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CONTENTS.

CONTENTS.

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TRESTLE BRIDGING

Launching a Trestle by Floating Derrick.

TRESTLE BRIDGING.

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

AN apology is perhaps due for a paper on a subject with which most R.E. officers are well acquainted. It is probably enough to say that the experience here related has not elsewhere been published, and has generally been found successful. The results of experiments in a great many fieldwork and other courses are given.

There is no doubt that although increased knowledge is gained every year by individuals in their training, much of it is lost to the Corps through non-publication. It would be of great value if the new methods tried in all our fieldwork courses were systematically collected and published every year.

The use of trestles is so predominant in military bridging that any substantial advance in methods of construction and erection should be recorded. The text book, although carefully written in this branch, as in all others, has given no new information for some years.

The present article deals principally with methods of erection. This is undoubtedly the most important part of the subject, since the time of making the bridge is generally ruled by the time of placing the trestles. Trestle bridging is rarely difficult, and there are usually plenty of men to carry out the important bridges, or plenty of time to build less urgent ones. But with an army at the front time is always of the first importance. Any number of trestles can be *made* simultaneously, but they can rarely be *placed* more than two at a time. The rate of placing the trestles therefore rules the rate of building the bridge, and moreover it is in placing the trestles that such natural difficulties as exist will be found.

The parts of the subject will be treated in the order in which they are encountered in the field, viz.:—

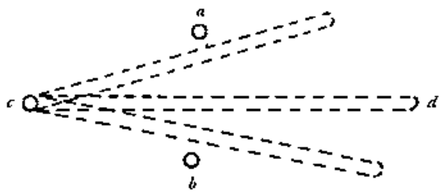
(1). Taking the section.
(2). Construction of trestles.
(3). Organization of the bridge party.
(4). Method of placing trestles.

And notes on

(5). Rapid pile-driving.
(6). Gabion bridges.

(1). TAKING THE SECTION.

The centre line of the bridge must first be marked out by two tall permanent pickets on shore, well in rear of the shore transom. Three pickets *a, b, c,* should then be driven to form a triangle in plan, as in the sketch (*cd* is the centre line of the bridge). *a* and *b* are levelled and a batten laid across them ; *c* is driven to the level of the top of the batten on *ab*. A field level can then be laid as shown by the dotted lines, so as to sight on any position of a trestle leg.



This method is simpler than the use of boning rods, which are not carried on service. The readings may be taken on any pole ; where the difference of level is great the pole may be slid up a 6-foot rod till its top is level with the field level. The depth of the top of the shore transom below the field level must of course be deducted from every reading.

The levels of the points where the feet rest are those required, and it must be borne in mind that the deeper the gap the further apart will be the feet of the trestle ; they will be at a distance each side of the centre line of the bridge equal to $\frac{1}{2}$ (clear width of roadway + 2 feet* + $\frac{1}{3}$ difference of level between top of transom and foot of leg).

In taking a section in water the following party is needed :—

On Shore.

1 man reading heights along the field level.
1 man holding measuring tape to give distance of boat from shore transom.

In the Boat.

2 men holding the boat in position at right angles to the centre line.
1 man holding the measuring tape and an offset rod for measuring horizontal distances each side of the centre line.
1 man holding the vertical staff on which the heights are read.
Total, 6.

As soon as the difference of level between the shore transom and the surface of the water is known, all subsequent levels may be found by soundings (if the water is smooth and there is no tide) without the use of the field level.

* For ribands and thickness of legs.

(2). CONSTRUCTION OF TRESTLES.

Material.—The text book deals principally with trestles of round spars lashed together with cordage. There would, however, be a scarcity of cordage on service, and wire would more often than not have to act as a substitute. Wire lashings can be made quite strong enough if a sufficient number of square turns, inversely proportional to the strength of the wire, be taken. The formula is as follows:—

$$n = \frac{25W}{12r},$$

where n = number of square turns to be taken,
 W = maximum vertical stress which can come on the lashing (*after* reducing live load to dead),
 r = breaking stress of wire used.

The formula includes a factor of safety of 5.

Instead of frapping turns a long nail may be used to twist the returns of the square lashing at each corner where they pass from one spar to the other.

It may be mentioned here that when placing the diagonals of a two-legged trestle it is advisable to have both tips on the opposite side of the legs to that on which the transom is placed (one butt being on either side); the transom can then be lowered if required without interfering with the tips of the diagonals.

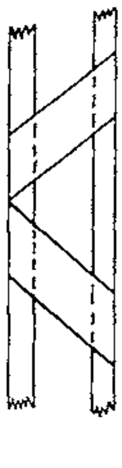
Planks nailed together make excellent material for trestles. They are light and possess no great buoyancy, and are therefore easily launched in deep water. They are also very quickly put together, and have the further advantage that their transom is easily adjustable, if the section has been inaccurately taken or if a leg sinks. The following scantlings are suitable for ordinary 9-foot roadway traffic:—

Each Leg.—Two 8″ × 2″ planks, 2 inches apart.

Transom.—Three 8″ × 2″ planks, 2 inches apart (the centre of the three planks being between those of the legs, and the other two outside of them).

Ledger.—One 8″ × 2″ plank between the planks of the leg.

Diagonal Braces (Each).—One 8″ × 1″ plank between the planks of the legs.



The planks of the legs and transom may be blocked apart at intervals, and the strength of the legs may also be increased by nailing diagonal battens as bracing, as in sketch.

If n = number of nails required between one end of the transom and a leg, then

$$n = \frac{FW}{r},$$

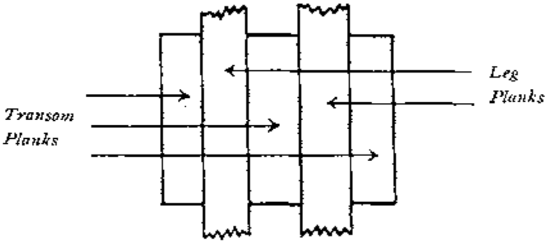
where F = factor of safety,
 W = maximum load on one end of transom (*after* reducing live to dead),
 r = mean ultimate holding power of one nail.

The writer carried out experiments to ascertain r. The mean was as follows:—

For 6-inch wire nails, $r=750$ lbs.
For 6-inch cut nails, $r=600$ lbs.

These values were for 1-inch planks; 2-inch planks gave about 10 per cent. greater holding power.

If three transom planks are nailed to two leg planks, as in the sketch,



then for 15-foot bays, carrying infantry in fours, 9 or 10 6-inch nails will be needed between each end of the transom and a leg. It would be possible to use plank cleats underneath the transom if there were not a sufficient nail area otherwise. Bays for plank trestles should not, as a rule, exceed 12 feet.

When a plank trestle is put together, only the centre plank of the transom is nailed, and that lightly, so that its nails can easily be drawn, and its position altered if not at the right level when launched.

The best method of preventing trestles sinking in mud is to fit a shoe to the butts of the legs. 2-inch planking may be used for this purpose, and the area of the butt can be easily increased to 2 square feet, which will sustain a great weight in very soft mud after sinking a few inches beneath the surface.

Two-Legged Trestle with Adjustable Transom.

A two-legged trestle, whose transom is continually adjustable in a tidal river, is often needed. The Welldon trestle, which answers this purpose, is not generally available. The following method has been tried, and appears to be suitable (see *Fig.* 1):—

A two-legged trestle is lashed up in the ordinary way, but the transom lashings consist each of two square turns and one frapping turn of 1-inch rope, instead of four square turns and two frapping turns of 2-inch rope.

Auger holes 1 inch or $1\frac{1}{4}$ inches in diameter are bored through the legs 4 feet above the highest level of the transom, the axis of the hole being parallel to the plane of the trestle.

Each end of the transom is then slung by 12 pieces of annealed wire (No. 11 gauge), which are doubled, and the bights passed round the transom outside the leg; the 24 ends are passed through the auger hole, and the spare lengths wound lightly round the leg, clear of the handrail. The length to which these wire slings must be cut depends, of course, on the amount the transom will have to be lowered.

It is a good plan to allow the slings to hang well down below the transom at first, and to windlass them up *below* the transom. By loosening this windlass, the transom can be lowered more quickly than by letting out the slings through the auger holes. This method is suitable for small adjustments of levels, but for larger adjustments the slings must be paid out.

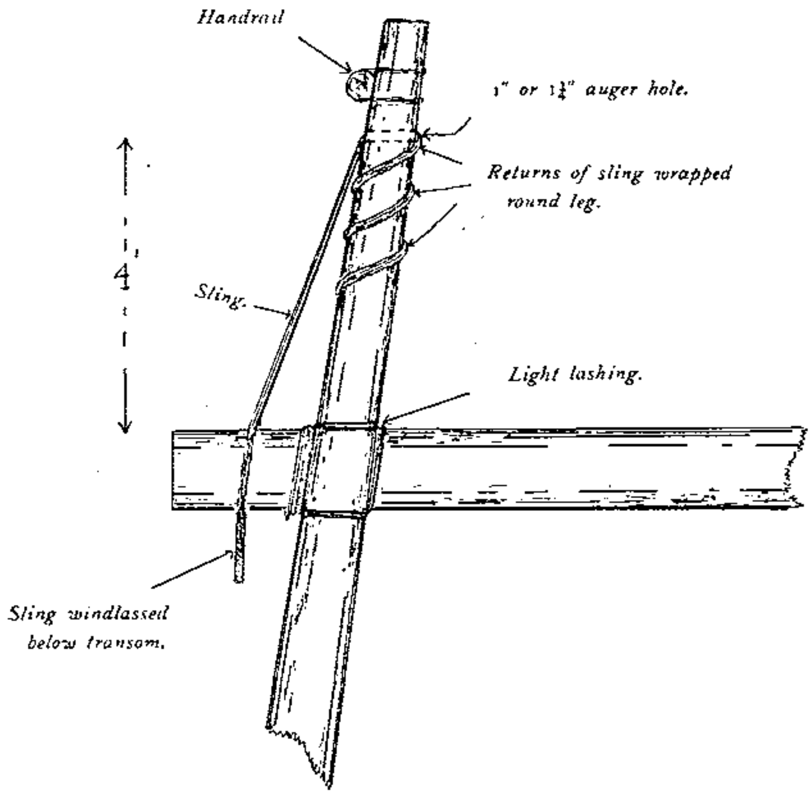


FIG. 1.—*Trestle with adjustable Transom.*

If either end of the transom is found to be too high, after launching the trestle, the weight of that end is taken by a rope made fast round the handrail close to the leg, and the windlass below slackened off. The light transom lashing is then removed, and the rope paid off till the transom has fallen to the correct level, when the wire sling is again windlassed up. The sling may be windlassed up above the transom if only a little tightening is required, but it must be windlassed below if the slackness is considerable. The rope which takes the weight can then be slackened off, and the transom lashing put on again lightly. The transom lashing is not essential, but gives longitudinal stability to the bridge.

If one end of the transom has to be raised, it can be done in the following manner :—

Undo the light transom lashing.

Reeve a light double and single tackle, with a 1-inch or 2-inch lashing.

Hook the double block into the lashing connecting the handrail to the leg.

Lash the single block to the end of the transom.

Hook a snatch block into the nearest racklashing, and pass the end of the fall through it.

Two men with the fall, standing *off* the bay which the transom supports, can easily raise the latter.

The strain on the fall is kept until the wire slings are windlassed up above or below the transom, or else taken in through the auger holes. The tackle is then cast off and the transom lashing replaced.

The whole of the above operation took two men six minutes.

A single block is not sufficient to raise the transom ; a tackle must be used.

This method may do away with the necessity of using tripod trestles with slung transoms in tidal rivers.

Both three-legged and four-legged trestles are most cumbrous to use, and should be avoided if possible. To launch them in deep water is almost an impossibility without a floating derrick.

Four-legged trestles are of little practical value. Their power of giving longitudinal stability to a bridge can always be obtained by the use of "fore and aft" struts or longitudinal diagonals, lashed to two-legged trestles ; moreover, they rarely rest firmly on the bottom with equal inclinations of the legs. Three-legged trestles are even more difficult to launch than four-legged. Their only real use is in tidal rivers, and in such cases they should be placed by hand at low tide.

(3). ORGANIZATION OF THE BRIDGE PARTY.

It is not possible to lay down the strict duties of each man in trestle bridging. Some such scheme as the following should, however, be worked to, in order that the various operations may proceed at equal rates. The time taken in launching can never be calculated with any exactness, and the launching party frequently requires extra help.

Organization at the Start.

A. Section party ; 6 men.

B. Shore transom party ; 3 men.

C. } D. } Construction parties ; each of 8 men.

Total, 25.

Duties.—For A, see p. 262.

B. Prepare the footing for the shore transom; drive four pickets to keep it in place, and two long stout pickets for the ends of the handrails.

C and D. These parties make the first two trestles, the sections for which will have been taken by the time that the materials for them have been collected.

Subsequent Organization.

E. Section party; 6 men.
F. Construction party; 8 men.
G. Launching party; 8 men.
H. Handrail and riband party; 4 men.
K. Longitudinal bracing party; 4 men.
Total, 30.

Duties.—For E, see p. 262.

F. As for C and D. The parties constructing the trestles also fix the handrails, so as to be ready when the launching party comes for them.

G. (*a*). *If Launching from the Head of the Bridge.*—Lash slide-poles to the transom of the last trestle in bridge. Fix foot-ropes. Carry up the trestle; launch it down the slide-poles and push it upright. Remove the slide-poles and lay the baulks and chesses to the trestle; the outer baulks should be lashed at each end (preferably with spunyarn) to the transoms.

(*b*). *If by Other Methods,* see pp. 267 to 275.

H. This party assists G to launch the trestle, two men being on each handrail. As soon as the feet are rightly placed and the trestle vertical, they lash their handrails to the legs of the previous trestle. They then riband down the last bay but one, and may assist to bring up planks.

K. These men fix longitudinal bracing and props between the trestles, where directed, to give longitudinal stability.

In addition to the above, a man is required in a boat to give assistance from the water, and to judge of the verticality of trestles which are being launched.

(4). METHODS OF LAUNCHING TRESTLES.

(*a*). *By Means of a Floating Derrick.*

This method was first devised by Capt. C. E. P. Sankey, R.E. It has been found to be very much the quickest and most accurate way of placing them, and practically the only way of launching them without great delay in deep water. The raft and derrick take 12 men four hours to build. This generally allows the derrick to be ready for use by the time the bridge has advanced into deep enough water to make its use possible. The writer has worked with floating derricks for several years, and the pattern, of which a description is here given, has been found to be a perfectly satisfactory one.

The raft on which the derrick stands is built up of two smaller rafts, X and Y (*Fig.* 2), each of three barrel piers. X has seven 40-gallon barrels to a pier; Y has nine barrels. The two small rafts are placed at right angles to each other.

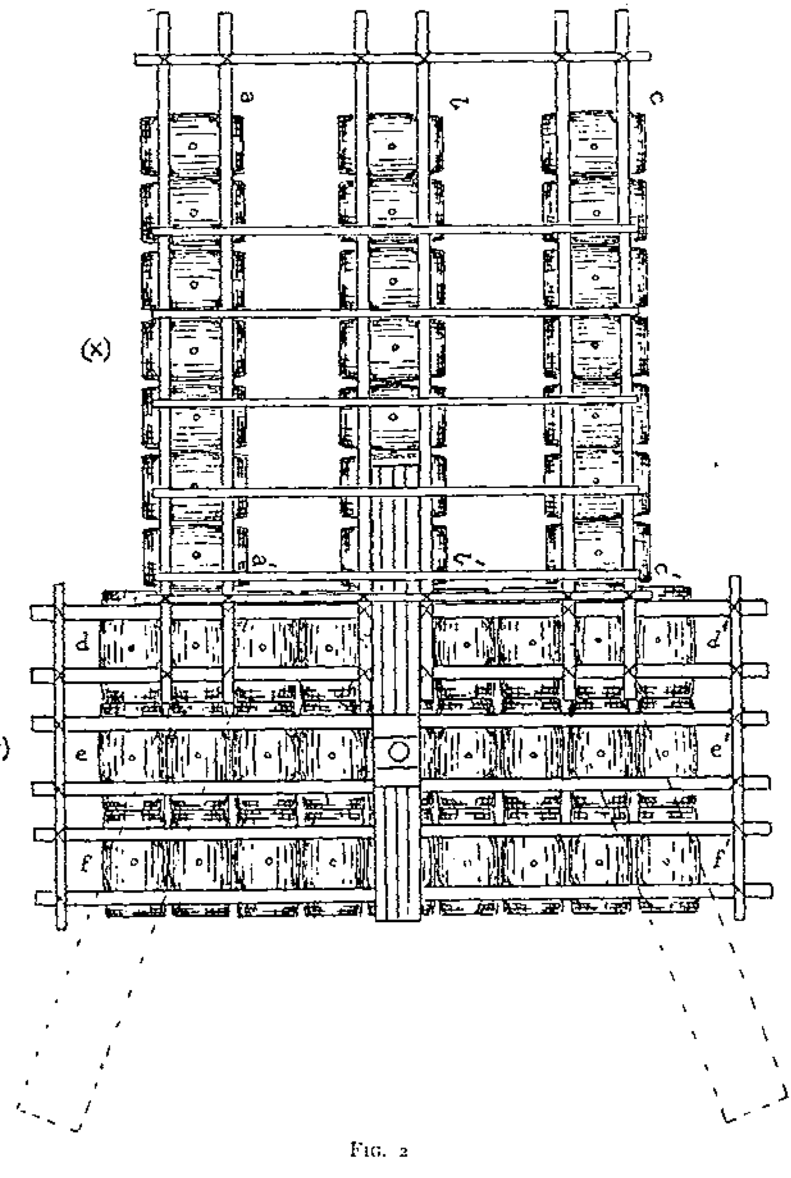


FIG. 2

The piers *aa'*, *bb'*, *cc'* of the raft X are placed at 5-foot central intervals. The piers *dd'*, *ee'*, *ff'* of the raft Y are placed touching each other.

The piers of the raft X are connected with tie-baulks as usual. The raft Y has tie-baulks connecting the ends of its piers, and also four tie-baulks close together (or, better still, a 12" × 3" plank), placed across the centre of the raft perpendicular to the gunnels, as a foundation for the derrick. The gunnels of the pier X should have sufficient overlap at *a'*, *b'*, *c'* to rest right across those of the pier *dd'* of the raft Y. The ends *a'*, *b'*, *c'* are lifted on to the pier *dd'*, so that the gunnels of *bb'* are either side of the four central tie-baulks of Y. Blocks or wedges are inserted to give a tight fit between them, and the gunnels of X lashed to those of *dd'*. On the four central tie-baulks of Y, which form the foundation for the derrick, is placed a seating, as in *Fig.* 3. The raft X is then baulked, chessed, and ribanded. There will be a small space on the raft X (at the ends *a*, *b*, *c*), which can be chessed without baulks. The raft Y needs no baulks, but is chessed at right angles to the gunnels of the piers. Light lashings are used to hold down the chesses, instead of ribands.

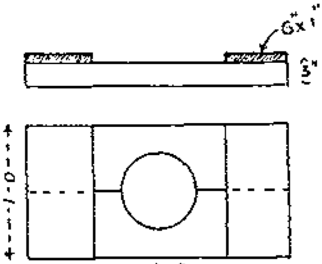


FIG. 3.

The derrick consists of a 20-foot vertical spar, 8½ inches at centre, with a 15-foot swinging arm, 7 inches at centre. The derrick has four guys to the four corners of the raft; these may at first be of cordage, for convenience in raising, but should be replaced by wire (three-strand, No. 11 gauge, for back guys; two-strand, No. 11 gauge, for side guys). In place of fore guys, an inclined braced strut, consisting of two tie-baulks braced together, rests against the back of the derrick, 7 feet or 8 feet up, its foot butting upon one of the barrels of *bb'* (see *Fig.* 4).

The upright spar must have an initial set-back of at least 12 inches at the top, to allow for the back ties stretching when the weight comes on the swinging arm.

The swinging arm has two side guys. Two treble and double tackles are used to raise the swinging arm and the trestle respectively. The upper block of the lower tackle should be about 9 feet above the water when the slope of the swinging arm is 45 degrees.

Two small projecting platforms (each built up of two barrel-pier baulks, 2 feet apart, centre to centre, with planking on them) are lashed as shown in *Fig.* 2, so as to project 7 feet from the raft each side of the trestle. They should have an outward splay in plan, and should be at least 20 feet apart in the clear at their outer ends, to allow room for the ledgers of big trestles to be lowered between them. They should be given a slope upwards and outwards to allow for sag. These platforms allow footrope men to have great control over the trestle. The platforms are not shown in *Fig.* 4.

The raft carries three anchors and cables and a line to attach to the bridgehead.

