THE ROYAL ENGINEERS JOURNAL.

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Authors alone are responsible for the statements made and the opinions expressed in their papers.

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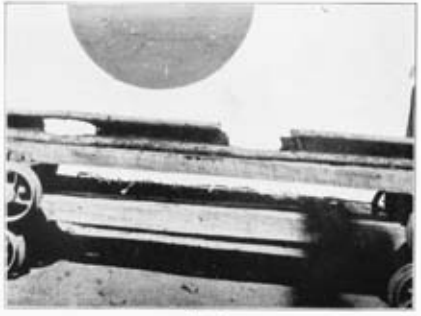


Photo 3.

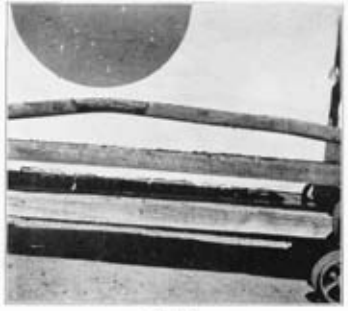


Photo 4.

AMMONAL EFFECTS

AMMONAL.

By Lieuts. C. Hordern and B. H. Fox, R.E.

The following remarks on Ammonal, an explosive lately introduced for the first time into India, may be of interest to R.E. officers who are unacquainted with it. The Indian agents for this substance state that it has already been in use in England, for the last two years or so, as a substitute for dynamite in mining work.

Nature of Ammonal.

Ammonal consists of a mixture of ammonium nitrate, finely-divided aluminium, and a small percentage of vegetable charcoal, in proportions which vary in the different grades of the explosive. It thus differs essentially from dynamite, nitro-glycerine, or guncotton, in which the explosive ingredient is a chemical compound.

In appearance, it is a powder of a light chocolate colour, of the consistency of fine river sand, the particles of metallic aluminium being clearly visible on a close examination.

It is intended for use wherever dynamite, or similar explosives, would be suitable; no claims are made for it as a propellant.

It is made up for use in 2-oz. cartridges, which consist of cylinders of well-waxed paper filled with the explosive. Nine different grades are manufactured; the cartridges of No. 5 ammonal, which we saw used, were $5\frac{1}{2}$ inches long by $\frac{7}{8}$-inch diameter, and were packed in watertight tins, each containing 5 lbs. of ammonal.

Claims Made for Ammonal.

1. It is cheaper to manufacture than dynamite, and costs about £5 a ton less.

2. No. 5 ammonal, which was used at Craigmore (*vide* Appendix A), is about 20 per cent. stronger than No. 3—the grade used in the quarrying experiments—and about 25 per cent. stronger than dynamite.

3. It is eminently safe both to manufacture and to handle, as it is unaffected by flame or shock, and can only be detonated by a detonator.

4. Its action, in all cases, is slower, more rending, and less shattering than that of dynamite—resembling, in this respect, that of gunpowder—while it possesses the strength of a nitro-explosive. The greater the proportion of aluminium the slower is its action.

5. It can be rendered harmless at once if necessary—*e.g.*, in case of a miss-fire—by wetting.

6. It evolves no noxious gases, and is therefore very suitable for use in tunnels and such places.

7. It does not freeze, and is unaffected by climate.

Remarks as to Claims Made.

1. As to cost, we have no *data* beyond this statement by the agent for the Ammonal Company.

2. We consider that the experiments—of which details are given below—show that ammonal is certainly stronger than dynamite.

3. Ammonal undoubtedly will not burn. To a lighted match it is indifferent, and we saw a length of fuze burnt, while embedded in a quantity of the explosive, with no effect except upon the nervous systems of the spectators. Advantage is taken of this property of ammonal in making up charges (see below).

The same lot of explosive, which was lying loose upon a stone slab, failed to detonate when violently hit with a hammer; a fuze and detonator were then inserted and detonated it successfully.

4. As to this, the Craigmore experiments do not give much information; the action, in fissured rocks and in the quarrying experiments, tends to confirm the claims made, as might perhaps be expected from the fact that steam is one of the main products of detonation (see Remark 6 below).

5. This is obvious from the chemical composition, and is certainly an advantage where miss-fires are concerned. In this respect, moreover, ammonal is clearly superior to dynamite from the point of view of safety, there being nothing corresponding to the exudation of nitro-glycerine, which is such a well-known defect of the latter.

At the same time ammonal cartridges are quite waterproof enough to be used in very damp bore-holes, and are easily used under water if the charge is made up in a waterproof covering.

6. The products of detonation vary in the different grades, but may be generally represented by the equation

$$3 . NH_4 . NO_3 + 2Al = 3N_2 + 6H_2O + Al_2O_3.$$

An advantage of ammonal is that it does not produce the familiar dynamite headache.

7. We had no opportunity of verifying this, but on the face of it, the statement seems probable, damp excepted.

Mode of Use.

Ammonal is used in exactly the same way as dynamite, except as regards

(*a*) Amount of charge;

(*b*) Position of detonator.

The tabulated experiments show all that is wanted as to (*a*).

