After the first few engagements the respective effectiveness of these various weapons became apparent.

The howitzers were the first to prove useless. They had been mounted on the highest points, so that fire could be brought to bear on the decks of vessels and the inner roadstead rendered inaccessible. But owing to the mobility of the enemy's vessels, fire from the howitzers was quite ineffectual.

As regards the 26 light guns, these were used on the three occasions when the Japanese attempted to block the fairway. An examination of the vessels sunk revealed the very slight destructive power of these weapons; consequently they were considered useless for coast defence purposes, except in case of attempted landings.

Leaving the 33 howitzers and 26 light guns out of account, only 53 medium and heavy guns remain, and of these the 9″ and the 6″ of 63 cwt. proved to be too slow in firing and also not sufficiently powerful as regards range to be effective.

Hence the 10″ and the 6″ Kanet guns, 25 in all, formed the total effective armament available, about equal to that of any Japanese ironclad. It proved sufficient, however, to keep the hostile ships at a respectful distance from Port Arthur, even after the distruction of the Russian fleet on November 27th. From January 27th to December 19th the Japanese fleet did not make a single attempt to crush the batteries.

The 10″ battery (No. 15) fired on January 27th and made some successful practice; but as a rule this battery was not often used, as the larger vessels never came within range, and the smaller craft and torpedo boats were not worth the expenditure of 10″ shells. When the close investment began the 10″ guns fired across the town at the siege batteries.

Most of the work fell to the lot of the batteries of 6″ Kanet guns (Nos. 2, 9, 16, and 22). They fired indifferently on the sea and on the siege batteries. They were nearly identical as regards field of view, equipment, and trace.

An account is given of the work done by No. 2 Battery, as being typical of the work done by the others. It was situated on the extreme right. When the Japanese fleet appeared on January 27th it was found to contain no ammunition except twelve practice shell filled with sand, so ammunition had to be brought from No. 9. From January 27th till December 19th the battery fired 1,444 rounds; when the town surrendered there were still remaining 92 cast-iron and 51 steel shells. A list is given of the various kinds of shell expended :—

Common cast-iron shell	279
Naval " " "	313
Steel shell	275
Naval steel shell (pyroxiline)	355
Segment shell	212
Instructional shell	10

Steel and cast iron shell appear to have been supplied in about equal quantities and to have been used indifferently. Pyroxiline shells were mostly used against siege batteries. The writer considers that the Japanese were correct in their estimate of the value of high-explosive shells and that the Russian supply of this kind of shell might well have been larger.

Cast-iron shell were most popular after pyroxiline shell; a supply arrived towards the end of June, and some were borrowed from the Navy.

Segment shell were a good substitute for shrapnel, and in all the batteries they were used as such; they were nearly all expended on living objects.

Out of the 1,444 rounds expended, 657 were fired in land defence and 507 in coast defence, the large number of the latter being accounted for by the fact that Japanese torpedo boats continually approached the roadstead and carried out reconnaissances nightly.

The 657 rounds expended on land defence were used as follows :—

Against 2 Japanese batteries and troops assaulting ...	143
Against troops assaulting	491
Against a dummy battery	23

From August 7th till December 9th, *i.e.* in the course of 134 days, 343 rounds were fired at siege batteries, an average of 2½ rounds per diem. This was an inconsiderable amount when it is remembered that the Japanese batteries were firing daily and, before the assaults, at night as well, and one which could have produced but little effect. The occasions on which an enemy's battery was silenced were rare, and were probably to be accounted for by the accidental dropping of a shell into a magazine or onto a gun.

There follows a list of shells expended against troops assaulting "High Mountain" on September 6th to 10th and on November 22nd—405 in all. During assaults an alternating fire was kept up on siege batteries and assaulting columns. The number of shells fired on these occasions naturally decreased as the supply became exhausted; in the August assaults 40 shells were fired, in the assaults from 6th to 10th September 352, from 12th to 19th October 158, from 13th to 17th November 53, and on November 22nd, when "High Mountain" fell, 53. The small number of shells fired in the August assaults shows that at that period the land batteries were still able to hold their own against the siege batteries and assaulting columns.

The longest range at which an accurate fire could be brought to bear on the siege batteries was 10½ versts (12,250 yards).

March, 1907.

RECOLLECTIONS OF THE SIEGE OF PORT ARTHUR.—The writer gives an account of his experiences in setting up search lights at Port Arthur. Traction engines and boilers from steam pinnaces had to be used for generating steam; dynamos and projectors were taken from naval vessels. In the section of which the writer was in charge a steam roller was used; the wheels were fixed on wooden shoes which were let into the ground up to the axles, and crib-work was built under the fore part. It had to work two dynamos, one for a 75-cm. projector, the other for a 40-cm. projector. The flywheel of the engine served to run the dynamo of the former; and the dynamo of the latter was run by an engine (taken from a steam pinnace) worked by steam from the boiler of the steam roller. After the first trial it was found necessary to steady the engine by concrete filling round the wheels, to resist the vibration caused by the rapid revolution of the flywheel. The writer gives details of the construction of the lights, and states how they were used for signalling at night by long and short flashes.

Some details are given about the land mines used at Port Arthur. An experiment was first carried out with an old submarine mine containing a charge of 120 lbs. of pyroxiline, wooden dummies being set up at distances of from 20 to 50 paces; the experiment showed that only the dummies within a radius of 30 paces were injured, but was on the whole considered satisfactory.