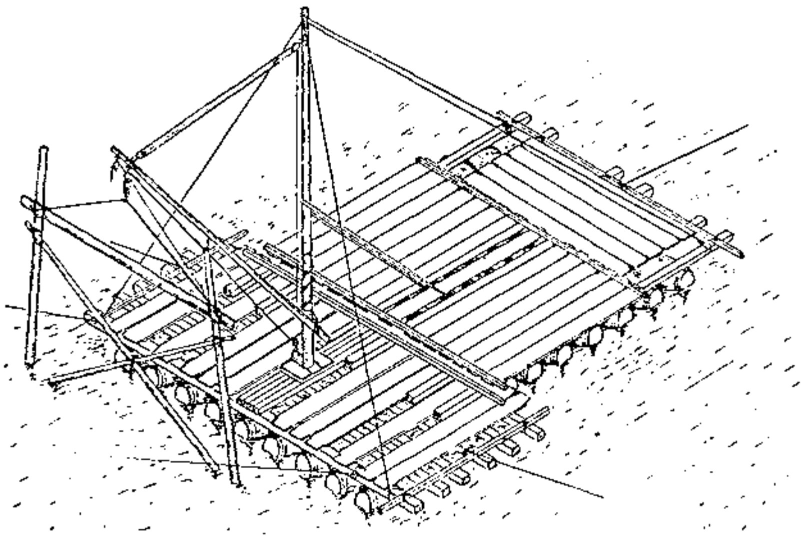


FIG. 4.

The following party is required to place a trestle with the floating derrick:—

On the Raft.

2 men in charge of anchor cables.
3 " " the falls.
2 " " the footropes to the trestle.
1 " " a line fastened to the centre of the transom of the trestle.
Total, 8.

On the Bridge.

2 men in charge of the footropes.
1 " " a line to the centre of the transom of the trestle.
1 " " a line from the raft to the bridge.
Total, 4.

Total party required, 12 (but large trestles have been launched by eight men with a little more time).

Method of Launching Trestles with Floating Derrick.

The trestle, before it is put into the water, is fitted with two handrails (marked to show length of bay), four footropes, and two lines to the centre of the transom. A sling is placed over the ends of the transom, by which the trestle is raised. The raft is moored opposite the head of the bridge, and about 20 feet away from it, with three anchor cables—one offshore, one upstream, one downstream—and a line to the head of the bridge (this line need not be fixed till the trestle has been raised, unless a strong wind from the shore is blowing).

As soon as the previous trestle is in position, with handrails and road-bearers lashed, the next trestle is warped along to the head of the bridge, while the roadway of the last bay is being completed. The trestle is placed between the raft and the bridgehead, with the handrails toward the latter. The four footropes are taken in charge, two by men on the projecting platform of the raft, and two by men at the head of the bridge. The two lines to the centre of the transom are passed respectively to a man on the raft and a man on the bridge.

The lower tackle of the derrick is then overhauled till the block can be hooked into the sling of the trestle. This must be at the centre, and to ensure the hook not slipping along the sling it should be made fast by means of a blackwall hitch.

When the four footropes, two handrails, and two transom lines are in the hands of the men told off to them, those on the fall raise the trestle into a vertical position and then drop it again; the trestle, while being lowered, is kept vertical by the footropes, transom lines, and handrails. The trestle can be dropped into its exact position with great ease by manipulating the anchor lines of the raft, the line from the raft to the bridge, the side guys of the swinging arm and the upper tackle, as may be required. It has been found to be a good plan to make fast the handrails to the legs of the previous trestle at the marked points as soon as the trestle is vertical. The trestle is then under perfect control, and can be raised and slewed right or left, or the feet pulled in or out as required.

The following timetables of the launching of various trestles will show the great speed of the process. In no case had the men who carried out the work seen it done before. The party consisted of cadets in every case, except that of the plank trestle (C), which was launched by infantry officers under instruction. There was no current, but a continuous wind. The bridge was strong enough to carry infantry in fours.

A.	Four-legged	spar	trestle in	11	feet of	water;	legs	16	feet long.
B.	Two-legged	„	„	13	„	„	„	19	„
C.	„	plank	„	11	„	„	„	18	„
D.	„	spar	„	12	„	„	„	18	„

	A.	B.	C.	D.
Trestle warped from shore to head of bridge,* footropes, etc. passed to men in charge of them, tackle overhauled and hooked into sling in (minutes) ...	15	30	15	Time not taken
Trestle hoisted vertically and lowered (first attempt)	17	15	9	7
Ditto ditto (second attempt)	12	15	—	—
Total time of operation	44	60	24	—

The time for B included lashing handrails and road-bearers. This case presented exceptional difficulties.

Trestles C and D were lowered into their right places at the first attempt.

Trestle C, which was lighter than the others, was launched by a total party of eight men.

Tripod trestles, 19 feet to the crutch in 12 feet of water, were also placed by the derrick. Tripod trestles cannot be kept vertical with the footropes so easily as 2-legged or 4-legged trestles, so the following device was adopted to keep the trestle vertical while lowering it (the feet were of course weighted):—

The lower tackle of the derrick was hooked into three slings connecting the three pairs of legs just above the centre of gravity of the tripod. A single block (see *Fig.* 4) was lashed to the extreme end of the swinging arm, and a line passed through this and made fast to the crutch of the tripod. By means of this line the crutch could be kept nearly vertically above the centre of the base of the trestle while lowering it. *Each* tripod takes a little longer to launch with a derrick than would a 2-legged or 4-legged trestle on the same site.

All trestles in deep water should have their feet heavily weighted before launching.

(*b*). *Launching a Trestle by Means of Rollers* (see *Fig.* 5).

The following method has been tried and has worked very well. The trestle, with its feet well weighted, is carried out along the bridge in the usual way, and is lowered until it stands just in front of the last trestle in bridge in an upright position. It is advisable to keep the trestle a few feet off the ground by making fast the footropes temporarily. Handrails are also put on.

Two large wooden rollers, smooth and stripped of bark, 3 feet long, 20 inches in diameter, are placed on the bridge, with their axes perpendicular to its centre line, and a little more than half the length of a bay from the last chess in bridge. On the top of each roller is placed a strong lever (barrel-pier gunnels, $22' \times 5'' \times 4''$, are suitable for

* This distance was:—For A, 40 feet; for B, 70 feet; for C, 60 feet.

11-foot bays), and the forward ends of the levers are placed under the transom of the trestle to be launched, and are lashed to it. Men then bear down on the inshore ends of the levers, thus lifting up the trestle, and then push out on the levers, which will go forward on the rollers, carrying the trestle with them. The trestle is kept upright by means of the weight on the feet and by the handrails. Footropes and boathooks will be useful to keep the feet of the trestle down, if there is any tendency on their part to rise, but if they are sufficiently weighted these will not be needed. It is obvious that the trestle will go out twice as fast as the rollers. As soon as the trestle is the right distance out, as shown by the usual marks on the handrails, the men on the levers allow it to drop into place. By means of the levers the trestle can be "rowed" right or left to get it in the exact centre line.

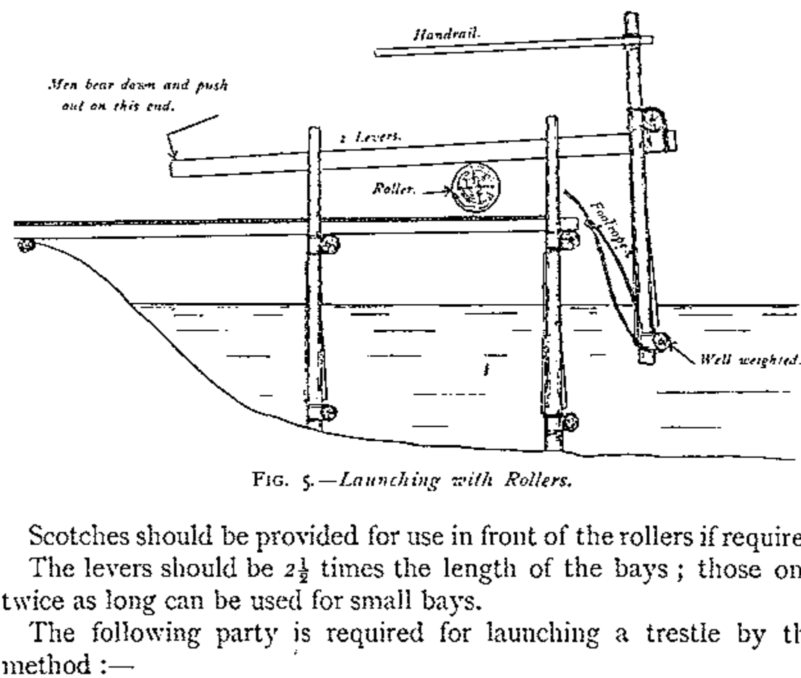


FIG. 5.—*Launching with Rollers.*

Scotches should be provided for use in front of the rollers if required.

The levers should be $2\frac{1}{2}$ times the length of the bays; those only twice as long can be used for small bays.

The following party is required for launching a trestle by this method:—

3 or 4 men on each lever.
2 " " handrail.
1 commander of party in charge of scotches.

(c). *Launching by Means of a Raft.*

Probably the simplest way of using a raft is as follows:—

Suppose the raft to consist of two pontoons. Carry the trestle (without handrails) on board the raft, with the transom and ledger parallel to the pontoons, and the feet overhanging the outside of that pontoon which will be nearest the bridge when moored. Moor the raft opposite the head of the bridge, and a little more than a bay's distance clear of it. The raft requires an offshore cable, two lines to the bridge (one on either side), and, if there is a stream, an upstream cable. It is moored with the pontoons perpendicular to the line of the bridge. Two footropes and two back guys are then made fast to the feet and tips of the trestle's legs, and are carried back to cleats on the offshore pontoon. Two fore guys are also made fast and passed to men on the bridge.

The trestle is then easily up-ended by the following party :—

On the Raft.

Commander.
2 men, each to pay out a footrope and a back guy.
3 „ to lift ledger forward and to lift up on the transom.
1 man on offshore anchor.
Total, 7.

On the Bridge.

4 men on fore guys.
2 „ with long boathooks, or pike-poles, to move the trestle or the raft.
Total, 6.
Total party, 13.

The case might arise where no access could be had to the far shore, and it was required to connect a floating central portion to the far shore with trestles, for tidal or other reasons. In such a contingency the trestle would be put together on the floating portion. Two strong baulks, at least 10 feet apart, would be lashed down as cantilevers, hanging over the end of the floating portion towards the far bank. The trestle, with footropes and back guys on and handrails lashed to the tips, can then be slid out on these baulks, ledger leading, till the transom is close to their outer ends, and the feet are floating in the water. The handrails are then pushed out and the footropes pulled in, the tips of the legs meanwhile being lifted by men standing on planks across the overhanging baulks, and the trestle will come into an upright position. The handrails will then be made fast to part of the floating portion, and the roadway placed from the floating portion to the trestle transom.

The above operation has been carried out by the writer at Wouldham, with a rising tide, in 50 minutes (from the time the raft was anchored to the time the trestle was secured in an upright position).

(*d*). *Launching by Means of Projecting Road-Bearers from the Preceding Bay* (see *Fig.* 6).

The preceding bay must have road-bearers twice the ordinary length, so as to overlap the last trestle in bridge by the length of a bay, as CDE. They must be lashed down at C. The trestle is floated out into the position AB, A being the ledger and B the transom. Two handrails, of considerable length, and two foot-ropes should be fixed to the trestle beforehand. A stout plank E is placed across the ends of the cantilever road-bearers to act as a fulcrum. The feet of the trestle A are then supported by the foot-ropes from the handrails above, while they are being weighted. When sufficient weights have been fastened to the feet, the following party prepares to place the trestle :—

2 men on the handrails.
2 „ „ foot-ropes.
2 „ with levers, which they insert under the transom, using the plank E as a fulcrum to lift it up.

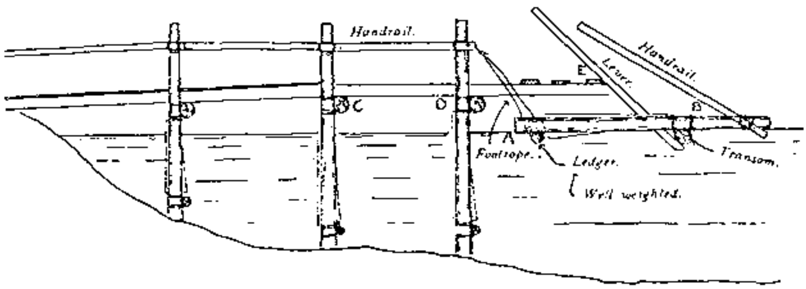


FIG. 6.—*Launching with Roadbearers as Cantilevers.*

As soon as the foot-ropes are paid off, the feet will sink. The transom is kept just beyond the ends E of the road-bearers by means of the handrails ; the levers under the transom assist to raise it.

If the feet as they sink take ground in the wrong position, the trestle can be lifted by a long lever placed under the meeting of the diagonals, using the last chess in bridge as a fulcrum. The trestle can by this means be lifted and easily " rowed " right or left.

When the trestle is in its right place, the road-bearers are slid forward a few inches and lifted on to the transom. They will probably have to be blocked up on the transom of the previous trestle.

Two guys to the tips of the trestle may be used to assist in raising it ; they will, however, have a tendency to pull the whole trestle too much towards the bridge. It has been found necessary to keep the feet A somewhat out from the bridge at the start to allow for this tendency.

(5). RAPID PILE-DRIVING.

The following method of driving light piles, similar to that described in para. 120, Part III., *I.M.E.*, has the advantage of considerable speed (see *Fig. 7*) :—

Lash a stout plank A under the last road-bearers in bridge (which must themselves be held down to the caps of the piles supporting them). Place long spars BC as cantilevers projecting beyond the last pile trestle a distance equal to the length of the next bay + 2 feet 6 inches. The piles are then carried out on the platform thus formed and dropped into their place between pairs of such cantilevers, which must be placed so as to enclose them. The pile is then mauled by men standing on the platform till it will stand upright by itself. The pair of spars on either side of a pile are then lashed to it; the plank A is removed, and the pile driving continued, the long spars supporting the driving party and falling with the pile.

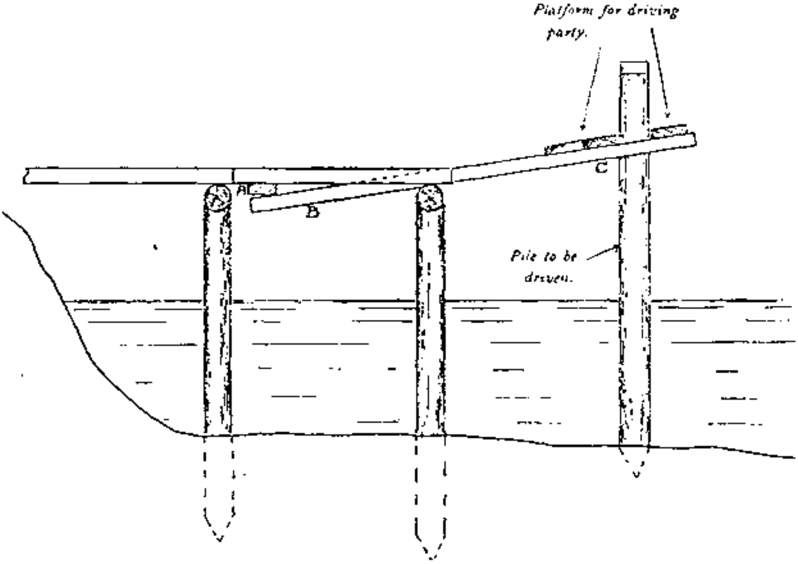


FIG. 7.—*Pile Driving with Cantilevers.*

When preparing piles, wire or thin sheet iron (Jones' iron bands are suitable) must be nailed round the head to prevent it splitting. The foot may be cut to a square pyramid with a blunt nose, and armoured with strips of sheet iron nailed over the point. If solid bottom can be reached through the mud, the feet of the piles should be cut off square.

(6). GABION BRIDGE.

Mention is made of these bridges in para. 102, Part III., *I.M.E.*, but only normal gabions, 3 feet long and 2 feet diameter, are shown in the accompanying plate. It is, however, possible to make each pier of such a bridge of specially large gabions. Where these gabions are placed upright, two are required, each having the required height; when they are placed on their side, the gabion is constructed with a diameter sufficient for the depth of the section at the point (up to at least 7 feet). The construction of such gabions presents no difficulties. It is necessary to be careful that the pickets remain parallel during the waling; they have a tendency to open towards the top, and it may be necessary to lash them together, which can be done without interfering with the work. The rate of building large gabions is approximately the same, per square foot of surface, as in the case of small gabions.

If they are to be used on their side, they must, if large, be fitted with internal diametrical struts of about 3-inch thickness. The gabion should, at every 3 feet or 4 feet along its axis, have three such struts, placed like a six-spoked wheel. The struts are driven through the waling, to which they must be firmly wired. If this wiring is not well done, the gabion will distort when the weight comes on it.

It is more easy to launch the gabion which is to lie on its side when in bridge than the one that is to be upright. In the former case, two inclined ways are pushed forward from the bridgehead, and the gabions rolled or slid down, with foot-ropes to guide them. Two gabions, each 6 feet long, side by side, with axes in one straight line, provide a substantial pier. The transom is lashed on the top of them.

The upright gabion is more difficult to place in position, but needs no radial struts, and is quite solid. It can be filled with stones if desired. The transom should rest on four short crosspieces, two on each gabion.

The writer has made bridges of each kind. When using the gabions on their sides, the bridge was tested with the following load:—

> 14 men, approximate weight 2,100 lbs., crowded immediately over one pier and, jumping together, produced no distortion in gabions of 4 feet, 5 feet, or 6 feet diameter.

Twenty-two men, approximate weight 3,300 lbs., similarly placed and jumping, produced no distortion in 4-foot or 5-foot gabions, but slightly flattened one 6-foot gabion, owing to the web being insufficiently wired to a strut.

An upright gabion bridge was also tested by the same weights. No failure resulted.

The gabions rested in soft mud, into which they sank very little. They are suitable for such sites where brushwood is plentiful.

DIRIGIBLE BALLOONS.

A LECTURE DELIVERED AT THE S.M.E., CHATHAM.

By BREVET COLONEL J. E. CAPPER, C.B., R.E.

PRELIMINARY.

IN lecturing to an audience of Royal Engineer officers on the subject of dirigible balloons, I do not propose to give what may be called a popular lecture, as the daily papers and magazines give enough information on the subject to those who only take a casual interest in it, but rather to treat of the technical details, with a view to stimulating the inventive faculties of those among you who may be inclined to make a serious study of a novel and possibly a terrible instrument of war.

Numbers of people who have never even seen a dirigible balloon, much less have ever been in one, are absolutely certain that they have invented the perfect airship; and we are inundated with shoals of crude and undigested ideas from would-be benefactors, whose beneficence to the public usually entails no inconsiderable emolument for themselves.

Even when patents are taken out, such trifling details as nature of material, joints of framework, design of engine, fans and connections, etc., which give us endless thought, are all conveniently slurred over by adding the words "some suitable"; whilst not infrequently a vessel built as they propose would hardly float on water, still less in air.

I cannot too strongly impress on you that, whilst really efficient dirigibles are likely to be produced in the near future, they will not be the outcome of the sudden idea of some genius, but the result of patient labour and investigation on the part of many really practical men.

The more of us who work at it, the better will the result be; but all who work must be prepared to consider every detail of design, before any such design can hope to be of practical utility.

That you may understand clearly the problems that have to be faced in designing a practical dirigible balloon it is first necessary to explain the physical conditions which are common to all balloons.

Balloon.—You all know that a balloon itself is a vessel made of some light material which is capable of holding gas. When inflated it displaces an equal quantity of the surrounding air, and if the gas it contains is sufficiently light it will rise in the air. The balloon proper is technically known as the envelope.

Gas.—In order to obtain the best lifting power for a given size of balloon, in all military balloons the lightest gas available, *i.e.*, hydrogen, is used.

Envelope.—Various materials have been used for envelopes, viz., varnished cotton and silk, rubber fabric, rubber, goldbeater's skin, and even thin sheet metal. None of these, when very thin, are absolutely hydrogen tight, except goldbeater's skin and metal.

Most varnishes rot the material, and rubber perishes to a certain extent under the action of sunlight, though this action of the sun's rays can be greatly reduced by colouring the envelope yellow.

Rubber also becomes very brittle in extreme cold.

When a balloon rises the pressure of the surrounding atmosphere diminishes, and the gas inside the envelope expands. In a non-elastic balloon this expansion gives rise to great internal strains, and unless some of the gas is allowed to escape, the balloon will soon burst. In an elastic balloon, such as one of pure rubber, very great expansion can take place without danger of bursting, but the slightest puncture of the fabric will entail the immediate collapse of the entire envelope, and death to the occupants of the balloon.

Metal envelopes cannot be made strong enough to stand the strains of any but moderate elevations, without being too heavy to rise.

Fabrics are practically non-elastic.

Rubber alone is too dangerous for practical use.

Goldbeater's skin has some of the advantages of rubber, being to a certain extent elastic, whilst not subject to the disadvantage of an immediate disruption on being punctured. An envelope made of this material, therefore, allows of manœuvres between considerable differences of altitude without losing hydrogen. Any loss of hydrogen lessens by so much the capacity of a balloon to keep up in the air, and is therefore unsatisfactory.

As it may often be necessary, especially in dirigible balloons used for military purposes, to vary one's elevation considerably, it is obvious that a material which is hydrogen tight, and allows of alterations of elevation without loss of gas, has many advantages over other materials, and it is this material we are at present using for our military balloons. It is, however, subject to the disadvantage of absorbing moisture with avidity, so that in a water-laden atmosphere its weight considerably increases.

Changes of Temperature.—Changes of temperature equally with changes of altitude affect the gas, a rise of temperature causing expansion and a rising of the balloon, whilst a fall of temperature contracts the gas and makes the balloon fall. In order to keep in equilibrium during changes of temperature, rises of temperature must be counteracted by letting out gas, and falls of temperature by lightening the balloon. The former is effected by the use of a valve in the top of the balloon, the latter by throwing out ballast, which is usually carried in the form of sand or water.

Atmospheric conditions are rarely stable for long; difference of temperature of the air occur frequently at very moderate heights; clouds often cross the sun, causing temporary coolness; rain showers add greatly to the weight of a balloon, necessitating a corresponding loss of ballast, whilst on the subsequent drying off of the rain a corresponding rise of the balloon occurs.

As soon as all the ballast is expended, the life of the balloon in the air is nearly over, whilst the more gas one lets out, the higher must the balloon rise before the remaining gas expands sufficiently to fill it.

Loss of Gas and Ballast.—The converse is of course true, that is, in order to keep in the air for a long period of time it is necessary to lose as little gas and as little ballast as possible.

Special Difficulties of Dirigibles.—With an ordinary balloon, whether it is full or partly empty, and whatever the strength of the wind, the whole mass moves quietly along as a portion of the air current, the relative positions of the various parts remaining stable, except when sudden cross currents, or upheavals are met, which latter occur only under unusual conditions. When, however, one attempts to give a velocity of its own to a balloon, the conditions alter. The vessel then meets opposing currents, which tend to make it pitch and roll, the resistance of the air presses in its head unless this is kept rigid, and constant small eddies cause it to move to one side or another of its course.

The wind resistance on so large a body is very great, and is increased by the friction of the air rushing past the surfaces of the structure, especially if these are rough; and this resistance increases as the square of the velocity.

The average speed of the wind in England at elevations of 1,000 to 4,000 feet is believed to be about 18 miles per hour, so that in order to obtain a really practical machine we ought to get about 30 miles per hour out of it. Such a speed requires powerful and very light engines.

Moreover, whatever power is used for propulsion, this power, except in the case of stored electricity, necessitates the consumption of fuel, whilst every pound of fuel consumed (unless the products of combustion can be preserved) entails the loss of a pound of ballast, and a consequent lightening of the vessel. This loss of ballast is very considerable, *e.g.*, a 50-h.p. petrol engine will consume some 30 to 40 lbs. of petrol every hour, which is equivalent to the lifting power of 500 feet of hydrogen; so that in a 10 hours' run it will, unless otherwise compensated for, necessitate the loss of 5,000 cubic feet of gas.

As long as a dirigible balloon remains in the air it may be looked on as being tolerably safe, both in itself, and as a conveyance for passengers. Even if the engine breaks down it is in no worse case than an ordinary free balloon. When, however, it is brought in contact with the solid ground it is a different matter. Even in light winds, unless it is very heavily overweighted, it constantly rises a few feet and drops with considerable force, so that the fragile framework containing machinery and passengers is liable to serious damage; whilst in high winds the pressure tending to tear it away is so great that even large numbers of men are incapable of holding it, and its struggles to escape become so violent that any rigid structure attached to it will be dashed to pieces.

Points Required in a Dirigible Balloon.—The points which require attention in designing a dirigible balloon are :—

(*a*). The envelope material should be

(1). Light, but strong.
(2). Hydrogen tight.
(3). Elastic.
(4). Not liable to sudden collapse if punctured.
(5). Should not absorb moisture, but should throw off rain.

(*b*). The shape should be such as to offer the minimum of resistance to the air, and this shape must be preserved.

(*c*). The envelope, car, and methods of suspension should be as smooth as possible to avoid skin friction.

(*d*). The engine must be very powerful, to give a high speed to the vessel.

(*e*). The most effective method of propulsion must be used.

(*f*). Mechanical arrangements must be made by which the balloon can be pulled upwards or downwards to compensate for temporary changes of atmospheric condition, or for loss of gas and ballast.

(*g*). Horizontal and vertical controls must be provided, partly fixed in such a way as to prevent the vessel pitching and yawing, and partly movable, so that direction in either plane can be controlled.

(*h*). Everything must be kept of the very lightest.

(*j*). It must not be possible for escaping gas from the balloon to come in contact with any spark or flame from the engine, or the result will be a disastrous explosion and destruction to the vessel and its occupants.

(*k*). Finally the construction must be such that the balloon can be kept secure from damage when landing, and safe from destruction by ordinary winds when stabled in exposed positions on the ground.

Envelope.—The material chiefly used for the envelope is rubbered fabric, an excellent gas-holder, and strong. At present we are using goldbeater's skin, but balloons made of it are expensive, difficult to construct, take long to make, and if numbers are required we shall have to take to other materials. It is difficult also to attach any framework to a goldbeater's-skin balloon without using a net or silk cover.

The envelope of a cylindrical balloon should be twice as strong parallel to the axis as it is on the great circle.

Shape.—Various shapes have been used, but the perfect shape is still to be obtained; a torpedo shape offers least resistance to wind pressure and skin friction, but it is not certain that this is the easiest shape to keep on its course.

The design of the rear of the balloon is as important for lessening resistance as is the design of the head; unless sloped off gradually suction is set up behind, which draws the balloon back considerably. The front may be considerably rounded without ill-effect.

Having decided on the shape, steps must be taken to preserve it. Now in an envelope of large diameter a very slight internal pressure per square inch will keep it taut. Thus if the pressure per square inch on a sphere of 30 feet diameter is 1 oz., the tearing strain per running inch of circumference is, from the formula,

$$\frac{p \times \left(\frac{\pi d^2}{4}\right) = \text{area}}{\pi d = \text{circumference}},$$

where p = pressure per square inch = 1
and d = diameter in inches = 360

$$\frac{1 \times 360}{4} = 90 \text{ oz.} = 5 \text{ lb. } 10 \text{ oz.},$$

and this strain is sufficient to stretch the fabric well.

Incidentally it is seen that the strain on the fabric for a given internal pressure per square inch is directly proportional to the diameter, so that the envelopes of large balloons have to be much stronger than those of small ones.

In order therefore to keep the envelope taut against the wind, it is only necessary to keep it at a slight internal pressure. Should the balloon, however, rise at all suddenly, or the gas grow warm, the internal pressure rapidly increases, and this is not permissible to any great extent, or the envelope would burst. Gas has therefore to be let out, and this is usually effected by automatic valves. On a descent, or on the gas cooling, the envelope would lose its internal pressure, and according as much or little gas had been let out would become more or less flabby, offering more resistance to the wind, and it might also break its back.

To overcome this difficulty it is usual to place another smaller balloon or "ballonet" inside the envelope. Air is driven into this ballonet (which is fitted with an automatic valve working at a lower pressure than those in the main envelope), and thus the balloon is kept distended.

The normal working pressure of fabric balloons is understood to be about 2 ozs. to the square inch, which only allows a margin of 1 oz. before gas escapes. This means that a rise of altitude of 125 feet, or a rise of temperature of the gas of $2\frac{1}{2}^\circ$ Fahr., necessitates with non-elastic envelopes the loss of gas.

The goldbeater's-skin balloon has the advantage that it expands considerably at pressures well below the safe working strain, and if at very slight pressure on the ground, it can with safety rise to 2,000 feet without loss of gas, so that for peace practice a ballonet is not a necessity.

In order not to lose gas the balloon may ascend with the ballonet full, losing air instead of gas as it ascends. This has the disadvantage that there is considerable loss of lift at the start. It is usual to allow a ballonet of about $\frac{1}{6}$th the capacity of the balloon, so that in a balloon of 100,000 cubic feet, with a total lifting power (including the weight of the ship) of 7,000 lbs., the sacrifice of lift would amount to over 1,000 lbs. It appears preferable always to go up with as much gas as possible, losing it to compensate for loss of fuel, or, if necessary, at times to ascend to great heights. If starting for a long run in the afternoon, the balloon should be as full of gas as possible, as the gas will certainly cool at night, and air must be pumped into the ballonet, whilst the sun next day will warm the gas up and refill the balloon, so that if convenient a descent may be made in the morning for more ballast.

In some makes of airships the shape of the balloon is maintained by building a rigid framework of metal, over which some fabric is stretched, whilst inside this are placed a number of gas bags which are only partially filled. This system has the following advantages:—

(1). The outer covering maintains the general shape of the ship against resistance of air or buckling, whatever may be the state of slackness of the interior balloons.

(2). The air between the inner and outer coverings is a bad conductor of heat, and the gas is therefore little affected by changes of temperature.

(3). The rigid framework allows of great facility of attaching the car, propellers, and controls.

The disadvantages will be dealt with later.

Suspension.—The positions of the car containing engines and passengers, and of the propellers, have to be carefully considered.

In order to obtain high speed the car should be close to the balloon, as all suspending ropes cause great head resistance. If it is very close, however, it is difficult to distribute the weight of a single car over a cigar-shaped balloon, and there is some danger of escaping gas being ignited by the engine.

It is probably better, therefore, to place the car some 12 feet or more below the balloon, using as few suspension ropes as are compatible with keeping the car from oscillating, or from too great a strain being brought on any one rope should the balloon get slack.

Various designs are used to distribute the pressure—cars extending the length of the balloon in some cases—as in the "Ville de Paris"—two cars being used in the Zeppelin balloon, and a small car in "La Patrie." On the whole the long car appears to have advantages, though it entails the carrying of some unnecessary weight.

Engine.—The engine universally used for aerial work at the present time is some form of internal combustion engine. Electrical accumulators are too heavy; the weight of fuel and water for a steam engine puts it out of court for any extended run, whilst petrol engines give a very great horse power compared with their weight, and the weight of fuel consumed is comparatively small. It may be taken as about 0·6 lb. per horse power for a well-designed engine. The quantity of lubricating oil used on a long run is also considerable; it varies greatly in different makes of engines, but cannot be neglected.

Certain French engines have a well-deserved reputation; but we are far as yet from a perfectly satisfactory design, though I am glad to say that some English makers are now attracted by the subject, and we hope to get engines in our own country which will beat anything produced by foreigners.

And here I wish to give you a word of warning. You constantly see in aeronautical journals accounts of engines which weigh as little as 2½ to 3 lbs. per horse power. These figures are very deceptive. It is true that the engine in itself may weigh as low as this, but when are added carburettors and piping (or pumps for forced carburettion), lubricating devices, pumps, radiators and water for water-cooled engines, batteries and coils, or magneto, and leads for firing, and fly-wheels, which are often necessary, the weight goes up by leaps and bounds, and it is found that fitted with everything except fuel necessary for a run of more than a few minutes, one of these light engines weighs at least 6 lbs. per horse power for its maximum load, whilst at the average working load it may easily weigh as much as 10 lbs. to the horse power.

Absence of vibration and economical working at low speeds are of importance, and extreme reliability is necessary in an airship engine, whilst in a military machine silence is very desirable.

Vibration tells greatly on the nerves after a time, and in the air one does not want one's nerves unduly affected.

It may often happen that the wind is blowing nearly in the direction one desires to go, and it may be economical just to keep steerage way on the ship, letting the wind do most of the work, keeping one's petrol for the stiff beat back against the wind.

As for reliability, a breakdown in the air is a calamity, and generally necessitates coming to ground for repairs; even the breakage of a petrol pipe, or of a small belt driving a pump or magneto, is very difficult to repair in the air with few tools and no spares handy, and only a light framework to hang on to whilst effecting the repair.

You can easily understand that one would not wish as a rule to attract attention when running near the earth in warfare, and a noisy engine can be heard for considerable distances.

The conservation of the products of combustion is very important; one form of engine, devised by Colonel Templer, enables us to keep most of these, but the engine is not light, and apparently the power is considerably reduced by the additional mechanism. This point is one that deserves very great attention, though very little appears to have been given to it. If you can invent a light and reliable method of effecting this saving, a dirigible balloon can, under favourable circumstances, be taken great distances, merely coming to earth from time to time to put out the waste products and take in fresh supplies of petrol in their place, whilst not expending its hydrogen or its ballast.

Propulsion.—The most effective method of propulsion in air has yet to be ascertained. Paddles, screw propellers, and jet propulsion have all been suggested, and many ingenious devices have been invented. It is not possible to more than touch on the subject in a short general lecture—but screws are practically the only method at present used. They cannot be said to give a very satisfactory result, and laboratory work is often very misleading. Experiments tend to prove that there is no enormous benefit gained by alterations in the curvature and shape of screws, though flat blades are not as efficient as curved ones; but a good deal depends on size of screw, rate of revolution, and proper design for the pace at which the machine will probably move through the air.

Speaking generally, it appears that large screws moving slowly are more efficient than small ones moving fast, and this is a great source of disappointment when judging from experiments made on a model scale. Thus a fan of 4 feet diameter worked by a 1½ horse-power engine may possibly give a thrust as high as 40 lbs. per horse power, but when high-powered engines are used, considerations of weight preclude making fans of proportions capable of giving the same ratio of thrust, and we have to be content with thrusts as low as 6 or 7 lbs. per horse power.

It is possible that it may be necessary to use small engines driving a number of screws, but these would require numerous drivers; or developments may be made by placing a number of screws on one shaft; but all this entails a great deal of extra weight, which we probably cannot afford.

When one considers the tremendous force required to drive a screw in the air at great speed, and the solidity which has to be given to both it and to the transmitting mechanism, in order to stand the strains, the useful thrust of the screw is so contemptible in comparison that it almost appears that this form of propulsion is unsuitable for bodies moving in the air. We do not yet, however, know of any better, so must adhere to it until some new method is discovered which will revolutionize our designs.

Screws.—The position of the screw propeller has to be considered. It has been placed in front as a tractor, in the centre, and at the rear, or both front and rear. In some designs it is at or near the axis of the balloon, in some a long distance away.

It is practically impossible in an ordinary dirigible balloon to get the thrust in the line of the centre of resistance to forward motion, which would be the ideal spot. With rigid envelopes it is possible to get the thrust fairly near this point, but ordinarily, with a non-rigid balloon, the screws must be some little distance below, attached to the framework of the car; and this should be so suspended that the whole system is fixed, or oscillation of the car will take place.

With a tractor screw the tendency to yaw is much reduced, and it is easier to keep the ship in horizontal equilibrium, but a considerable blast is blown back on the car.

With a screw astern steering appears to be much more difficult.

A centre screw gives fair facility for steering, but necessitates placing the car low down, so that the screw can operate between it and the balloon.

In any case the screw should not be placed so that the tips of the blades come below the car, or if on landing it touches the ground, damage to it may result.

Twin screws have advantages if placed amidships, as the car can be placed closer to the balloon. They do not appear advantageous if placed at either end, and if so placed must move in opposite directions, or they will cause the ship to describe a circle. Amidship this is immaterial.

Alterations of Elevation.—It is important to be able to raise or lower the balloon mechanically, or to resist mechanically atmospheric changes which affect the equilibrium.

This can be effected in various ways :—

(1). By shifting ballast, which by being drawn to one or other end of a long car will lower that end, and so incline the nose of the balloon upwards or downwards.

(2). By aeroplanes placed fore and aft, which can be inclined upwards or downwards, so that the head resistance of the wind will cause the whole structure to rise or fall on an even keel.

(3). By using two ballonets, one fore and one aft, so that either end of the balloon can be weighted by pumping air into one and forcing it out of the other.

(4). By inclining the propeller screws upwards or downwards, or using horizontal screws capable of reversing, so as to draw the whole structure up or down.

The aeroplanes add greatly to the head resistance, and are only effective when the forward speed is considerable; and the same may be said of alterations in the inclination of the balloon, whilst it is difficult to design a light but satisfactory method for inclining the propellers, and separate propellers with their mechanism add considerably to the weight.

The direct action of the horizontal propellers is very advantageous for ascending from or descending into comparatively confined situations, without loss of ballast at the start or of gas at the descent.

Horizontal and Vertical Control.—I have mentioned the pitching and yawing action of an airship when moving at speed. The vertical oscillations, if not controlled, are very considerable, most uncomfortable, and may be dangerous. Those in a horizontal plane detract greatly from the speed of the vessel.

Fixed vertical and horizontal surfaces at the rear of the vessel, or appendages, such as in the "Ville de Paris," are necessary, but the attachment of these is not without difficulty. Some attachment to act as do the feathers of an arrow is absolutely necessary. Probably a balloon so shaped that the bulk of the weight can be carried far forward is easier to steer than one of uniform shape both fore and aft from the centre. Movable controls for steering in a horizontal and vertical plane are also necessary. Ordinary rudders of tightly stretched silk can be used for these, and if the fixed controls are sufficient to keep the ship on a fairly steady course in both planes the actual steering presents no great difficulty.

However, the task of the helmsman is no light one; he has to watch both aneroid and compass all the time, besides examining his map and the ground below. The direction of wind currents often varies so greatly at different elevations, and over different areas, that there is no means of allowing for the drift, and direction is purely guess work when out of sight of the ground. The aneroid especially requires to be closely watched, as changes of altitude take place with great rapidity, and it may be necessary to throw ballast or open an additional valve at almost any moment should the vertical controls prove insufficiently powerful.

Lightness.—The weight of all parts of an airship and its accessories must be very carefully considered. In the smaller vessels this is especially necessary, as the margin of lifting power is so small that a few additional pounds may make a great difference. With a vessel of 500,000 cubic feet capacity, the total lifting power is about 35,000 lbs., of which vessel and accessories may weigh 25,000, allowing 10,000 for passengers, petrol, ballast, etc., whilst in one of only 50,000 cubic feet the total lift is only 3,500 lbs., of which only 600 or 700 may be available after the dead weights are allowed for.

The propellers and their fittings must not, however, be made too light; they have to stand very heavy strains, and if one flies off it may pierce the balloon and cause a bad disaster.

Danger of Explosion.—The exhaust should be led away from the balloon, and no free sparking is permissible. The "Pax" was destroyed by the gas igniting.

Ordinarily hydrogen is so light that it will escape upwards, even from a hole low down in the balloon; but should the ballonet leak we may get an explosive mixture in it, and this being comparatively heavy may easily get down to the engine, with very disastrous results, unless sparks are properly guarded against.

Landing.—The question of keeping the balloon safe when on the ground is a very important one, if it is to be of serious utility when working with an army in the field. With a rigid balloon it is practically impossible. The balloon has a considerable momentum, and if it touches the ground at speed it may easily be so broken as to be wrecked; nor have any means been devised to keep it safe in the open on land when exposed to the force of the wind. Swatz's aluminium ship was totally wrecked on its first landing, and Zeppelin's always lands in the water, and shelters in a floating shed, so constructed that it can always enter head to the wind.

Semi-rigid balloons, as "La Patrie" and our "Dirigible No. 1," are certain to be damaged in high winds, and are most difficult to anchor.

For all field work it appears to be preferable to have a non-rigid balloon, the car of which can readily be detached from the envelope, which latter can be pegged down close to the ground, and furnished with a curtain, which prevents the wind from getting underneath it. So picketed, a cigar-shaped balloon can safely remain in the open in considerable winds, whilst the car reposes beside it.

The non-rigid system also allows of a balloon being packed and carried empty on a wagon, with the car on others, and gas compressed in tubes, so that it can be inflated if necessary comparatively close to where it is required for work.

For fortress work this question is not so material, as the vessel will return after comparatively short runs to its own shed, from which it will only issue in favourable weather.

THE USES OF A DIRIGIBLE BALLOON IN WARFARE.

I wish to say a few words regarding the probable uses of a dirigible balloon in war; and here I can only speak, of course, from theory, and do not presume to lay down the law.

It appears to me that we shall have to possess two different classes of vessels. The first will be the comparatively harmless small class of balloon of from 70,000 to 100,000 cubic feet capacity, to be used for scouting, and possibly for attempts at destroying, by high explosives or incendiary mixtures, important iron bridges or store depôts close to the army or fortress; or for harassing the enemy by dropping a few bombs into his camps at night, and so keeping him constantly on the *qui vive.*

It is probable that a reconnoitring balloon to be safe during the daytime will have to manœuvre at an altitude of at least 5,000 feet, from which height only large bodies and important movements would be readily visible. At night, however, a balloon can descend with safety to within a few hundred feet of the ground, and may get valuable detailed information. Even on a bright moonlight night it is difficult to see a balloon at 500 feet up, and it is very difficult to keep a search light on it. With a light wireless apparatus in the balloon much valuable information might, under favourable circumstances, be obtained, without undue risk of losing the vessel. In any case the cost of such a vessel is comparatively small, and the loss of a few would be a small matter to an army.

The radius of action of such a balloon will be, perhaps, 100 or 150 miles.

The second class (and the more important one if really seriously developed) may revolutionize the strategy of war.