Most of the observation mines appear to have been made from the explosive portions of Whitehead torpedos. There was a deficiency of insulated wire, so in some cases an aerial line of bare copper wire had to be used, and this was naturally unsatisfactory. The writer considers that leads for observation mines should be laid at a depth of 3 to 4 feet for sake of protection from splinters, etc., and that measures ought to be taken to prevent the explosion of mines by lightning. During a thunderstorm 70 per cent. of the mines were exploded.

For the explosion of contact mines the following device was employed. The charge contained in a wooden box was set in a small hole in the ground; the detonating cap was fixed in the top of the charge with a nail in it point downwards; a small knob, held immediately above the nail by a spring, projected through the top of the box; above the latter was a board concealed by earth, one end resting on firm ground and the other weakly supported. When the board was trodden on the supports gave way and the nail was driven by means of the knob against the fulminate in the cap. Sometimes a thin board was used supported at both ends; it bent under a weight and produced the same result.

The writer gives some account of the wire entanglements used. They were of the "high" variety, but made in a rather haphazard fashion; they were usually 15 to 20 feet wide and from 100 to 200 paces in front of the trenches. Electric entanglements were tried, but were not of use in practice as the wires were always being cut by splinters. An experiment carried out on a mule was entirely successful.

A. H. BELL.

CORRESPONDENCE.

PREVENTION OF CONDENSATION IN UNDERGROUND MAGAZINES.

SIR,

On reading the excellent paper by Lieut.-Colonel Ward, R.E., in the April number of the *R.E. Journal*, on the "Prevention of Condensation in Underground Magazines," it struck me that the proposals made in it were not unfamiliar; and getting down an old book called *Permanent Fortification for English Engineers*, by Major J. F. Lewis, R.E., published in 1890, I found the following sentences (p. 172 *et seq.*) :—

"It is necessary to have large ventilators which shall be capable of being readily opened and closed by the magazine man, according to the weather; and the openings into the magazine should be so placed as to ensure a thorough current of air passing through the magazine when they are open" . . .

"The ventilating shafts should start from the end opposite the door."

"The 9-inch glazed earthenware pipes which are often used are too small, . . .

"A better form, where there is room to carry it out, is a brick shaft about 2 feet 6 inches square in section," . . .

"A shaft of this nature has been tried on a large and damp magazine with excellent results."

I would submit that this is the same as Colonel Marshall's "revolutionary" system, described by Lieut.-Colonel Ward.

It is interesting to hear that the arrangement has been again tried with success. In time it may even be adopted generally.

I may be pardoned for thinking that this shows that *Permanent Fortification* is not yet entirely obsolete, and that it may be found to contain other useful hints for my brother officers, for whose benefit it was written.

I am, etc.,
J. F. LEWIS,
Colonel, late R.E.

The Editor, "R.E. Journal."

RECENT PUBLICATIONS.

Training Manual—Signalling. Official. (5 × 4. 6d. Wymans).

Guide to Military History for Military Examinations. Part III. Peninsular War, 1813-14: Wellington's Campaign in the South of France, 1814 to end of War, by Capt. G. P. A. Phillips. (7½ × 5. 2s. Gale & Polden).

Bush Warfare, by Lieut.-Colonel W. C. G. Heneker, D.S.O., Connaught Rangers. (8½ × 6. 6s. Rees).

Napoleon's Conquest of Prussia, 1806, by F. Loraine Petre, with an introduction by F.M. Earl Roberts. (9 × 6 12s. 6d. Lane).

Erinnerungen aus meinem Berufsleben, 1849 bis 1867, von Freiherrn v. Loë. (Deutsche Verlags-Anstalt, Leipzig).

1870. La Perle de l'Alsace, par Ernest Picard, chef d'escadron d'artillerie breveté. (3.50 frs. Plon-Nourrit, Paris).

Erlebnisse und Erinnerungen aus dem Russisch-Japanischen Kriege, von Friederich v. Nottbeck, reservefähnrich der Russischen armee-infanterie. (Wigand, Berlin).

Two Years on Trek. Being some Account of the Royal Sussex Regiment in South Africa, by the late Lieut.-Colonel Du Moulin, edited by H. F. Biddar. (9 × 6. 10s. 6d. Murray & Co.).

The Natal Rebellion of 1906, by W. Bosman. (7½ × 5½. 5s. Longmans).

La Guerre et le Mouvement Economique, leurs Relations et leurs Actions Reciproques, par Bernard Lerrigny, capitaine breveté d'état-major. (Lavauzelle, Paris).

The Life of Wellington. The Restoration of the Martial Power of Great Britain, by the Right Hon. Sir Herbert Maxwell, Bart, M.P. 6th edition, complete in one volume. (9 × 6. 18s. Sampson, Low).

Instructions Ministérielles relatives à l'Emploi du Béton Armé. Commission du Ciment Armé: Experiences, Rapports, et Propositions. (4to. 27.50 frs. Dunod, Paris).

Mars and its Canals, by Prof. Percival Lowell. (10s. 6d. Macmillan Co., New York).

Letters from the Far East, by Sir Charles Eliot, K.C.M.G. (9 × 6. 8s. 6d. Arnold).

The Truce in the East and its Aftermath. Being the sequel to "The Re-shaping of the Far East," by B. L. Putnam-Weale. (9 × 6. 12s. 6d. Macmillan).

A Cruise across Europe, by Donald Maxwell. (9 × 5½. 10s. 6d. Lane).

The Desert and the Sown, by Gertrude Lowthian Bell. (9 × 6. 16s. Heinemann).