Large vessels of from 500,000 to 1,000,000 cubic feet capacity, capable of travelling at a speed of 40 miles per hour in a calm, and of carrying considerable quantities of high explosives, can set out and, with a favourable wind, can cover vast distances in a few hours. When they will come, and what their objective will be, cannot possibly be known to the enemy, who cannot always be looking with guns ready pointed into the air; whilst they will pass over country so quickly as to be out of range almost as soon as seen. Keeping high up in the daytime and descending at night, they can keep their direction with practical certainty, and hovering close over any desired spot, may launch explosives with delay action fuzes, which will enable them to retire to a safe distance before the explosion occurs; or they may even risk destruction to effect some notable exploit.

Their objectives would be not the enemy's armies, but his dockyards, arsenals, storehouses, railway centres, etc., where the maximum of damage can be caused at a minimum of cost. Possibly they might even attack the enemy's navy if he has one; but probably the same effect would be produced in a more humane manner by merely destroying the docks, etc.

There would appear to be but little difficulty in lodging the explosives with great accuracy if good plans are available to work by, whilst the expense, even should several airships be lost, would be insignificant.

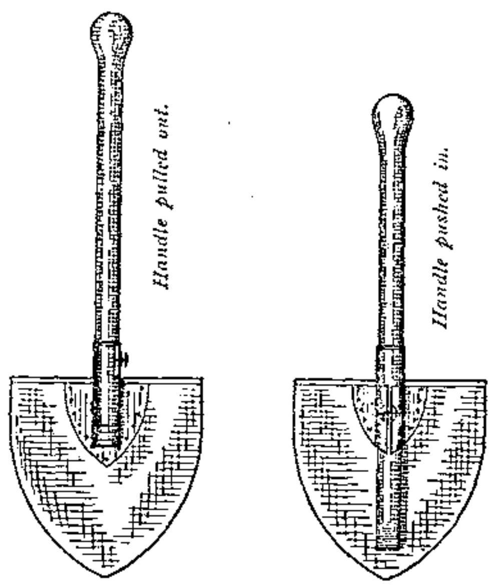
Should all the Powers of the world agree that aerial warfare should not be carried on, then there is no necessity for us to move in the matter, though as long as those on the ground can shoot at those in the air I see no logical reason for refusing these in their turn their power of offence. But as other nations are taking up and developing their airships, we cannot afford to be behind them.

As a citizen of an island power I even welcome the airship, feeling that the idea of an invasion by an army transported in these vessels is chimerical, and that he would indeed be a bold general who would dare to transport a hostile army to our shores, crowded up in fragile transports, in the face of a serviceable fleet of dirigibles, which at the shortest notice could sally forth and deal frightful destruction among them.

A FULL-SIZED PORTABLE SHOVEL.

By 'E.'

In an article in the *Militär Wochenblatt* of the 6th February on "Approaches in Field Warfare, and Entrenching during an Action," Major Mohr proposes a new form of portable shovel.



Front View. *Back View.*

In the first place, he proposes that the blade should be pointed, instead of rounded, at the cutting edge, as in the present German pattern; secondly, he suggests that the handle should be removable, and capable of being pushed down the blade, so as to shorten the length of the tool for carriage. To do this he would have an iron sleeve on the blade of the shovel, "cut through for half its length, and closed up by a wing or female screw."

The advantages claimed for this form are:—(1). That it is more easily portable; the blade and handle can be carried separately, or the shortened tool can be attached to the waistbelt, wood downwards, as at present worn. (2). That while a short shovel, or, at times, the iron alone, is more handy for work lying down, a long shaft is less fatiguing when digging standing, and both lengths are provided. (3). That, as the blade can be carried separately from the handle, a larger one becomes possible. (4). That the blade can be used stuck on its point in the ground as a shield, or, at least, support for the rifle, without being conspicuous as a shovel. (5). That the sharp point can penetrate any ground, and renders it unnecessary to carry a pick.

The rounded handle is used universally in the German Army both for full-sized and portable shovels, and is said to be less liable to give untrained men blistered hands than the T-head of the British pattern.

LORD CROMER AND SIR CHARLES WILSON.

By COLONEL SIR C. M. WATSON, K.C.M.G., C.B., LATE R.E.

LORD CROMER'S book, entitled "*Modern Egypt*," is undoubtedly the most important of the numerous works, dealing with the history of modern Egypt, which have been published since the date of the British occupation of the country in 1882. His Lordship's complete knowledge of all the circumstances, and the wonderful work that he has done in Egypt, give an authority to everything that he says, and a weight to any opinion that he has formed which can attach to the words of no other writer.

It is, therefore, probable that a majority of the readers of his book will accept, without hesitation, the conclusions at which he has arrived as the last word which can be said with regard to the subjects of which he treats. For this reason it is all the more necessary that, in cases where Lord Cromer expresses views that are open to criticism, the public should be made acquainted also with the other side of the question. This remark applies especially to those parts of the work which treat of the abandonment of the Soudan, the mission of the late General Gordon to Khartoum, and the failure of the British Nile expedition to reach that city in time to save it from capture by the Mahdist insurgents.

With the first two of these questions I do not propose to deal in this paper, as, although they are of great importance, to treat them properly would take more space than is here available; it is, therefore, the third point to which I wish to direct attention. Lord Cromer gives an account of the origin and progress of the Nile expedition, and, having spoken of the advance of the desert column from Korti to Abu Kru, where the leader, Sir Herbert Stewart, was mortally wounded, he goes on as follows :—

"The chief command devolved on Sir Charles Wilson. At 3 p.m., on the 19th, the force advanced in square, and, after a sharp engagement, in which an attack of the Dervishes was successfully repulsed, occupied a position on the Nile a short distance north of Metemmeh. The British loss on this day was 9 officers, and 102 non-commissioned officers and men killed and wounded.

"On the following morning (the 20th) the force moved to Gubat. At 10 a.m., on the 21st, four steamers, which had been sent by General Gordon, arrived from Khartoum. They brought his journal and several letters, in one of which, dated December 14th, he said that he expected a catastrophe in the town after 10 days' time. The latest news was written on a small scrap of paper. It was to the following effect :—'Khartoum is all right. Could hold out for years.—C. G. Gordon.—*29. 12. 84.*' It was believed at the time that General Gordon wrote this so that, in the event of his letter falling into the hands of the Dervishes, they would be deceived. In reality, he was in the greatest straits. Obviously the next thing to do was to send the steamers back to Khartoum with some soldiers on board of them. It was not, however, until the morning of the 24th that two steamers, the *Bordein* and the *Telahawiyeh*, left. The interval between the 21st and the 24th was occupied in reconnaissances both up and down the river, and in making arrangements for the proper protection of the force at Gubat." And in a footnote Lord Cromer adds :—

"The delay at Gubat has formed the subject of much discussion. The conclusion at which I have arrived, after a careful examination of all the facts, is that if the steamers had left Gubat on the afternoon of the 21st, they would probably have arrived at Khartoum in time to save the town."

These words of Lord Cromer distinctly imply that he considers that Sir Charles Wilson was to blame for not starting for Khartoum on January 21st, and that, if he had done so, the town would probably have been saved. This is a serious charge to bring against Sir Charles Wilson, and, as he is not alive to answer it himself, it is incumbent on those who are acquainted with the circumstances to show ; first, that the so-called delay of three days was unavoidable, and, secondly, that it had no effect whatever on the fate of Khartoum.

It is not for the first time that this accusation has been brought against the late Sir Charles Wilson, as a similar statement was made in several articles which appeared in newspapers and periodicals soon after the fall of Khartoum. These were answered at the time, and it was proved over and over again that it would have made no difference as regards Khartoum whether Wilson had started on the 21st or the 24th January, and that no blame whatever could be attached to him for not starting on the first date. The most complete answer is contained in a book entitled "*Why Gordon Perished*," by a War Correspondent, published in 1896, which contained a careful *résumé* of the whole question of the failure of the Nile expedition. One might have hoped that the discussion upon the subject had been closed years ago, and it is to be regretted that Lord Cromer has again reopened it, and has made it necessary once more to give the reasons for believing that Wilson was entirely free from blame in the matter.

Lord Cromer has described the long delay that took place before the British Government would agree to any expedition being sent for the assistance of General Gordon ; but there are some points as regards that delay which it is desirable to refer to, especially as concerning the dates, in order to make the situation quite intelligible.

General Gordon arrived in Cairo from London on January 24th, 1884, and, leaving for the Soudan on the 26th, he reached Berber on February 11th, and Khartoum on February 18th. While he was on the journey south, serious events had taken place in the Eastern Soudan. General Valentine Baker had proceeded to Suakin in December 1883, in command of a force, principally composed of Egyptian police, in order to relieve the garrisons of Tokar and Sinkat, which were besieged by the Dervishes under Osman Digna. On February 4th Baker advanced towards Tokar and was defeated with great loss, and on February 8th Sinkat surrendered. The British Government then decided to take steps to relieve Tokar, and on February 28th General Sir G. Graham landed at Trinkatat with 4,000 men to effect this. Tokar had fallen a week previously, but General Graham advanced, and, after defeating the Arabs at El Teb, occupied Tokar and brought the inhabitants back to Trinkitat. The British force then proceeded to Suakin and defeated the Dervishes again at Tamai on February 13th, after which an advance was commenced in the direction of Berber.

The defeat of General Baker had greatly encouraged the rebels, and had had the effect of closing the road to Berber; Gordon saw plainly that the closing of this road would have a most prejudicial effect with regard to carrying out the policy of abandoning the Soudan, and telegraphed on March 4th urging that the road should be re-opened, and that a small force of cavalry should be sent across to Berber. General Graham pointed out the importance of carrying out Gordon's wishes, and Lord Cromer pressed the British Government to allow it. But the representations of the authorities in Egypt had no effect, and on March 26th a definite order was sent to General Graham, forbidding the advance to Berber, and ordering the re-embarkation of the British troops. At that time Colonel Herbert Stewart was at Tamanib, on the road to Berber, and could have reached that place without difficulty in a fortnight. As it turned out in the end, this decision sealed the fate of Gordon and Khartoum; the road from Khartoum to Berber was interrupted in March, and in May Berber surrendered, as the garrison felt that they were abandoned.

In April Lord Cromer pointed out that an expedition would be necessary for the relief of Khartoum, but nothing was done until the following August, when Parliament was asked for a small Vote of Credit to defray the expense of a force going up the Nile. General Sir F. Stephenson, who was commanding in Egypt, was asked for his views as to the course of action to be followed, and on August 11th he proposed to send a force to Dongola at once, which was quite feasible, as the Nile was then high, and there was sufficient transport.

But the authorities in London had decided on sending the expedition up the river in boats to be specially built in England for the purpose, and the troops were kept back until the boats had been placed upon the Nile above the second cataract. The first boat was not ready to start from Gemai until November 1st, and by that time the river had fallen, so that navigation was much more difficult than it would have been if General Stephenson's proposal to start in August had been adopted. Lord Wolseley arrived at Korti on December 16th, two days after Gordon had written his last letter, in which he said that he expected Khartoum to fall in about 10 days. It was then arranged to send a force across the desert under the command of Sir Herbert Stewart, and the column started from Korti on December 30th, but for various reasons did not reach the Nile at Metemmeh until January 19th, 1885.

It is a little difficult to determine what proportion of the delay in proceeding to the assistance of Khartoum was due to each of the causes to which I have referred, but it is easy to calculate the total amount of delay due to them combined. As I have already explained, Sir Herbert Stewart was at Tamanib, on the Suakin-Berber road, on March 26th, 1884, and could then have reached the Nile at Berber in a fortnight, say on April 8th. But he actually did not reach the Nile until January 19th, 1885, about 9½ months later. It is remarkable that Lord Cromer does not dwell more fully on this great delay, when he implies that Khartoum might have been saved if Sir C. Wilson had started three days earlier from Gubat. But, on the other hand, it would not be an excuse for Wilson delaying three days, assuming that he had done so, because other people had delayed for 9½ months, and it is necessary carefully to consider the charge against Wilson apart from other considerations. This charge may be divided into two heads:—

1st. Was Wilson to blame for not starting on the 21st January?
2nd. Had his not starting on that day any effect on the fall of Khartoum?

When Sir Herbert Stewart was directed to proceed from Korti to Metemmeh in command of the Camel Corps, Sir Charles Wilson, who was chief of the Intelligence Department in the Nile expeditionary force, was ordered to accompany him, and in the orders which he received with regard to his duties were the following paragraphs:—

"I am sending Lord Charles Beresford, R.N., with a small party of seamen, to accompany Sir H. Stewart to Metemmeh, where, if there are any steamers, Lord C. Beresford will take possession of one or two of them, as he may think best. Any Egyptian (Fellaheen) soldiers on them can be converted into camel drivers, and come back here with the empty camels."

"As soon as Lord C. Beresford reports that he is ready to proceed with one or more steamers to Khartoum, you will go to that place with him and deliver the enclosed letter to General Gordon. I leave it open so that you may read it."

"Orders have been given to Sir H. Stewart to send a small detachment of infantry with you to Khartoum. If you like, you can, upon arriving there, march these soldiers through the city, to show the people that British troops are near at hand. If there is any epidemic in the town you will not do this. I do not wish them to sleep in the city. They must return with you to Metemmeh. You will only stay at Khartoum long enough to confer fully with General Gordon. Having done so, you will return with Lord C. Beresford in steamers to Metemmeh."

It is perfectly clear, from these orders of Lord Wolseley to Sir C. Wilson, that the latter was to be simply in the position of a staff officer carrying a message from his Commanding Officer to another general. The duty of preparing the steamers for the trip to Khartoum was allotted to Beresford, not to Wilson, and the latter was to embark when the steamers were reported ready. There is not a word of any great haste being imperative, and so far from it being intended that Wilson was to relieve Khartoum, he was to inform Gordon that no steps would be taken to effect this until General Earle, who was coming up the Nile with a force in boats, had reached Metemmeh, which could not be before the second week in March at the earliest.

When the desert column arrived upon the Nile, on the evening of January 19th, it was in a somewhat broken condition; it had suffered severely in the fights with the Dervishes at Abu Klea and at Abu Kru, and a considerable number of officers and men had been killed and wounded, including a large proportion of the Naval Brigade, who had been detailed to take charge of the steamers on the Nile. Sir H. Stewart was mortally wounded; Colonel Burnaby, who was to act as Commandant at Metemmeh, had been killed at Abu Klea, and Lord Charles Beresford, who had been ordered to proceed to Khartoum in command of the steamers, was seriously ill. As Sir H. Stewart was quite incapacitated, the command of the force devolved on Sir C. Wilson, who was the next senior officer, and whose position was thus entirely altered, as from being simply a staff officer, charged with the duty of carrying a despatch to General Gordon, he became the officer in command of a force in a very difficult situation.

Although a part of the British column had arrived on the Nile late on the evening of January 19th, it had been necessary to leave the wounded and the baggage at the last camp, and the whole of the 20th was occupied in bringing these in, and in forming an entrenched camp at Gubat, near the Nile. The original orders given to Sir H. Stewart included an instruction that he was to attack and occupy the town of Metemmeh, which was two miles north of the British camp, and was strongly held by the Dervishes. Sir C. Wilson, therefore, having assumed command, decided to attempt the capture of Metemmeh, and, with this object in view, moved his force out on the morning of January 21st.

With reference to this operation, it is desirable to quote from the *Official History of the War* :—

"With the occupation of this village (*i.e.*, Gubat), the first part of Sir H. Stewart's mission was accomplished in spirit if not in letter. Metemmeh, it is true, had not been taken, but British troops had established themselves within two miles of it, in a defensible position, which, judging by their performances in the open, they were capable of defending against any odds. The main object of the desert march, the opening of communications with Khartoum, would apparently be capable of accomplishment the moment General Gordon's expected steamers should arrive. It now became a question whether the political effect of the capture of Metemmeh would be worth the loss of life which it would entail."

"Its possession was of considerable importance, and Sir C. Wilson decided that unless the operation proved to be more difficult than he had then reason to anticipate, the capture of the town should be attempted."

The account describes the attack on Metemmeh at considerable length, and then goes on as follows :—

"As he (*i.e.*, Sir C. Wilson) was doing so, a message was brought in from Colonel Barrow, saying that the expected steamers from General Gordon were in sight, and, before the village had been regained, a contingent of blacks and Shagiyeh, under Khashm-el-Mus Bey and Abd-el-Hamid Bey, had landed and joined the force. They were brought up by Capt. Verner, who had gone on board one of the steamers at Gubat, and were moved with their guns to open fire on the west end of Metemmeh, which it was then Sir C. Wilson's intention to attack. But hearing from Khashm-el-Mus that a large force under Feki Mustapha was on its way down from Khartoum, and might be expected at Gubat within the next 24 hours, Sir C. Wilson did not consider that he was justified, with his already enfeebled force, in risking a further loss, and accordingly gave orders to retire. During his retreat he destroyed the three villages between Metemmeh and Gubat."

It has been mentioned that Gordon's steamers arrived while the action at Metemmeh was proceeding. It might be supposed from Lord Cromer's description that they had just been sent down from Khartoum. But this was not the case; the steamers had been waiting for nearly four months, and the officers on board were almost in despair in consequence of the long delay in the arrival of the British troops. Gordon had calculated that the relief expedition would arrive at Metemmeh by the end of October, as would have been the case if Sir F. Stephenson's advice had been followed; and on the 30th September he sent four of his best steamers to

Metemmeh with orders to wait for the English expedition. They cruised up and down the river, constantly fighting with the Arabs, and when the Battle of Abu Klea was fought, were at a point some miles above Metemmeh. As soon as they heard that the English had actually come, they moved down the Nile to Gubat.

Sir C. Wilson returned to Gubat on the afternoon of January 21st, and received Gordon's last mail from the officer in command of the steamers. It was quite out of the question that he should have started for Khartoum that night, as it was absolutely necessary that he should be perfectly satisfied as to the safety of his small force before leaving them. He had had intelligence that strong bodies of the enemy were advancing from north and south to attack the English, and he therefore decided to make a reconnaissance in both directions on January 22nd to ascertain the true position of affairs. Colonel Barrow was ordered to reconnoitre up the river, while Sir C. Wilson himself proceeded down the Nile as far as Shendy in the *Tel-el-hoween*, accompanied by the *Bordein*. I will now give a further quotation from the *Official Account of the War*:—

"During this trip it was discovered that certain repairs to the machinery were necessary, and could not be carried out until it had cooled down. On the following morning (January 23rd) they were taken in hand, and at 3 p.m. on that day Lord C. Beresford reported to Sir C. Wilson that the steamers were ready."

Even then the steamers were not quite ready to start that evening. To quote a newspaper correspondent who was present:—"As an eye-witness, the author can bear testimony to the diligence and earnestness manifested in these preparations, which were carried on with a view at first of getting the steamers off that day. It was too late to accomplish this, but all was made ready for an early start next morning."

Having regard to all the circumstances of the case, I do not think it would have been possible for Sir C. Wilson to have started from Gubat before the morning of January 24th, and it is perfectly clear that no blame whatever can be attached to him for not having started on the 21st. It is, therefore, much to be regretted that Lord Cromer should, by implication, lead his readers to suppose that the non-starting of the steamers on the 21st probably caused the failure of the effort to relieve Khartoum.

Having thus shown that the 24th was the earliest day upon which the steamers could have started, I will now give my reasons for believing that the fact of their not starting three days sooner was not a matter of the least importance so far as the final catastrophe at Khartoum was concerned. All the evidence available proves quite conclusively that the town was taken, not for want of soldiers or want of ammunition, nor by treachery, as some people tried to make out, but for the simple reason that the garrison and inhabitants were absolutely starved, and the soldiers were unable to make any resistance.

In the letter which Lord Wolseley received from Gordon, dated November 4th, 1884, he said that he could hold out for 40 days, *i.e.*, to December 16th, but that after that it would be difficult; but he carefully husbanded the provisions, and in a letter I received from him, dated December 14th, he said that he expected the catastrophe after 10 days. Survivors related that the last issue of rations was made about January 4th; Bordeini Bey, who had been one of the leading merchants of Khartoum, gave the following account of this terrible time:—"Soon all that had been collected in the commissariat was finished, and then the inhabitants and the soldiers had to eat dogs, donkeys, skins of animals, gum, and palm fibre, and famine prevailed. The soldiers stood on the fortifications like pieces of wood. The civilians were even worse off. Many died of hunger, and corpses filled the streets; no one even had energy to bury them."

It is really marvellous how Gordon made the place hold out for three weeks longer. At that time the river was falling rapidly, leaving a gap between the fortifications and the White Nile, but the soldiers had no strength to make new earthworks. On January 5th Omderman fell, and the Dervishes gathered closer round Khartoum. They could have entered any time they pleased, but the Mahdi waited, knowing that starvation was doing its work as surely as the sword. Then came the news of the advance of the British troops across the desert, and of the Battle of Abu Klea. The time had come to act, and as soon as word was brought that the steamers were about to leave Gubat, the order was given and the Dervishes entered the town. It was a massacre rather than a battle; the soldiers, dying of hunger, could make no effective resistance, and in a short time all was over. It would have made no difference if the steamers had left Gubat three days earlier; Khartoum would have fallen three days sooner, that is all. The game was played out before the British troops reached Gubat, and after January 20th nothing could have saved the town. The expedition failed because it started too late and took too long on the road to Gubat, and it is most unjust to the late Sir C. Wilson to imply that he was in the smallest degree responsible for the fall of Khartoum and the death of Gordon, when he, like Gordon himself, "tried to do his duty."

C. M. WATSON.

THE SURVEY SCHOOL AT THE SCHOOL OF MILITARY ENGINEERING.

By LIEUT.-COLONEL B. R. WARD, R.E.

PREVIOUS to 1833, cadets who had qualified for commissions from the R.M.A., Woolwich, and who desired to enter the Royal Engineers, had to attend a course of instruction in Survey under the superintendence of the Director of the Ordnance Survey.

While going through this course cadets were designated "Candidates for the Royal Engineers," and on the completion of the course, they were gazetted to the Corps as vacancies occurred.

"In the autumn of 1832 it was decided that the Survey Course of the candidates for the Royal Engineers should be removed from the superintendence of the Director of the Ordnance Survey, to that of the Director of the Royal Engineer Establishment at Chatham; and in February, 1833, that decision was acted upon, Lieut. W. T. Denison being ordered to Chatham to take charge of that branch of instruction. Those cadets who were appointed to the Engineers, were still to continue as cadets under his immediate command, until their Survey Course was completed.

"The earnestness with which he took up the subject is shown by the fact that the transit instrument and the altitude-and-azimuth instrument, now in the Observatory at Chatham, were purchased by himself for use in his instruction, and were left by him, while still his property, for the use of his successor, on whose recommendation they were subsequently purchased by the Government. While he was there they were placed under two very small wooden huts, which after a few years were removed to make way for the present permanent building. He must, however, be regarded as the founder of the Observatory, a necessary adjunct to the English School of Military Engineering, but which, without the comprehensive view of his subject, taken by Lieut. Denison in 1833, would most probably never have been given to it."*

The Observatory originally stood at the south end of the R.E. Drill Shed, on the opposite side of the road to the main entrance of the S.M.E. Workshops.

* "Memoir of Lieut.-General Sir William T. Denison, K.C.B.," by Major-General Harness, C.B., in *R.E. Professional Papers*, 1872, Vol. 20, New Series, page xi.

At the time when Colonel Warren was Instructor in Survey it was taken down, and rebuilt near the top of the Inner Lines, and in 1904 it was again taken down, and rebuilt at the back of the R.E. Institute, the work being carried out by a class of bugler boys under instruction in the workshops.

At first Lieut. Denison's work appears to have been confined to the instruction of cadets from Woolwich, who had been sent to Chatham as "Candidates for the R.E." In 1835, surveying was added to the R.M.A. Syllabus, and cadets were no longer sent to the R.E. Establishment at Chatham. An advanced course for officers would, however, appear to have been instituted at Chatham simultaneously with the withdrawal of the cadets.

From the "Abstract of Orders for the Officers doing Duty at the Royal Engineer Establishment, Chatham," issued by Sir Frederick Smith, when Director in 1847, it would appear that the Survey Course included reconnaissance, sketches, and reports, besides chain survey of detail between fixed trigonometrical points. Attendance at the Observatory for astronometrical observations also formed part of the course.

In the *Synopsis of the Course of Military Instruction at Chatham*, published in January, 1853, by Colonel Harry D. Jones, Director of the Royal Engineer Establishment, the last seven pages (60 to 66) are devoted to details of the "Course of Practical Survey and Astronomy," as taught to the officers, and to the "Instruction in Surveying," as taught to the men of the Royal Sappers and Miners.

The following is the general description of the officers' course :—

"The Course of Survey Instruction, in which the junior officers of the Royal and Honourable East India Company's Engineers are taught and practised at the Royal Engineer Establishment, is intended to be such as shall fully qualify them for carrying on survey operations—either for general purposes, such as occasion may demand, whether on Home service or in the Colonies, but which may be considered as perhaps more especially applicable to the latter—or for military purposes, as reconnaissances, or sketches of positions, etc., on active service in the field—or for special purposes, as the purchase and sale of lands, the framing of plans for the purpose of laying out towns or fortresses (in which the practice of contouring forms an essential part)—or, finally, for taking part in the operations of the Great National Survey, under the Ordnance, or of the Indian Survey, under the Indian Government; and the Course is embraced under the following general heads, viz. :—Trigonometrical and General Surveying, including topographical plan drawing, hand sketching, levelling, special surveying and contouring of ground, Military Reconnoitring, Barometrical Measurements, and Practical Astronomy" (page 60).

The following were the principal subjects taught to such men of the Royal Sappers and Miners as were, "by their requirements and abilities, considered likely to prove themselves useful on the Ordnance Survey of Great Britain":—Arithmetic, Mensuration, and Logarithms, Form of Field Book and Plotting, Chain Surveying, as practised in the Ordnance Survey, Traversing with a Theodolite, Levelling, Drawing a Fair Plan and Contouring.

When Capt. H. Y. D. Scott first occupied the position of Instructor in Survey (1855–1865) the course occupied only about six weeks.

In 1860, when Sir Henry Harness took up the appointment of Commandant of the School of Military Engineering, the course of survey for the junior officers occupied about five months, out of a total of 18 months spent under instruction.

Only one officer was employed as Instructor in Survey, and Sir Henry Harness pointed out that the number of officers to be instructed was far too great for one officer to carry out the work efficiently.*

As a result of this recommendation an Assistant Instructor was appointed shortly afterwards.†

Sir Henry Harness, as Director of the R.E. Establishment (1860–1865), did much to promote efficiency of instruction at the S.M.E., and the system he introduced was carried on by Sir Lintorn Simmons (1865–1870).

In 1868 the Survey Course for officers lasted for six months.

The course was divided into two parts:—

The first part consisted of instruction in survey processes generally. Instruction in taking astronometrical observations occupied the first days of the course. This was followed by the measurement of a base line with a chain and a 5-inch theodolite.

This measured base was extended by means of triangulation over some 10 square miles of country, the detail of a portion of this area being afterwards filled in by means of theodolite traverses and observations with a prismatic compass and portable level.

This was followed by the chain survey of a small tract of country, about half a square mile in area, contours being inserted, and areas of enclosures calculated. A military sketch of some 6 square miles of country was next undertaken.

A base line in this case was measured by pacing, and the triangulation effected by means of a box sextant. The detail was put in by means of prismatic compass observations and pacing. The second part of the course consisted of the application of the knowledge gained in the first part of the course to military and civil engineering problems.

* *Life of Sir Henry Harness*, pp. 212–213.
† *Ibid.*, p. 221.

For instance, a fort to occupy a given site was designed, and a road or canal laid out between two given points.

The N.C.O.'s and men, whose course of instruction lasted from four to nine months, were selected from volunteers whose qualifications seemed to promise their probable fitness as surveyors.

Their course consisted of instruction in chaining, use of theodolite, Y-level, and pocket sextant; and lastly in geometrical drawing, and in drawing hill forms from sketches and from models.

Lieut.-Colonel A. A'C. Fisher, who was Superintendent of Survey when Sir Lintorn Simmons was Director, made many improvements in the Survey Course.

Lieut. W. G. Morris joined at Chatham as an Assistant Instructor in 1877, after passing the Staff College Course. Classes were taken by him for infantry officers in reconnaissance work, and the instruction in this branch of survey was placed by him on a thoroughly sound footing.

These classes were discontinued in 1900.

From 1881 to 1884, Lieut.-Colonel Warren, C.M.G., held the position of Instructor, and reorganized the system of instruction for R.E. officers. He laid great stress upon the necessity of distinguishing between military sketching, in which rapidity is the chief requirement, and surveying proper, in which accurate methods are essential, but rapidity of less moment. The present text book of military sketching inculcates this teaching.

Coast reconnaissances from Brighton to Pegwell Bay were also instituted by Colonel Warren. A few miles of coast line were reconnoitred by each officer of a batch under instruction, the various sketches being afterwards pieced together at Canterbury, where the officers assembled on completion of the work.

A course of mounted reconnaissance was also organized about this time, Lieut. Bogle generally taking charge of the work, and geological tours, conducted by Professor Green, of Leeds, were also carried out.

The geological tours were shortly afterwards discontinued, but were re-introduced again, for a short time, under Major A. O. Green (1889–1893).

The course of mounted reconnaissance formed, at one time, part of a Part II. Survey Course for officers selected for service in India. This course was discontinued in 1907, so that the time devoted to survey instruction at the S.M.E. has been reduced by 22 days.

Owing to the development, in recent years, of instruction in military sketching at the R.M. Academy, Woolwich, and the large reduction in the S.M.E. Survey Course, instruction at the S.M.E. in military sketching, has been considerably curtailed.

The whole Survey Course now covers a period of about three and a-half months, divided up as follows :—

Subject.	Working Days.	Remarks.
(i.). Military Sketching	12	Application of Sketching to Tactical Schemes.
(ii.). Topographical Surveying...	46	Triangulation, Accurate Plane Tabling & Field Astronomy.
(iii.). Cadastral Surveying.........	18	Chain Survey and Levelling.
(iv.). Road & Railway Surveying	10	Reconnaissance, Setting Out Curves, etc.
(v.). Map Reproduction...........	4	Work of a Field Litho Section.

Subhead (ii.) includes the practical carrying out of a small survey in Wales or other suitable district.

Capt. E. H. Hills, when Assistant Instructor in Chemistry, had, in 1895, worked out a practical method of determining longitudes by photography, and it was considered desirable to still further develop the utility of photography and lithography, to the purposes of survey and of map production in the field. Hence in 1904 the War Office approved of the so-called Chemistry Schools of Printing, Lithography and Photography being brought under the Instructor in Survey.

As a result, assistance has been rendered to the War Office in getting out the establishments and equipments of field printing and field litho sections. During the manœuvres of the Eastern Command at Salisbury in September, 1907, a field litho section from the S.M.E. was attached to the staff, and was employed in reproducing each night maps showing the disposition of the troops to illustrate the Director's printed narrative. The instruction of the forces exercised was thereby considerably assisted.

Lieut. F. V. Thompson, as Assistant Instructor in Chemistry, co-operated in survey instruction, and recently designed a stereo-plotter, an instrument for utilizing the resources of the camera and stereoscope in the topographical surveying of mountainous country. For small scale maps of such country, this photographic method could replace the slow method of the plane-tabler by more rapid and yet sufficiently accurate work. The distinctive feature of Lieut. Thompson's instrument is that it far surpasses any method hitherto used in the rapidity and cheapness of its map plotting from photographic views.

In 1904 Major C. F. Close, C.M.G., as Instructor in Survey, obtained authority to carry out the trigonometrical survey course for officers under instruction in a camp at Stockbury, instead of round the barracks at Chatham. The innovation of breaking fresh ground and working under practical conditions was a great advance in efficiency of instruction. This principle has since been continued.

A second camp has been held at Stockbury, and tours have been carried out in South Wales, and in the Cumberland Lake District.

Classes of some 12 N.C.O.'s are formed annually from volunteers in the Corps. The course lasts about seven months. Only intelligent men of good character who are in possession of at least a 2nd class certificate of education are selected for this course.

These men, after completing their course, are drafted to field and fortress companies, in order to keep up the establishment of surveyors in those companies.

The annual Foremen of Works Class receive a month's instruction in the Survey School, chiefly in the use of the level and in chain survey.

Before the completion of the R.E. Institute in 1873, the office of the Superintendent of Survey and the officers' halls of study were situated in A House, Brompton Barracks, on the first floor. The Survey School was located on the floor of B House, and was principally used for training men of the Honourable East India Company's Sappers and Miners in survey duties for India.

The offices and halls of study of the Survey School are now located in the south-eastern wing of the R.E. Institute, on the upper floor.

All military manuals and instruments relating to survey have either originated in the Survey School, or the latter has had considerable influence in their production.

The following are the most important text books that have been prepared by officers in the Survey School:—General Frome's *Surveying*, revised and enlarged in 1873 by Capt. C. Warren. General Frome, as a lieutenant, had been an Instructor in Surveying at the S.M.E. from 1835 to 1840. *Notes on Astronomy*, 1902, by Lieut.-Colonel A. C. Macdonnell. *Text Book of Topographical Surveying*, 1905, by Major C. F. Close, C.M.G. This text book is a model of its kind. It co-ordinates information scattered amongst various books, and has met a much-felt want.

The utility of the Survey School in the past has not been limited to the Corps of R.E., nor even to the Army. It has furnished instruction and assistance to officers and civilians employed under the Foreign and Colonial Offices, as well as the Egyptian and various colonial governments. This circulation of experience has been valuable to the school as well as to the offices concerned, as tending to keep the instructional staff up to date, and in touch with practical work.

The Montgomerie Prize, which was originally awarded for proficiency in survey work, is now no longer given for this object; but as it was instituted in memory of a distinguished Indian surveyor and geographer, it may well be alluded to in this article.

Colonel T. G. Montgomerie, R.E. (Bengal), F.R.S., was born in 1830, and passed out first of his term at Addiscombe and winner of the Pollock Medal. His obituary notice appeared in the *Journal* of the 1st April, 1878, written by the most distinguished geographical author that the Corps has ever produced, Colonel H. Yule, R.E. The following is a short *résumé* of some of his principal services :—

After completing his course at the R.E. Establishment he went to India in 1851, and after a year's service with the Bengal Sappers and Miners was posted to the Great Trigonometrical Survey, a service on which he had set his heart from the first.

His earliest survey work was carried out near Attok, on the Indus, in 1853, and at Karachi (1854–55). On the conclusion of this work he was appointed to the charge of the Trigo-Topographical Survey of Kashmir, and this duty occupied the next nine or ten years of his life. As Colonel Yule points out, the great difficulty of this task consisted in its being carried out amongst the most stupendous mountain tracks in the world, the observing stations ranging between 15,000 feet to 20,000 feet in height, and the work itself consisting of a "net of geometry cast out with infinite labour and bodily fatigue over the unknown." It was, in addition, carried out in the territory of a quasi-independent prince, at the very time when the Great Mutiny of 1857 broke out, reached its zenith, and was finally quelled. From this it is easy to realize that the praise accorded to Capt. Montgomerie, for the tact and ability with which he maintained amicable relations with the court and had preserved discipline among his own large and mixed establishment, was well deserved.

In 1864 the Kashmir Survey was completed, and in 1865 he received the Founder's Medal of the Royal Geographical Society for his Himalayan work.

In 1867 Montgomerie was placed in charge of the Himalayan Survey in Kurmaon and Gurhwal, and in 1870–71–72 he temporarily officiated as Superintendent of the Great Trigonometrical Survey of India. Meanwhile his health had suffered from exposure when on the Kashmir Survey; he was compelled to return to England in 1873, and as he was unable to return to India, he retired from the Service in 1876, dying in 1878, at the early age of 48.

The principle of extending accurate reconnaissance to the countries beyond the Indian frontier, and consequently practically inaccessible to British officers, was initiated by Montgomerie, who suggested that native surveyors be trained and employed on this duty. This suggestion was carried out, and has proved eminently successful ever since.

In 1902 the prize was instituted by Colonel Montgomerie's family, and consists, as a rule, of books of travel and exploration, etc., and is awarded for contributions to the *R.E. Journal* or *Professional Papers*.

The following is a complete list of the officers who have been employed as Instructors in the Survey School :—

SUPERINTENDENTS OF SURVEY.

Lieut. W. T. Denison	1833-1835
„ E. Frome	1835-1840
„ H. D. Harness	1840-1844
„ J. G. McKerlie	1844-1855
Capt. H. Y. D. Scott	1855-1860

INSTRUCTORS IN SURVEY.

Capt. H. Y. D. Scott	1860-1865
Lieut.-Colonel A. A'C. Fisher ...	1865-1870
Capt. F. E. Pratt	1870-1875
Major C. N. Martin	1875-1879
„ M. Lambert	1879-1881
Lieut.-Colonel C. Warren, C.M.G. ...	1881-1884
Capt. J. du T. Bogle	1884-1889
Major A. O. Green	1889-1893
„ C. W. Sherrard	1893-1896
„ A. C. Macdonnell	1896-1902
„ C. F. Close	1902-1905
„ E. P. Brooker	1905-

ASSISTANT INSTRUCTORS.

2nd Capt. W. D. Marsh	1860-1865
Lieut. C. H. Craigie-Halkett	1865-1872
„ A. Featherstonhaugh	1872-1873
2nd Capt. J. Fellowes	1872-1877
Lieut. R. A. Livesay	1873-1879
„ W. G. Morris	1879-1882
Capt. J. du T. Bogle	1879-1883
Lieut. C. B. Mayne	1882-1886
„ W. F. H. Stafford	1883-1888
Capt. W. A. Gale	1886-1889
Lieut. C. W. R. St. John	1888-1893
„ A. E. Haynes	1889-1894
„ C. H. Enthoven...	1893-1898
„ A. E. G. Watherston	1893-1898
„ W. J. Johnston	1898-1901
„ A. J. Woodroffe...	1898-1901
„ C. J. Heath	1901-1904
„ C. Russell-Brown	1901-1905
„ F. V. Thompson (Assistant Instructor in Chemistry) ...	1904-1908
„ G. F. Evans	1904-1908
„ L. N. F. I. King	1905-
Capt. T. T. Grove (Assistant Instructor in Chemistry)	1908-
Lieut. T. N. Dunman	1908-

MEMOIRS.

Lieut.-General Sir Richard Strachey, G.C.S.I., F.R.S., late R.E.

By the death, on the 12th of February last, of Lieut.-General Sir Richard Strachey, the Corps loses not only one of its oldest members, but one whose career of public service, lasting as it did over 70 years of active work, was one of unusual length and distinction.

Born in 1817 of a Somersetshire family, he inherited the tradition of administrative ability from both sides of his family. His paternal grandfather, Sir Henry Strachey, began a distinguished career as private and political secretary to Lord Clive when he returned to India in 1765; while his mother's father, Major-General William Kirkpatrick, served with distinction in India in various political offices, and was military and private secretary to Lord Wellesley. Richard Strachey left Addiscombe at the head of his term in 1836, and after a short interval at Chatham was appointed to the Bombay Engineers, and transferred to the Bengal Engineers in 1839. His active military service was confined to a share in the first Sikh Campaign of 1845–6, when he served on the staff of Sir Harry Smith, and was present at the Battle of Aliwal, where he had one horse killed under him and another wounded, and at the Battle of Sobraon. He was mentioned in despatches and received a brevet majority.

In his professional duties as an Engineer he was mainly employed in irrigation work on the Jumna Canal, in Bundelkhund, and on the Ganges Canal, where he commenced the construction of the head works at Hurdwar.

It was in 1856 that he first became connected with the Secretariat of Public Works, as acting Under-Secretary, and thus entered on the career of administrative work, for which his abilities were so eminently suited. The department was then in its infancy, having been created by Lord Dalhousie in 1854, under the pressure of the development of irrigation canals and railways. Sir William Baker, R.E., was the first Public Works Secretary, succeeded in 1857 by Major (afterwards Sir Henry) Yule, R.E., on whose retirement in 1862 Strachey was appointed to the office. In the meantime, during the Mutiny year, 1857, he accompanied Mr. John Peter Grant to Allahabad, the head-quarters of the temporary Lieutenant-Governorship of the Central Provinces, acting under him as secretary in all departments, and on his return to Calcutta in 1858 he was appointed Consulting Engineer in the Railway Department.

The position of the Secretary for Public Works differed from that of the other secretaries to Government, inasmuch as there was no member of the Supreme Council possessing expert knowledge of the matters with which the Department had to deal; the secretary was brought into close personal contact with the Governor-General, and had necessarily considerable departmental power. But in Strachey's case it did not end there; under three viceroys, Lord Elgin, Lord Lawrence, and Lord Mayo, he exercised a far-reaching influence over public affairs altogether outside his special sphere. Perhaps the results of his nine years of office cannot be better summed up than in the words of his brother, Sir John Strachey, who for the greater part of the time was working beside him. "It is to him," writes Sir John in his preface to the latest edition of *India*, "that India owes the initiation of that great policy of the systematic extension of railways and canals which has been crowned with such extraordinary success, which has increased to an incalculable extent the wealth of the country, and has profoundly altered its conditions. To him is due the conception of those measures of financial and administrative decentralization which have had the most far-reaching consequences, and which were pronounced by Sir Henry Maine to be by far the greatest and most successful reforms carried out in India in his time. To his active support is largely due the initiation of the measures, which have proved of the highest value, for preventing the destruction of the Indian forests, and for their scientific protection and management. He it was who first organized the great department of Public Works, and laid the foundations of the scientific study of Indian Meteorology. . . . If the weights and measures of India are still in a condition of mischievous chaos, it is because, through the powerful influence of ignorant prejudice, the Act, which he passed through the Legislature and which is still on the Statute Book, has remained a dead letter."

Strachey left India in 1871, receiving the unusual honour of a resolution from the Government of India thanking him for his services, and after acting for a time as Director-General of Stores at the India Office, he was appointed by Lord Salisbury, in 1875, to a seat on the Indian Council. In 1877, during the vice-royalty of Lord Lytton, he was again sent to India, on a special mission connected with the purchase of the East Indian Railway, by the Government, from the guaranteed company. Before his return in 1879 he had been appointed President of the first Famine Commission, and subsequently acting Finance Member of Council in place of his brother, whom ill-health had compelled to take leave to England. In the former capacity, he laid down those principles which have guided all subsequent efforts to combat the periodical famines from which India suffers. As Finance Member he wrote a highly important minute containing proposals for a reform of the

Indian currency, which, had they been then carried out, would have saved India from incalculable loss. Fourteen years later similar proposals were adopted as the result of the Committee on Indian Finance, presided over by Lord Herschel, of which Strachey was a member. He also acted as Military Member of Council for a short time at the beginning of the Afghan War.

Strachey was re-appointed as a permanent member to the Council of India, but resigned his seat in 1889, and accepted the chairmanship of the East Indian Railway Company, to which he devoted the remainder of his life. His energy, his wide and public-spirited views of policy, and his remarkable capacity for mastering details made his management a memorable one. Under him, the line—already, from its natural advantages and excellent management, the most prosperous in India—attained a level of financial prosperity, which alone has enabled the Government of India to reckon its railway policy as a financial success. It may be added that the increased returns to revenue have been coincident with a considerable decrease in traffic and passenger rates. His rule has been commemorated in the name of the Strachey Bridge, across the Jumna, which was opened a few weeks before his death. He was also for several years chairman of the Assam-Bengal Railway Company.

Although thus actively engaged in the public service over a length of 70 years, this was not the only field in which Strachey's abilities were exercised. He attained distinction in various branches of science, as a scientific explorer and geographer, a geologist, a botanist, and a meteorologist. He was a President of the Royal Geographical Society, and an honorary member of the Italian and the Berlin Geographical Societies. His meteorological work was specially valuable; for 22 years he was chairman of the Meteorological Committee, and received the Symons Medal from the Royal Meteorological Society. He served for a considerable period on the Committee of Solar Physics, and was for many years on the Council of the Royal Society, which awarded him the Royal Medal in 1897.

In 1884 he was a delegate to the International Congress, held at Washington, for determining the Prime Meridian, and in 1892 was also delegate to the Monetary Conference held at Brussels. The University of Cambridge conferred upon him the honorary degree of LL.D. in 1892, when the late Duke of Devonshire, a former Secretary of State for India, was appointed Chancellor.

For his public services Sir Richard Strachey was granted a Distinguished Service Reward in 1866, was made C.S.I. in 1865, and, finally, in 1897, on the occasion of the Diamond Jubilee of Queen Victoria, was awarded the well-merited distinction of a G.C.S.I.

J. M. STRACHEY.

CAPT. SIR HENRY WHATLEY TYLER, K.C.B., LATE R.E.

WHEN asked by the Secretary of our Institute for a short memoir of his father, the writer naturally thought at first that such a memoir would come better from some brother officer who was not also a son. His father had, however, outlived most of his contemporaries, and his retirement at a comparatively early age, and previous civil employment for 15 years, had put him of late years out of touch with his old friends in the Corps. But those who knew Sir Henry will regret that the privilege of writing this was not given to someone whose pen could have done better justice to the theme.

Henry Whatley Tyler, the eldest son of John Chatfield Tyler, Esq., a Deputy Lieutenant of the County of Gloucestershire, was born in Chesterfield Street, Mayfair, London, on the 7th of March, 1827. He joined the Royal Military Academy, Woolwich, at the age of 15, and got his commission in the Royal Engineers in the shortest time possible, in December, 1844. After the usual course at the S.M.E., he was sent to Ireland for a year, and then to the West Indies. During four years in St. Lucia he added the duties of Private Secretary to the Civil Governors and Administrators of the island to those of an Engineer officer. Fond of horses from boyhood, he employed his leisure whilst in St. Lucia by training raw mustangs from Mexico. He also became a corresponding member of the Royal Zoological Society, supplying them at one time with the larger portion of their stock of snakes, and contributing a very interesting series of articles descriptive of snakes and their habits to the Society's proceedings.

On returning home after a tour through the other West Indian islands, Lieut. Tyler was one of the several R.E. officers specially employed in the great International Exhibition of 1851. And he continued in charge of a collection of permanent exhibits he had been the means of forming there, which afterwards became the nucleus of the South Kensington Museum.

In 1852 Lieut. Tyler married Margaret, the daughter of Lieut.-General Sir Charles Pasley, K.C.B., R.E., and at the same time was appointed Engineer to the Colony of Victoria. On the way to Australia all three masts went by the board in the Bay of Biscay, the rigging fouled the propeller, and the captain of the ship called the passengers together and told them that the ship was unmanageable, and that he could do nothing more for them. Fortunately the passengers were of better metal, and they organized themselves and cut away the wreckage, and the ship eventually reached Lisbon. Lieut. Tyler sailed twice more, the ships breaking down on both occasions, and on return from his third attempt he was offered, and he accepted, the appointment of Government Inspector of Railways under the Board of Trade. His brother-in-law, Capt. Charles Pasley, R.E., took up the colonial appointment in Victoria.

In 1868, when within three months of his lieutenant-colonelcy, Capt. Tyler was retired from the Corps of Royal Engineers without pension, under regulations then in force; as these regulations were altered shortly afterwards in regard to military officers holding civil employment, he was the only officer to whom they were thus applied.

From 1853 to 1877 Capt. Tyler was continuously employed in inspecting new railways, reporting on railway accidents, enquiring into complaints of Metropolitan water supply, and a host of special services in the United Kingdom and on the Continent. In 1865 he read a paper on "The Festiniog Railway" at the Institution of Civil Engineers, and in the same year made experiments with Mr. Fell's third-rail system, with a view to its adoption on the Mont Cenis. In 1866, 1867, and 1869 he examined and reported on the means of accelerating communication with India, after three visits to the various ports of Italy, and careful examination of the different routes to them through France and Italy, which led to the adoption of the Brindisi route for the Indian mails.

In addition to all his railway and other work Sir Henry invented in 1853 the galvanized sheet-iron gabions, afterwards modified by Sergt.-Major Jones into iron-band gabions (*R.E. Professional Papers*, Vol. VIII.). He wrote many articles for the *Quarterly Review*. He read papers at the Royal United Service Institution—in 1858 on "The Effect of the Modern Rifle upon Siege Operations and the Means Required for Counteracting It"; in 1859 on "The Rifle and the Spade, or the Future of Field Operations"; in 1860 on "The Principles of Fortification advocated by Mr. Ferguson"; in the same year on "The Rifle and the Rampart, or the Future of Defence"; in 1864 on "Spithead and Harbour Defence"; in the same year on "Railways Strategically Considered"; and in 1866 on "Routes of Communication with India." In 1859 he contributed a paper on "The Probable Influence of the Modern Rifle in the Field, and the Necessity for an Increased Use of Entrenchments in Future Field Operations" to the *Corps Papers*. In 1862 he wrote a memoir of Sir Charles Pasley for the Royal Society of London (Vol. XII.).

Sir Henry Tyler continued to discharge duties, which would have overwhelmed many a younger man, with all his usual care and skill until within a week of his death on the 30th of January, 1908, a few weeks under 81 years of age. His last public speech was to the Peruvian bondholders, as chairman of the Corporation, on 31st December, 1907, a speech of three-quarters of an hour's length, fully explanatory of the new agreement between the Corporation and the Government of Peru, composed with all his customary lucidity, and clearly audible through the hall.

In 1867 Capt. Tyler spent his leave making an inspection of the Grand Trunk Railway of Canada, and also read a paper at the Institution of Civil Engineers on "Railway Gradients and Curves." In 1868 to 1869 he spent his leave constructing the first railway in Greece, between Athens and the Pyraeus, and hired six brigands to police the line. He opened this railway in March, 1869, and enquired into the means of communication between England and France on the way home.

He was next chairman in 1875 and 1876 of the English Channel Tunnel Commission, whose meetings in Paris and London, with the French Commission, resulted in a treaty between the two countries. So far from regarding such a tunnel as a menace to our insular isolation, he held that if only we could induce a hostile army to enter a pipe 30 miles long and 30 feet in diameter, it would be worth while spending three millions on the construction for that sole purpose.

From 1871 to 1877 Capt. Tyler was Chief Inspector of Railways at the Board of Trade, and his annual reports, published as Blue Books, on railway statistics and railway accidents became text books of great value, and were studied and quoted in all civilized countries. They contributed materially to the general improvement of, and rapid adoption of modern appliances on, the railways of this country.

In 1871 he gave a series of four lectures at the S.M.E. on railways; made another inspection of the Grand Trunk in Canada, and of the International Bridge over the Niagara River; and in the same year made a second report on the Metropolitan water supply, and served on a Board of Trade Commission to settle regulations for the water companies. In 1872 he gave evidence before the Select Committee on the Euphrates Valley Railway scheme. In 1874 he inspected the Erie Railway and its connections, and a paper he wrote on "Simplicity as the Essential Element of Safety and Efficiency in the Working of Railways" was read in his absence by Colonel Yolland, R.E., at the Society of Arts.

In 1875 there was a debate in Parliament on the propriety of Capt. Tyler being allowed to spend his leave inspecting railways in European Turkey, at the request of the Turkish Government, through the Foreign Office. The President of the Board of Trade, defending his action, stated that Capt. Tyler had already started. With his colleagues, he inspected about 900 miles of railway in Roumelia, and from Salonica to Mitrovitza, and afterwards, at the special request of the Grand Vizier, Essad Pacha, rode on horseback for about 400 miles through Bosnia, which he described as "like hunting for a whole fortnight, with sundry adventures thrown in." Bosnia was at the time seething with revolt, and he called it "a country of mountains without the usual intervening valleys." He wrote his report in French, and got back inside his two months' leave.

In 1877, at the request of Mr. Westinghouse, Capt. Tyler became chairman of the Westinghouse Brake Company in England. The post was of course incompatible with continuance in his appointment at the Board of Trade, and accordingly he resigned after serving as an

Inspector of Railways for 24 years, of which he was Chief Inspector for seven. As he had not attained the age of 60, he was again refused a pension, and claimed to be the only instance of a public servant who had given his best work to his country for 33 years without becoming a burden to her in his age. He received, however, the honour of knighthood for his services.

The unstinted praise of all the newspapers on Sir Henry's retirement everywhere prove the thoroughness of all his work, and that the additional duties which he undertook, concurrently with his duties in the Board of Trade, in no way interfered with them. The Executive Council of the Amalgamated Society of Railway Servants passed the following resolution in 1877:—"That this council has heard with regret of the retirement of Capt. Tyler, R.E., from his position of Chief Inspector of the Railway Department of the Board of Trade, and expresses its admiration of the faithful and fearless manner in which he discharged his arduous duties many years, to the advantage and greater safety of the public and of railway servants. This council also tenders its best thanks to Capt. Tyler for his invariable courtesy to railway servants, and to representatives of the Amalgamated Society present at his numerous official enquiries."

Among the reforms in railway conduct for which he had fought most strenuously were extensions of stations and sidings, wide and clear platforms, continuous footboards which should fit the platforms, footbridges or subways at crossings and in stations, and continuous automatic brakes.

So much was Sir Henry's name before the public a generation ago that he was known by his works in all parts of the civilized world, and the *Globe*, in a leading article of December 9th, 1876, says: " . . . Capt. Tyler once a year has a story to tell which far exceeds Aladdin and Ali Baba in the fascination of its incidents for the children of a larger growth. In his general report to the Board of Trade, Capt. Tyler reviews the whole railway system of the British Empire. A great master of style, uniting the official and statistical with the popular form of elucidation, Capt. Tyler puts into a few pages, for a few pence, more information than any writer we know . . ."

He made a practice of walking the whole length of every new line he opened, often to the no small discomfort of the officials who accompanied him.

Already president of the Grand Trunk Railway of Canada, Sir Henry became chairman of the Rhymney Iron Company, a director of the Great Eastern Railway, of the National Mutual Assurance Co., and of the Globe Insurance Co., besides being engaged in many less known undertakings. In this year (1877) he again went over the Grand Trunk, for which purpose he visited Canada every year for the term of his presidency. With able assistance from the many excellent officers of the company, he built up the Grand Trunk into a system which has been very beneficial to the country it serves. The international tunnel under the St. Clare River, between Sarnia on the Canadian side and Port Huron in the United States, remains a lasting monument of his presidential enterprise. It is 3,851 yards long, including approaches, and was made under the compressed air system through about the worst material possible, a mixture of sand and clay. The air pumped into the tunnel during boring appeared at all sorts of places on the river surface, up to a quarter of a mile away from the site.

In 1877 to 1878 Sir Henry spent three months visiting and reporting on the railways of the colony of the Cape of Good Hope, of which Sir Bartle Frere was then Governor. Incidentally the Zulu War broke out during this visit, and Sir Henry, himself unarmed, took an armed Zulu prisoner, and confiscated his rifle. He advocated that we should reorganize the intelligence system, and set ourselves the task of capturing chiefs by flying columns, as a means both of quelling and preventing native revolts.

Sir Henry Tyler sat in Parliament as member for Harwich from 1880 to 1885, when the borough was merged into a county division; and for Great Yarmouth from 1885 to 1892, being then defeated at the general election. A staunch Conservative, he was rather too independent in character to make an ideal pawn in the party; and he welcomed the relief from attendance at the House, and refused invitations to contest other constituencies.

As a boy equally successful in his classical and his mathematical studies, General Wrottesley very kindly writes of him: "He entered the R.M. Academy at the earliest age a cadet could enter in 1842, for he had only just completed his 15th year. He passed out as an officer of Engineers in December, 1844, when he could have been very little over 17 years of age, and I think you will find he was the youngest officer who ever entered our Corps. As a cadet he was remarkable for the energy he put into everything he undertook, and the quickness and accuracy of his work. I sat next to him in the fortification class, and the neatness and rapidity of his drawings were always a source of envy and marvel to me. He carried the same qualities into all his work in after life, and it was the secret of his success. He combined great energy in action with lucidity of thought and clearness of judgment. These were qualities which would have led him to distinction in any walk of life, and I always regretted for that reason that he relinquished the public service. He gave up in fact to commerce what was meant for his country and his Corps."

A great reader of newspapers, a careful student of all scientific progress and discovery, all things were real to him. He had at his command an enormous fund of anecdote and a keen sense of humour.

There was an extraordinary contrast between his character and the popular conception of a financier. With all the business and appointments he obtained, he never sought any. He was constantly declining offers, and many things which he accepted he took only because they were thrust upon him. As a director of public companies, if the company were in financial straits he would often forego his salary and give his services free till better times. He made mistakes in some cases, but frankly owned them. He was occasionally swindled, but he never led others into losses. Presiding as chairman at a company meeting in the case where a very interested opposition had been successful and obtained a vote contrary to the Board, amid cries of "Resign" Sir Henry, on one memorable and unique occasion, declined to resign, and before the next meeting the scheme was exposed, and collapsed. He continued in the chair of that company till the day of his death.

His generosity was unbounded, but unobtrusive. He made friends everywhere, and remembered them all. He served with the same zest on committees of the London Homœopathic Hospital, to which he gave large sums, as he did on boards from which he drew salaries. He took the same intense and scientific interest in his farm in Surrey as in the business of the Peruvian Corporation, to which his last public speech was addressed.

H. E. TYLER.

TRANSCRIPT.

EXTRACTS FROM THE SANITARY REPORT, HAMPSHIRE TRAINING AND MANŒUVRE AREA.

By Capt. R. Tilbury Brown, R.A.M.C.

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Sanitary Sections.

The system of sanitary sections was excellent; they were permanently employed, took an interest in their work, and I attribute the good results, shown during training and manœuvres in camp sanitation, to be due to the ready and intelligent manner in which they performed their duties.

The sections consisted of one non-commissioned officer and eight men from each regiment.

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The question as to *what* men should be employed as sanitary section men is left to commanding officers, some of whom have the pioneers, and others (the minority) have men from the companies.

I have been asked whether I consider the pioneers the best men to be employed.

At first sight the answer is Yes! but on consideration I think No! for the following reasons:—My idea is (1) that the sanitary section men should be permanently employed as such; (2), that they should have no other duties; (3), that they should have special training; and (4), that a certain number should accompany the regimental companies when on the march, and that the remainder should be together under the sanitary non-commissioned officer, ready to prepare the camping ground at any moment.

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Furthermore, the non-commissioned officer of the sanitary section should have sanitary authority, as far as lies in his province, over the *whole* camp or barracks, and not portions only, as is frequently the case.

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Water Carts.

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(A). *Metal.*—I consider that these carts should only be used as an extra supply for the filter carts, which might find difficulty in procuring water.

The washing-up water ought to be boiled or filtered just as much as the drinking water, but is often neglected.

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(B). *Wooden.*—I consider that these carts should be abolished; but in any case they should only be used to supply filter carts, and the above remarks apply concerning washing-up water.

(C). *Filter Carts (Field Service).—The Brownlow Patent Filter Water Carts.*—These carts produce excellent water.

I analyzed the water from five carts, and found no coli-like organisms, though in three instances they were present before filtration.

Each cart was worked by a *water-squad* of one non-commissioned officer (or senior private) and two men of the R.A.M.C. These men were attached to regiments.

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The carts were tried over very *rough country*.

They had to be dug out of bogs, were severely shaken over hidden ditches, and tested very highly. The results were good, and the carts sustained no damage, as far as I could ascertain, from the rough work, with the exception of one broken candle.

Output of Water from Carts.—When dealing with a *clear water* it was generally found that it took from 25 to 30 minutes to fill it, and the same to empty it. At this rate, and allowing the cart to be filled before commencement, the cart could supply about 100 gallons of filtered water in the first hour, and 200 gallons in $1\frac{1}{2}$ hours. One trial gave 140 gallons in an hour. I do not think it possible to get 210 gallons per hour, including the necessary filling.

When *very muddy water* was used, as an experiment, from a muddy and thick stream, it was found to take 50 minutes to fill the cart, and about 30 (as with clear water) to empty it through the candles; that is to say, 80 minutes to supply 100 gallons of filtered water.

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LATRINES.

The shallow trench system was used throughout the camps, and was most satisfactory.

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Size.—Where ground was limited, the trenches were dug 2 feet deep, otherwise 1 foot. Their length was 3 feet, breadth 1 foot, and the interspace was $2\frac{1}{2}$ feet. This interspace was sufficient to allow another row of trenches to be dug in it if ground was limited.

Odour.—There was no smell about the trenches.

Flies.—There was a marked absence of flies about the trenches. Although the weather was against the presence of flies, in a few instances deep trenches were dug on the arrival of the regiments and closed after two days. These deep trenches smelt very offensive and many flies were present, the difference to the conditions about the shallow trenches being very marked.

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Number.—Trenches were generally dug for 5 per cent. of troops.

Time they Lasted.—They generally lasted two days, but in one regiment for four days; this was because the earth, for covering, was finely sifted, and the contents of trenches, which tend to get heaped in the centre, were levelled down.

Orders were issued to the men to throw earth into the trench after using it, and the following means were adopted to enable them to do so:—

(1). Empty tins.
(2). Improvised scoops made of empty tins with wooden handles.
(3). Cheap grocers' scoops similar to (2).

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Supervision.—The following methods were adopted to supervise the carrying out of this order:—

(1). Policed by men who remained on duty until they found another man neglecting to obey the order.—This was very useful at first, but later on unnecessary.

(2). Policed by one of the sanitary police who was stationed at the latrine at fixed hours.—This method was most satisfactory and generally adopted.

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URINALS.

I tried making urinals by having shallow trenches leading into a pit filled with large stones.

The trench was for use and the pit to take the excess.

Size.—*Trenches.*—Depending on strength. For a regiment, two of 6 feet long were sufficient.

The gradient from commencement of trench to pit was 1 inch for each foot length.

Pit.—Depending on strength and soil. Three feet deep and 2 feet diameter was generally sufficient.

Time Lasted.—*Trenches.*—About two days. When foul, fill in and dig fresh ones.

Pit.—About 14 days.

The result was very satisfactory, and preferable to the usual open pit.

An inner screen should be put round the pit to prevent men from using it instead of the trench.

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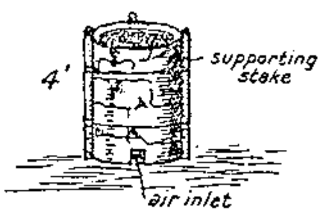
DISPOSAL OF REFUSE.

Camp.—The following methods were adopted:—

(*a*). High cylinder built of sods with air inlets at base.

This is a most efficient method, and is most suitable when the soil is turf; it burns away if it is peaty.



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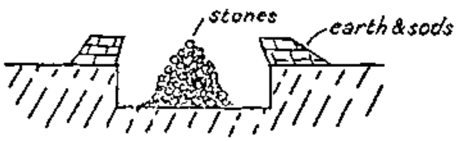
(*c*). Pit with central cone of stones.

Very efficient and quickly built. Suitable when stones are available. I tried empty tins filled with earth, but it was not a success.



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The above crematoria were very satisfactory, and, in the case of pattern (*a*), when once the fire was lighted it kept going for three weeks, and only relighted twice. The residuary ash in the crematory, after three weeks, was very small. In (*c*) the destruction was not so complete, and the residue was buried in pits.

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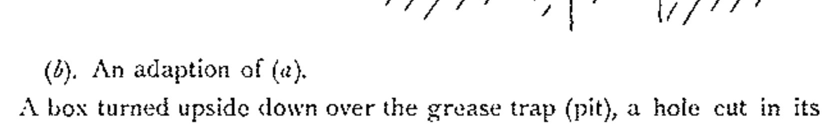
Kitchen (*Greasy*) *Water*.—All water was strained, and run into soakage pits.

The following methods were found to be good and easily improvised :—

(*a*). Two large biscuit tins, the upper one acting as a coarse strainer and, when required, emptied into a refuse tub, the lower directing the water over a small pit, which acted as a grease trap and was filled with furze (dried grass, heather, hay, etc., can be used), which was burnt and renewed daily.

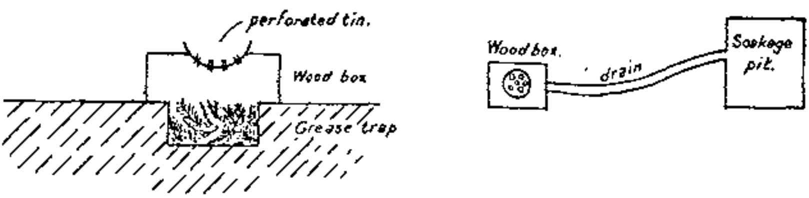
A narrow and shallow trench ran from this small pit into the large soakage pit.

The spout of the lower tin is easily made by making an inverted V-shaped incision, turning it down and rounding off.



(*b*). An adaption of (*a*).

A box turned upside down over the grease trap (pit), a hole cut in its bottom, and a perforated cullender or tin fitted into the hole.



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ABLUTION BENCHES.

I do not like the ordinary ablution bench, as, even when foot-gratings are used, the ground around always becomes wet and muddy.

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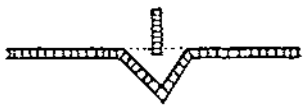
The —V— bench has many advantages (cleanliness, self-draining, etc.), but there are two disadvantages, viz.:—

(1). When emptying a basin, the water is very apt to go over the other side and wet the man opposite.

I suggest an upright plank over the **V**, thus:—



(2). The square box at the bottom of the overflow requires to be wider, as water splashes over and fouls the ground.

If these defects can be remedied, I think this bench would be much better than the ordinary grating bench.

CLOTHES DRYING.

Was generally done on the heather, gorse, or trees about the camp.

Some regiments had posts and ropes in regular drying grounds; this was an improvement.

One regiment had a marquee for drying clothes. It was fitted with posts and ropes, and had charcoal braziers on the ground. Tins or buckets, with holes, do for braziers. In this marquee the wet clothing of two companies was dried in two hours.

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NOTICES OF MAGAZINES.

JOURNAL DES SCIENCES MILITAIRES.

January 15th, 1908.

Lieut.-Colonel A. Grouard continues his criticisms on the "Strategy of the Franco-German War."

This paper deals with the actual and the possible dispositions of the French Army, after the defeat of General Frossard and the 2nd Corps d'Armée at Forbach, on August 6th, 1870. He blames Marshal Bazaine for not having proceeded to the field of battle, assumed command, and reinforced the 2nd Corps by the 3rd, which would probably have enabled the French to drive back the Germans beyond the Saure river, and to keep them there till the 10th or 11th. This success, although of a very temporary nature, would have materially assisted the organization of the troops in the rear.

A retirement of the whole French Army before that of the Germans, superior in numbers, organization, and elated at their success, was, however, inevitable, but Lieut.-Colonel Grouard considers that the retreat should have been in a southerly direction, the French right resting on the Vosges mountains; and that, preparatory to this retirement, the bulk of the French Army should have taken up a position between Morhange and Fenestrange, facing north.

In a future paper he proposes to show that the French could have held that position for some days, thus enabling the corps, defeated at Woerth and Forbach, to be reorganized.

Lieut.-Colonel Camon deals with "The Napoleonic Battle: Its Technical Preparation." This is a final article of a series. Examples are given showing how Napoleon, on discovering the dispositions of his opponents, at once assumed the initiative, by framing a well-considered scheme for the probable battle, on which preliminary orders were based; how this general idea developed into a more definite sketch of the battle on receipt of fuller information, and how the final orders for the battle were not issued until he had, with infinite trouble, not only verified the accuracy of the information itself and of the deductions he had made from it, but had also closely reconnoitred the enemy's position.

In his article, "Le Nombre des Corps d'Armée," Commandant Manceau favours the reduction of the number of army corps to 15, on the ground that the remaining corps could be maintained on a war footing, and would thus be composed of better trained men, who could be more quickly mobilized and better commanded—15 capable generals being more easily provided than 20. He contends that, with an army so organized, the needs for small wars could be more easily met than under existing conditions, and that, on a serious emergency arising, a fully prepared army could be concentrated on the frontier without awaiting the reservists, who could be organized at greater leisure.

This would provide France with an army somewhat similar to that of 1870. It would differ, however, in having behind it a large number of trained reservists, with the necessary organization for their mobilization.

In an interesting account of Masséna's attack on the Austrians at Ebersberg, on May 3rd, 1809, Capt. Briat speculates on the reasons which led him to attack, with the advanced guard of his corps, 40,000 men entrenched in a formidable position, after having been warned by Napoleon not to do so. In spite of the heroic behaviour of the French troops engaged in what Napoleon called a foolhardy enterprise, three French brigades lost 3,000 men, and were in the greatest jeopardy, when the approach of the Emperor with his main army forced the Austrians to retire. Capt. Briat rightly contends that Masséna's inordinate ambition, and desire to make amends for want of energy in a previous engagement at Landshutt, led him to commit this fault.

Lieut.-Colonel Souviat puts forward proposals for obtaining 10,000 men for the native armies, by applying to the Algerian tribes the French Conscription laws of 1832.

An anonymous article on "Quick-Firing Field Artillery" is completed. After a detailed examination of the steps taken by all military nations to provide such artillery, the conclusions arrived at are—that all countries either are, or will shortly be, provided with guns of the type first adopted by the French; that shields for the gun detachments are essential and do not ordinarily increase the visibility of the batteries; that limber boxes should be armoured, and that an observatory and telephone are needed for the officer commanding the battery. He also considers that a certain proportion of shells, with percussion fuzes, should be supplied to field artillery in addition to shrapnel, but that, in addition to quick-firing guns, quick-firing howitzers are needed in the field to destroy entrenchments.

It is pointed out that quick-firing ordnance, the carriages of which remain stationary under fire (the recoil being taken up in the carriage), can find firing positions with greater facility. The only drawbacks to the system are the possible waste of ammunition (this ammunition should be under the control of the officer commanding, and need not be considered). Another difficulty is that of replenishing the supply of ammunition. This has not been satisfactorily dealt with yet, and probably the use of motor cars will solve the question. The English field gun is said to be unnecessarily heavy, and the article shows that most nations have adopted guns similar, in calibre and weight, to the French gun of 75 mm.

Capt. Besset, after considering the great help a cavalry division would receive from a body of mounted infantry being permanently attached to it, suggests the formation of an experimental company, consisting of 7 officers (including medical and veterinary officers) and 230 rank and file, mounted on mules. In addition, there would be one machine gun, and each man would carry on his person or on his mule 256 rounds of ammunition.

'G.'

REVISTA DE ENGENHERIA MILITAR.

December, 1907.

DEFENCE OF THE PORT OF LISBON BY MEANS OF FIXED SUBMARINE MINES.—By Lieut. M. Silveira e Castro.—This article gives an account of what was apparently the first submarine-mining practice ever carried out at the mouth of the Tagus. It commenced on the 1st July, 1907, and was brought to a conclusion on the 4th September, when 28 E.C. mines, with their cables and junction boxes, were laid out in the presence of the late king. Many difficulties were naturally met with during the practice, the greatest being a deficiency in *personnel*, which was remedied on the 25th August by the transfer of 1 subaltern and 40 men from the Engineer Regiment to the torpedo company. Other difficulties were experienced from the strength of the tides, the width of the river, and the consequent difficulty of getting suitable alignments, and the unevenness of the bottom; but all were successfully overcome, and the detailed account of the final inspection is sufficient to gladden the heart of an old submarine miner, and to make him regret that our own splendid system of submarine mines has been swept away and put on the scrap heap.

On the inspection day work commenced at 6.30 a.m. The 28 mine cases were got out of the mine store, loaded with dummy guncotton, primed, and taken down to the pier. The positions of the mines and junction boxes were buoyed, the J.B.'s and main cables laid out, and by 11.30 a.m. 16 E.C. mines had been laid. A launch carrying spectators then fouled one of the branch cables, and there occurred one of those aggravating delays so well known to the submarine miner. It was not till 2.30 p.m. that work could be resumed, and all the 28 mines were not in position until 5 p.m., instead of at 3 p.m., as had been intended. The mines were very well laid, and with one exception showed on the surface simultaneously. The number of men engaged was 16 sergeants and 129 men, under the command of Major Gomes Teixeira, who is to be congratulated on the results obtained.

THE HAGUE CONFERENCES.—By Capt. João d'Oliveira.—This article, which is continued in subsequent numbers, gives a good general summary of the events that led up to the first Hague Conference of 1899, of the results of that conference, and of the chief matters which have been brought to arbitration since that date.

SOME EXTRACTS FROM THE REPORT OF THE ENGINEER REGO LIMA ON HIS EXPEDITION TO THE MINES OF CASSINGA IN 1898 (*continued*).—In this number the description of the geological features of the Bundambungo district is completed, and that of the Mocambangua district is commenced. A map is given showing the outcrops of quartz in Mocambangua.

NOTE ON THE CALCULATION OF THE CHARGES OF MINES.—In August, 1907, the Swiss *Revue d'Artillerie* published an article on this subject, and the results arrived at were tested at the Portuguese Engineer School of

Instruction at Tancos. They included a new formula, due to Professor H. Höfer—

$$C = gh^2 \sqrt{(1+n^2)^3},$$

where C = the charge in kilogrammes, h = the length of the line of least resistance in mètres, and $n = \frac{r}{h}$ also in mètres (r = the radius), and g is a coefficient, constant for the same kind of soil and same nature of explosive.

Other formulæ often employed are:—

$$C = gh^3 \sqrt{(1+n^2)^3} \text{ (Belidor).}$$

$$\left.\begin{array}{l} C = gh^3 \left(\frac{4+3n}{7}\right)^3 \text{ (undercharged mines)} \\ C = gh^3 (0{\cdot}09 + 0{\cdot}91n)^3 \text{ (overcharged mines)} \end{array}\right\} \text{(Lebrun).}$$

$$C = gh^3 \sqrt{(1+n^2)^3} - 0{\cdot}41^3 \text{ (French School of Mines).}$$

It will be noted that Höfer's formula differs from the others, in that it makes the charge proportional to the square, instead of to the cube, of the line of least resistance. The value of g in the case of each of these formulæ (ordinary soil and black powder) was found to be as follows:—

Belidor = 1·00. Lebrun = 1·41. School of Mines = 1·6. Höfer = 3·28.

Where the line of least resistance = 1 mètre, and n = 1, the four formulæ give the following surprisingly different results:—

C = 2·83 k.g. (Belidor).

C = 1·41 k.g. (Lebrun).

C = 1·6 k.g. (School of Mines).

C = 9·28 k.g. (Höfer).

Each of the above charges was actually tested, and it was found that the charge as given by Höfer's formula was the only one which produced the expected results.

DESTRUCTION OF JAPANESE SUBMARINE MINES AT PORT ARTHUR.—A translation from the *R.E. Journal* of an article which appeared in the *Voěnnyi Sbórnik.*

THE MILITARY MANŒUVRES IN SPAIN.—A brief description of the manœuvres which took place in Galicia last September, with a translation of the *précis* of the work carried out in them by the engineers, which appeared in the November number of the *Memorial de Ingenieros.*

REVIEW OF BOOKS.—*Notes on the Tactics and Strategy of Combined Operations between Land and Sea Forces* (*Apontamentos sobre tactica e estrategia nas operações combinadas entre forças de terra e mar*), by José Cardoso, 1st Lieutenant of the Navy. Coimbra, 1907.—The book is well reviewed, and, as the subject is one of the very greatest importance to ourselves, it will no doubt be read with interest by those of our officers who are acquainted with Portuguese.

January, 1908.

THE MILITARY BRIDGE TRAIN.—By F.C.—This is a *précis* of an article by General of Division Ribeiro d'Almeida, which was sent to the *Revista*, but proved too long for insertion *in extenso*. After some historical remarks on the employment and composition of bridge trains from the time of the Romans down to the Peninsular War, the author proceeds to consider the existing bridging equipment of the Portuguese Army, which he characterizes as insufficient, and he recommends that some officers should be sent to study the subject abroad.

DIRIGIBLE BALLOONS OF THE PRESENT DAY AND FIELD BALLOON PARKS.—By Lieut. Pedro Ribeiro d'Almeida.—This is an interesting article, and gives a good summary of the principal dirigible balloons which have been produced in recent years. The following data are extracted:—

The "Patrie."—Capacity, 3,150 cubic mètres; major axis, 60 mètres; greatest diameter, 10·50 mètres; shape, a solid of revolution, the maximum section occurring at a point $\frac{2}{5}$ths of the length of the major axis from the bow; permanency of form attained by an air compensator; stability obtained by a series of horizontal and vertical planes, some fixed, others movable; motive power derived from a Panhard 70-h.p. motor driving two propellers, one at each end of the car.

The "Ville de Paris."—Capacity, 3,195 cubic mètres; shape, fusiform; major axis, 62 mètres; greatest diameter, 10·50 mètres; permanency of form attained by an air compensator; stability is obtained by means of eight cylindrical balloons, disposed in pairs in the form of a cross round the rear portion of the main envelope; a 70-h.p. Argus motor drives a screw 6 mètres in diameter at the rear end of the car.

The "Zeppelin."—Capacity, 11,430 cubic mètres; shape, cylindrical, with ogival ends; length, 128 mètres; diameter, 11·70 mètres; permanency of form obtained by means of a series of aluminium rings, with spokes like those of a bicycle wheel, which divide the machine into 17 compartments, each of which contains a balloon filled with hydrogen; each compartment communicates with the next, and the whole is covered by an envelope of varnished silk; its stability is obtained by means of a series of planes; an 80-h.p. Daimler motor drives three pairs of screws placed between the car and the balloon.

The "Parseval."—Capacity, 2,800 cubic mètres; shape, cylindrical, with a hemispherical bow and ogival stern; length, 52 mètres; diameter, 8·90 mètres; permanency of form attained by two air compensators, placed one at each end of the cylinder, and capable of inclining the balloon either upwards or downwards; stability is obtained by two horizontal and one vertical plane, and by the power of altering the position of the car; a 90-h.p. Mercedes motor drives a screw placed between the car and the balloon; the screw is of cloth, and only takes a rigid form when in motion under the action of centrifugal force.

The "Gross."—Capacity, 1,800 cubic mètres; shape, cylindrical, with hemispherical ends; length, 40 mètres; diameter, 12 mètres; permanency of form is attained by an air compensator; stability is obtained by one vertical plane above the balloon and two horizontal planes placed on a level with the platform, which, in the "Gross," as in the "Patrie," is placed between the balloon and the car; a motor of from 30 to 35 h.p. drives two screws placed one at each end of the envelope, and as close to it as possible. This machine, like the experimental one of the Comte de La Vaulx, can be readily packed for transport in carts.

This article is to be continued.

THE HAGUE CONFERENCES (*continued from the December number.*)—The proceedings of the 1907 Conference are considered.

THE NEW REGULATIONS FOR THE MILITARY TELEGRAPH SERVICE.—The military telegraph service is under an inspector, with the rank of colonel, a sub-inspector (either a lieutenant-colonel or major), who is responsible for all financial details, and a captain and adjutant, who is in charge of the offices and of the electro-technical institute. There is one fortress telegraph company, commanded by a major, who is Director of the Lisbon Telegraph School, with four subalterns. Of these latter, one is quartered at Oporto, and is in charge of the Telegraph School in that city, where the men of the 3rd and 6th Divisions are trained, and he also commands the section in the districts garrisoned by these divisions. The three remaining subalterns are attached to the Lisbon school, and respectively command the sections in the 1st, 2nd and 5th, and 4th Divisions.

The telegraph company has now been given charge of the fixed military wireless stations, and of the balloon park.

CHRONICLE.—In Germany it is proposed to construct a network of military roads, suitable for motor traffic, along the western frontier, and connecting it with the Rhine and the Maine.

In France a large increase has been made to the number of the telegraph companies, which are now organized into a regiment of two battalions, each of four companies.

'M.'

RIVISTA DI ARTIGLIERIA E GENIO.

November, 1907.

ENGINEER TROOPS DURING THE RUSSIAN-JAPANESE WAR.—Monteleone (Capitano del Genio).—

RUSSIA.

Sappers.—At the commencement of the war the 1st and 2nd Battalions of Eastern Siberian Sappers, attached to 1st and 2nd Army Corps, as well as the sapper companies of Kuantung, were stationed in the Viceroyalty of the Far East. The mobilization of these troops took place on the 10th February, 1904. A third battalion of sappers formed part of the 3rd Army Corps. In March, 1904, the 4th Battalion of Sappers of Eastern Siberia was formed.

After the crossing of the Yalu by the Japanese in May, 1904, the technical troops were constituted as follows:—The 1st, 2nd, and 3rd Sapper Battalions had each four companies of sappers, one pontoon company, and one telegraph company, whilst the 4th Battalion, which served as a nucleus for the sapper companies of Western Siberia, consisted of two companies of sappers and one of telegraphists.

The sapper companies, after the Battle of Nanshan, were despatched to take part in the siege of Port Arthur.

The technical troops increased gradually with the formation of new Siberian army corps, and on the arrival of the European army corps the 5th and 6th Sapper Battalions were formed, each consisting of two companies of sappers and one of telegraphists, and each European army corps had a sapper battalion with three sapper companies, and one company of telegraphists.

It was soon found that one sapper battalion for each army corps was not sufficient, and in February, 1905, five new sapper battalions were sent out to the theatre of war.

Pontoon Companies.—The Pontoon Battalion of Eastern Siberia, consisting of three companies, was brought up to full strength in May, 1904. The three pontoon companies of the 1st, 2nd, and 3rd Sapper Battalions of Eastern Siberia were detached in November, 1904, from their respective battalions, and were formed into two new pontoon battalions. The 2nd Pontoon Battalion of Eastern Siberia was formed of the companies of the 1st and 2nd Sapper Battalions, the 3rd Pontoon Battalion, and one company of the 5th Pontoon Battalion stationed at Kiew.

In the spring of 1905 the 1st European Pontoon Battalion was also sent to the theatre of war.

Aerostats.—At the commencement of the war the Russians had at the theatre of war only one company of Siberian aerostats. The 1st Aerostat Battalion of the new Eastern Siberian formation was sent from Europe in October, 1904. The Siberian aerostat companies were transformed, in November, 1904, into the 2nd Eastern Siberian Aerostat Battalion. In July, 1905, a third Eastern Siberian aerostat battalion was formed from aerostat detachments of the fortified region of Varsovia.

Telegraphists.—Each sapper battalion had one company of telegraphists. During the war detachments of telegraphists were formed, who were directly posted to theGeneral Staff.

On the 23rd June, 1904, the 1st Eastern Siberian Telegraph Battalion was formed, and the 2nd Battalion on the 21st December. Each battalion had four companies.

At the same time as the formation of the 2nd Eastern Siberian Telegraph Battalion, the 1st and 2nd Telegraph Companies were created exclusively for radio-telegraph service, and in the spring of 1905 a third telegraph company was formed for the same service. Later on these three companies had another name; the first two were called the 1st and 2nd Eastern Siberian Radio-Telegraph Companies. These last did not arrive at the theatre of war before the conclusion of peace, and were assigned to the 1st Sapper Brigade.

Railways.—Whilst at the commencement of the war there were only

20 railway companies in Eastern Asia, the number had increased to 32 at the end of 1904.

These companies, together with two battalions of four companies, formed the railway brigade of Ussuri, and four battalions of six companies formed the Railway Brigade of Transamun.

At the commencement of 1905 the 3rd European Railway Battalion was sent to the theatre of war.

The Commander-in-Chief of the mobilized army had also ordered the formation of a railway battalion for field exercise. The number of companies of this battalion is not known.

Engineer Field Parks.—Each of the nine army corps at the theatre of war was provided with a section of the Engineer Field Park. The 5th Engineer Field Park furnished one section, and the 2nd, 3rd, 4th, and 6th Field Parks supplied two sections each.

Mining Companies.—The mining companies of Eastern Siberia, which belonged normally to the fortress troops, were attached to the Army of Manchuria.

Thus the following technical detachments were employed:—

(*a*). *European Field Formations.*

One sapper battalion and one section of engineer field park for each of the Ist, IVth, Xth, XVIth, XVIIth, XIXth, Vth Siberian, and VIth Siberian Army Corps, and at the disposition of the supreme command of the army.

The Sapper Battalion of Grenadiers.

The 5th, 8th, 9th, and 13th Sapper Battalions.

The 1st Pontoon Battalion.

The 3rd Railway Battalion.

The 3rd Railway (complementary) Battalion.

Half squadron of telegraphists and one sotnia of telegraphists; the two last of new formation.

(*b*). *Asiatic Field Formations.*

One Eastern Siberian sapper battalion to each of the Ist, IInd, IIIrd, and IVth Siberian Army Corps.

The sapper companies of Fruantang at Port Arthur, at the disposition of the supreme command of the army.

The Eastern Siberian 1st, 2nd, and 3rd Pontoon Battalions.

The Eastern Siberian 1st and 2nd Telegraph Battalions.

The Eastern Siberian 1st and 2nd Radio-Telegraph Companies.

The Eastern Siberian 1st, 2nd, and 3rd Aerostat Battalions.

The Ussuri Railway Brigade of two battalions.

The Transamun Railway Brigade of four battalions.

The Railway Battalion for Field Exercise.

JAPAN.

Japan had not only its own technical troops formed on mobilization, but also created new detachments during the war.

Before the commencement of hostilities the technical troops of the permanent army consisted of 13 pioneer battalions, one railway battalion, and one battalion of instruction for telegraphists with two companies, with one section of instruction for aerostats.

The pioneer and railway battalions had three companies each. Besides these there were three companies of pioneers in the island of Formosa.

Pioneers.—The distribution of battalions of permanent pioneers at the Battle of Mukden was as follows:—

1st Army—2nd and 12th Battalions of Pioneers of the Guard.
2nd Army—4th, 5th, and 8th Pioneer Battalions.
3rd Army—1st, 7th, and 9th Pioneer Battalions.
4th Army—6th and 10th Pioneer Battalions.
5th Army—11th Pioneer Battalion.
General Reserve—3rd Pioneer Battalion.

The Reserve Division of the 5th Army had one pioneer battalion (complementary) with three companies.

The other 12 companies of pioneers (complementary) were distributed among the several armies.

There were then 13 pioneer battalions of three companies, or 39 companies, 15 companies of pioneers (complementary); total, 54 companies.

At the end of the war the Japanese Army consisted of 17 permanent divisions, and two in reserve.

The pioneers were increased by four battalions of three companies, and five companies (complementary), or by 17 companies. So that at the end of the war there were 71 pioneer companies.

Telegraphists.—The pioneer battalions on mobilization furnished the General Staff with detachments of telegraphists, and each permanent division had one section of field telegraphs.

Owing to the formation of new divisions, the telegraph troops were increased, so that at the end of the war there were 17 field telegraph sections.

Railways.—There were at the theatre of operations—

One railway battalion of three companies.
Two special sections of field railways.
The railway administration for the Manchurian Army.

Comparing the effective technical troops of the belligerents, there were:—

Russia.	*Japan.*
55 sapper companies.	71 pioneer companies.
8 pontoon companies.	22 telegraph sections.
28½ telegraph companies.	5 railway companies or sections.
6 aerostat companies.	
50 railway companies.	
9 sections of engineer field park.	

It appears that all the Russian sappers and Japanese pioneers had received instruction in mining.

TELEGRAPH SERVICE.

Electric Telegraphs and Telephones.

Russia.—The first detachment of telegraphists appointed to the supreme command was formed at the end of 1904, and was called the 1st Telegraph Battalion of Eastern Siberia; the 2nd Battalion was only formed at the end of the same year. Both battalions had the defect of an improvised formation, more especially as the *personnel* had but little practice with the material at its disposal. The telegraph companies belonging to the sapper battalions responded indifferently to the exigencies of the service. In the telegraph companies of the 2nd Sapper Battalion there were only 50 men who knew how to read and write properly.

On the battlefields only the larger tactical units were connected by telegraphs or telephones. The ordinary communication between the smaller detachments of troops was either by signal horns or drums, or by flags and lanterns.

The experience acquired during the course of the war showed that during a battle the transmission of orders by telephone was limited to small distances, and the correspondence by visual signalling was not sufficiently rapid or secure.

Japan.—Contrary to what has been said in the case of Russia, the Japanese, at the commencement of the war, had made large use of the telegraph and telephone. By means of a proper organization, the divisions in peace times were conveniently provided with these important means of communication.

On the march the field telegraph sections, attached to each division, supplied, at first, telegraphic communication between the Q.G. of the division and the commander of the army, and then, if time permitted, extended a telephonic line alongside the telegraph. The Q.G. of the divisions also communicated telephonically with the brigade commanders and with the commanders of artillery. The rapid working of these means of communication was due, in a great measure, to the light material with which the divisions were provided. In spite of the intense cold during and after the Battle of Mukden, and the frozen condition of the ground, the extension proceeded at an average rate of one kilomètre per hour.

The infantry battalions were partly provided with portable telephonic apparatus and about five kilomètres of wire served by one non-commissioned officer and four men from the troops. The uncovered wire was generally held in more favour than covered wire, which was frequently broken by the troops or carts passing above. When the bamboo poles carried by the troops fell short, posts from woods or any material in the neighbourhood were substituted.

The field telegraph sections of the Divisions of the Guard constructed 960 kilomètres of lines, and repaired 200 kilomètres; those of the 2nd Division put up 1,034 kilomètres, and repaired 250 kilomètres; and those of the 12th Division put up 920 kilomètres, and replaced 300.

Radio-Telegraphs.

Russia.—Each company of radio-telegraphists was divided into two sections, each of which had three radio-telegraph stations of the Marconi system.

The strength of the companies in peace times was 12 officers, 208 men of the troops (of whom 187 were combatants), 22 horses, 194 carts; in war there were 12 officers, 426 men of the troops (of whom 187 were combatants), 270 horses, and 194 carts.

The train was composed, at the theatre of war, of two-wheeled carts. The technical train of a company contained 128 carts; that of a section, 62; that of a station, 14. The carts were divided into station carriages, antennæ, accumulators, receivers, machine, earth. The antennæ were of bamboo, composed of various parts, having their extremities wrapped round with metallic wire.

The 1st and 2nd Radio-Telegraph Companies of Eastern Siberia only, were employed at the theatre of war.

The first of these companies was charged with the communication of the 2nd Army with General Misctcenko's cavalry brigade on the extreme right wing. There were, besides, other stations, but, notwithstanding the short distance, the telegraph worked very badly. The superior commanders soon gave up using the radio-telegraph, and in the army this system of telegraphy, formerly *wireless*, came to be called *useless*.

The principal reason of the initial failure of the wireless telegraphy was, that the troops sent to the theatre of war had received no instruction. Besides this, the weather disturbances were very frequent at these stations. The instruments, although carried on two-wheeled carts, were too heavy to allow of their following the cavalry detachments.

However, owing to continued practice in the instruction of the *personnel* towards the end of July, the high military authorities recommenced to use this means of communication.

Wireless Telegraphy.

Russia.—During a reconnaissance made by the Japanese of the Corps of General Grekov, General Misctcenko made use of wireless telegraphy because the ordinary telegraphic service was interrupted. He obtained replies in 20 minutes, and from that time the value of wireless telegraphy was recognized. Telegrams were received with writing apparatus from a distance of 70 k.m. Rapidity of correspondence increased, and became finally over four times what it was when first started.

As the Russians and Japanese made use of the same system of wireless telegraphy, disturbances originated in the Russian correspondence owing to the working of the Japanese instruments. It was then proposed to institute two lines of stations, one to protect its own and to disturb the Japanese correspondence, and the other for the transmission of messages. However, this plan was never carried out.

Japan.—As the Japanese Army in the field was not provided with the apparatus for wireless telegraphy, the disturbances in the Russian correspondence were probably caused by the wireless telegraph stations in Corea.

VISUAL SIGNALLING.

Russia.—After experimenting for several years for a suitable means of communicating by visual signalling, it was concluded to use signalling flags similar to those adopted by other States.

But at the commencement of the war the Russian Army had not this means of correspondence.

The good results obtained by the Japanese, from the employment on a large scale of flags and lanterns, influenced the Russian Commander-in-Chief to make arrangements for a system of visual signalling, and this was introduced in a modest form in the Manchurian Army. An order was issued that each company, squadron, sotnia, or battery should have at least four men well instructed in this mode of correspondence. The officers of certain regiments were also required to understand visual signalling.

Red flags were exclusively used, and the signalling corresponded exactly to the German system. During the summer of 1905 lanterns of acetylene gas were partly used.

The heliograph was employed, by the telegraph companies of battalions, as a complement to the telegraph wire and telephone. Near Tachiciao, four stations were opened at a distance of 4 k.m. from one another.

At Liaoiang and Mukden there was a considerable extension of this means of communication.

In the positions on the Sciaho the heliograph stations were at a distance of 7,500 miles, and the instruments appear to have worked satisfactorily.

The Russians seem to have made frequent use of beacons on the heights near the occupied positions, but apparently they were not very successful.

Japan.—For about six months before the declaration of war, the Japanese had instructed many Chinese, from the districts of Corea and Manchuria, in signalling. By day and in sunshine heliographs were used, flags when the sky was obscured, and lanterns at night. The signallers were well paid by the Japanese.

During the frequent night combats at the end of 1904, in addition to the lanterns, the Japanese made use of small balloons inflated by hot air. The balloons had lamps of various colours which had conventional signals.

BALLOON SERVICE.

Russia.—The balloon companies of Siberia, at the beginning of 1904, went to Liaoiang from Europe.

At the end of July, the companies marched with the Xth Army Corps to Kuadsiatsi, 40 k.m. south-east of Liaoiang.

Notwithstanding the wretched state of the roads, the transporting of the material, with which the company was equipped, was effected in 76 carts. The gas was prepared with iron and sulphuric acid, and shortly after arriving at Kuadsiatsi it was possible to commence observations. The distance of the balloon from the enemy did not exceed 5 k.m. From the balloon, observers were able to see the Japanese detachments, their earthworks, their batteries, and even single men.

On the 23rd August a balloon-observing station was established near Liaoiang, between forts Nos. 2 and 3.

On the 31st August, the balloon was of great use to the Russians, as it was able to discover in time the threatened surprise on the Russian right.

On the same day the balloon was exposed to the enemy's artillery fire. The distance must have been known to the Japanese, as the first shell burst very close to the car.

Ten shots were fired without any damage to the balloon.

On the following days, fire was opened on the balloon, by the siege artillery, but without result.

In October, the Siberian Balloon Company took part in the general advance of the Russians, and marched with the advance guard of the Xth Army Corps on Sciahopu, where it made many observations. The observations were communicated from the balloon, by means of the heliograph.

By a decree of the 3rd November, 1904, the Siberian Balloon Companies were transformed into a battalion, which assumed the name of the 2nd Balloon Battalion of Eastern Siberia. Previously there had only been the 1st Battalion. Both battalions had a light equipment adapted for field service. With the production of gas by means of the hydrate caustic of soda and aluminium a considerable reduction of weight was obtained, so that the first stage for an ascent consisted of 26 carts.

The battalion proceeded to Mukden in December, 1904, and occupied some huts constructed near the station.

In this locality they continued to instruct the troops in the management of balloons and of signalling apparatus. At the end of February, the two companies continued their observations and reconnaissances of the Japanese positions in front of the 2nd and 3rd Armies. They observed that the Japanese continually increased the number of their trenches, and reinforced their positions. Photographs were made from the balloon of the village of Sandepu, and the entire region round about was found to differ with the maps.

The work was very difficult owing to the intense cold. The Japanese fired at the balloon from their advanced positions, and sometimes produced columns of smoke to conceal their positions.

The balloons were not only used for reconnoitring purposes, but also to conduct the fire of the artillery.

The balloons of the 1st Battalion were cannonaded nine times. Once a balloon was struck by three shrapnel bullets; two passed through; one remained in the covering and was discovered three days after when the balloon was being inflated. At great heights the balloon was quite secure from shrapnel.

Japan.—The Japanese do not seem to have used balloons in field warfare.

In conclusion it may be said that the telegraph and balloon service was incomplete in both armies. The Japanese, while they had provided sufficiently for the telegraph and telephone services, and for visual signalling, were wanting in a service of wireless telegraphy and of balloons; and the Russians, while having the advantage of these last, were not sufficiently prepared in the various branches of these two important services, and were not able to obtain good results.

It is now evident from the experience of this war that, with improvised formations, only scarce and insufficient results can be obtained.

EDWARD T. THACKERAY

THE ELECTRICIAN.

February 14th, 1908.

DRAWING OFFICE ILLUMINATION.—This is a description of the new drawing offices lately erected by Messrs. Armstrong, Whitworth & Co., Ltd., at their Elswick shipbuilding yard. In these offices the draughtsmen are continually at work for several hours without a break, and often on plans measuring 15 feet or more in length; hence the most even illumination, over every part of the drawing tables, is necessary. The lighting arrangements employed are the result not only of considerable experience in the older drawing office, but also of careful tests made with a view to determining the most suitable form of artificial lighting, and of diffusing and reflecting surfaces.

The drawing, designing, and tracing offices occupy two floors, the upper storey being lighted in the daytime by side windows and north lights in the roof, the lower one by side windows.

In order to diffuse the light as much as possible, the sloping roofs of the upper department are enamelled white, while downstairs the ceilings are whitewashed. Below these, at a distance of 10 feet from the floor, are suspended inverted arc lamps combined with conical reflectors, so arranged, that no light escapes from the crater of the arc at an angle from the horizontal of more than 5 degrees. Practically the whole of the useful light is thus flung upwards. In the case of the downstairs room this light is reflected downwards in a uniform manner by the ceiling itself, and a very close approximation to diffused daylight is thus obtained. In the upper department, however, the reflection obtained from the sloping ceilings was found to be totally inadequate. Several experiments were therefore made, and very good results have now been obtained by placing over the lamps a white enamelled reflector, 6 feet in diameter, 3 feet of which takes the form of a shallow inverted saucer, the remainder of the surface being flat and horizontal.

The lamps installed are of the Union Electric direct arc pattern (inverted light) of 10 ampères, at 43 volts. Five lamps are run in series on a 240-volt circuit, with a consumption of 10 ampères for the five lamps. One lamp is allowed for every 250 to 300 square feet, and they are placed at distances of about 18 feet from one another. In addition to the general lighting produced by these arc lamps, every fourth bench is provided with a special switch and flexible lead at the wall, running to a

16-c.p. incandescent lamp, which can be used for close detail work. The chief draughtsman's office, the plan stores, cloak rooms, etc., are lit by means of incandescent lamps, while, in the printing room, two intense enclosed arc lamps operate at the centre of a large rotary printing machine.

February 21st, 1908.

ELECTRIC POWER IN DOCKS.—During recent years the use of electricity for power purposes in docks has been greatly extended, and it offers many advantages over the hydraulic system. This is especially the case when electric power can be obtained at a reasonable rate from an outside source, and the user has not to incur the heavy capital expenditure involved in the provision of a generating station. From the user's point of view, the advantages of buying power are great. The installation cost for distribution is small compared with that for a hydraulic supply, there is not the same liability to failure, and the consumption is proportionate to the work done. The efficiency of electrical machinery is also much higher than that of hydraulic plant for the same purpose, and the distribution is more flexible and lends itself better to alterations and additions.

The author proceeds to describe the many uses to which electrical machinery has been put in connection with dock working, such as coal conveyors, hoists, wharf cranes, capstans, etc., and also for driving hydraulic pumping machinery. Particulars of the machinery in use at several large docks are also given.

February 28th, 1908.

A DIRECTIVE SYSTEM OF WIRELESS TELEGRAPHY.—A closed oscillation circuit, placed in a vertical plane, radiates principally in the direction of its plane, and is, in that respect, suitable for a directive transmitter system, but the radiation therefrom is weaker than from an open circuit. An experimental directive system was recently established by Messrs Bellini and Tosi between three stations, Dieppe, Havre, and Barfleur, on the Normandy coast, with the object of examining, by actual experiment, the suitability of closed triangular radiating circuits for use in radiotelegraphy. From the Dieppe to the Havre stations the distance is 50 miles, and from Dieppe to Barfleur 100 miles, the angle between the directions being 23 degrees. At each station was a mast 50 mètres high, which supported, by its apex, an isosceles triangle of wire. With this form of oscillation circuit at the sending station, good results were obtained, so long as the plane of the sending aerial triangle was directed towards the recieving station, but on turning the triangle round the mast, the strength of the received signals gradually diminished to zero. Similar experiments were made with directive receiving, closed oscillation circuits being used at the receiving stations; and it was found that the best results were obtained, when the plane of the receiving aerial triangle was directed towards the transmitting station, but that the signals diminished to zero as the triangle was turned round at right angles to this. It was thus found possible, by regulating the emitted energy and suitably orienting the sending circuit, to send signals, at will, to either of the receiving stations, without the other station receiving signals. The troops displayed a complete want of interest in engineering works, and took no pains to preserve their entrenching tools.

"The constant misunderstandings between sappers and infantrymen, arising from the disinclination of the latter to work, have made me fearfully disgusted.

"Under the immediate superintendence of the regimental officers, a heap of useless—if not actually harmful—works are being carried out."

Other passages are quoted from this book to show how complete was the want of sympathy existing between the sappers and the other branches.

A serious fault, was the apparent inability of the infantry to entrench themselves without delay, on points occupied during the progress of a battle, and also their unwillingness to forsake the shelter of prepared positions, where they would wait until they were ousted. In other words, the value of hasty—as opposed to deliberate—entrenchments was not realized.

The remedy is to be found in constantly combining tactical training with practice in entrenchments. The writer considers that the annual training of sapper battalions should be divided into three periods. In the first, the sappers would be put through their usual annual course of fieldworks independently; in the second, they would, as a part of the corps to which they are allotted, go through combined training with the other arms. During this period the infantry, under their guidance, would be instructed in the intelligent use of locality with a view to defence, and also in such work as the passage of obstacles, preparation of hand grenades, bridging, mending roads, etc. During the third period, examinations would be held both for instructed and instructors.

ARMY ORGANIZATION.—The writer begins by stating the three guiding principles on which the organization of a force should be based:—

(1). A tactical unit must be of a size convenient for command.
(2). It must be capable of independent action.
(3). The internal union of a tactical unit must be complete.

Considering the first of these, he states that a corps should consist of two to three divisions, a division of two to three brigades, a battalion of four companies, etc. He estimates that the size of a company should be from 150 to 200 men. The reason of this is because, at the beginning of a fight, a company in the advance would have from two-thirds to three-fourths of its strength in the firing line, extended at two to three paces interval—a length of 300 to 400 paces—and this is as much as a company firing line ought to occupy in order to fulfil condition (1). Hence the strength of a company must be between 150 and 200 men.

To satisfy the second principle, a tactical unit must consist of a proper proportion of all arms, each arm being, in strength, a multiple of smaller subdivisions, so that smaller complete tactical units can be formed. An infantry regiment (three battalions) requires to complete it artillery, in the shape of machine-guns, cavalry and cyclists to act as orderlies, and engineers to look after telephones. A battalion would consist of four companies, subdivided into four sections and 24 squads of eight rifles each.

Turning to larger units, under the present system a division consists of two infantry and one artillery brigade, and an infantry brigade contains two regiments. This is a most inconvenient arrangement when it is necessary to split up divisions into subordinate commands. A system, in which a brigade would consist of a due proportion of troops of all arms, would be far better; a suitable formation for a brigade would be:—Three regiments, two squadrons, a brigade of artillery (nine batteries of six guns each), and one sapper company of 108 men. A division again would consist of three complete brigades, two squadrons, a pontoon company, a telegraph section, and a balloon section. Similarly, an army corps, besides two divisions, would require an independent force of cavalry, reserve artillery of mountain guns and howitzers, engineer troops, and troops for the line of communications.

January, 1908.

This number contains an account of our new Territorial Army, and amongst other articles one on dirigible aerostats, but no mention is made in it of the "Nulli Secundus."

A supplement issued with the *Military Magazine* of January records the charges against Lieut.-Generals Stoessel, Smirnoff, and Fok, and Major-General Reuss, and a summary of the evidence on which the charges are based. Stoessel is accused under ten heads, briefly as follows:—

(1). Of not handing over the command of Port Arthur to General Smirnoff when he had been superseded by the latter.

(2). Of interfering with the duties of the Commandant of Port Arthur.

(3). Of failing to take the necessary steps to provision Port Arthur.

(4). Of receiving and reading, during the siege, certain remarks of General Fok, written in a manner derisive and cutting, calculated to undermine the authority of certain officers.

(5). With a view to his own aggrandizement, of falsely reporting himself as taking an active and energetic part in the Battle of Sinchau (Kinchau?), whereas he did not leave Port Arthur.

(6). With a view to his own aggrandizement, and wishing to represent the conduct of his subordinates in a favourable light, of making false statements regarding the nature of the retreat of General Fok's detachment.

(7). With a view to his own aggrandizement, of reporting himself as taking part in imaginary battles.

(8). In order to justify his premeditated surrender of Port Arthur, of falsely reporting that the Japanese were masters of the North-West front, and that the ammunition was almost exhausted.

(9). Under false pretences, of recommending General Fok for the Order of St. George of the 3rd Class.

(10). Of surrendering Port Arthur in opposition to the opinion of a Council of War.

A. H. BELL.

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