(*b*). A typical charge is shown in the figure. It will be seen that

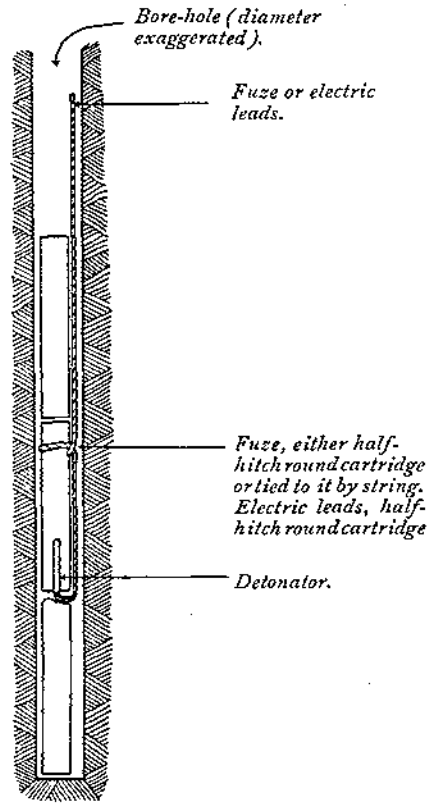
the detonator is placed at the bottom of the centre cartridge, an arrangement only possible because the fuze, burning past the upper cartridges, cannot fire them. This method has the following obvious advantages :—

(1). The tamping of the charge is not done directly on to the detonator.

(2). The better-tamped position of the detonator is claimed to give some extra pressure when the charge is fired.

(3). The portion of the charge, above the detonator, can be withdrawn by pulling on the fuze (or electric leads) without danger, as the pull does not come on the detonator, but on the cartridge itself.

(4). The accidents which occur when—as sometimes happens—unskilled men proceed to jump holes which are already charged, are prevented, as they cannot hit the detonator.



The bore-hole need not be made specially large to allow for the thickness of the fuze, as the latter can be pressed into the sides of the cartridges, which (ammonal being a dry powder) readily yield space for it.

The detonator used should not be weaker than No. 6 (commercial), and should be quite embedded in the powder.

In wet places, great care should be taken not to break the cartridges, and the one which contains the detonators should be specially protected. The Ammonal Company supply waterproof tubing for the purpose.

It is usual to ram down a piece of crumpled paper gently on top of the charge before tamping.

The instructions issued by the company embody the above points, and are headed " Keep your powder dry."

CONCLUSIONS.

Regarding ammonal from a service point of view, we contrast it with

(*a*) Guncotton ;
(*b*) Gunpowder ;
(*c*) Dynamite.

(*a*). The strength of ammonal is probably about equal to that of guncotton. As regards dry guncotton, it is decidedly safer. It is true that in the experiments described in Appendix B a bullet did (probably only imperfectly) detonate a quantity of ammonal; but whereas in the case of dry guncotton (primers, for instance) or dynamite such a result would be almost a foregone conclusion, in the case of ammonal it undoubtedly was exceptional, and altogether unexpected by those best qualified to judge. Ammonal has also the advantage over wet guncotton that no primer is required. On the other hand, the necessity of tamping, and the nature of its action, render ammonal unsuitable for hasty demolition work, with the possible exception of the "towers" of the N.W. Frontier; it cannot, therefore, take the place of guncotton in the equipment of sapper, cavalry, or pioneer units.

We have no *data* as to its use from a submarine mining point of view; it is not likely to be as good as guncotton, except perhaps for removing sunken rocks.

(*b*). Wherever gunpowder would be used, ammonal could probably be substituted with advantage. It is less bulky to transport, far safer, more powerful, and not dissimilar in its action. The necessity of carrying detonators may perhaps detract somewhat from these advantages.

(*c*). Where hasty demolitions are concerned, ammonal does not compare favourably with dynamite. But for blasting purposes—and it is in this direction that the claims of ammonal are urged—it is on the whole distinctly superior. Its safety renders it particularly suitable for use in roadmaking and similar work on active service, more especially where coolie or other unskilled labour is employed; even under fire the risk in using it is reduced to a *minimum*.

To sum up, it would appear that wherever dynamite is carried for blasting or quarrying, ammonal might, with great advantage, be substituted; and that in all demolition work, where gunpowder would be suitable, ammonal—preferably in this case one of the slower grades—might take its place. The chief drawback to ammonal seems to be its susceptibility to damp; it is, however, so carefully packed that in all probability there is little to fear in this respect.

It may be added that ammonal is manufactured by the Ammonal Explosives Co., of 29, Great St. Helen's, London, E.C., and that the Indian agents are the South Indian Export Co., Ltd., P.O. Box 37, Madras. To the representative of the latter firm, the writers are indebted for such of their information as was not gathered from the experiments which they witnessed.

APPENDIX A.

RESULTS OF SHOTS FIRED AT CRAIGMORE, ON THE OOTACAMUND EXTENSION OF THE NILGIRI RAILWAY.

Witnessed by Lieuts. Hordern and Fox, R.E., on 14th December, 1907.
Explosive.—Ammonal No. 5.
Rock.—Hard grey granitic.
Bore-Holes.—1 inch diameter in every case.
Object.—Removal of rock in cutting (*i.e.*, blasting pure and simple).
All charges fired by time fuze.

No.	Depth of Hole.	No. of 2-oz. Cartridges Ammonal used.	Estimated corresponding No. of Dynamite Cartridges necessary.	Remarks.
	′ ″			
1	3 0	4	5	Miss-fire; fuze cut by explosion of No. 2. Charge drawn; fired; results good.
2	4 0	4	5	
3	3 0	2	3	Results very good; quite equal to dynamite.
4	3 0	2	3	
5	2 0	2	3	Results poor, owing to miss-fire of No. 1, which failed to clear rock in front.
6	1 6	1	2	
7	3 10	4	4	Excellent.
8	1 0	1	1	Old hole; fired to shift loose stuff; good.
9	3 6	3	4	
10	4 0	3	4	Results good; equal to dynamite.
11	4 0	3	4	
12	4 0	3	4	
13	4 3	3	4	Bad. L.L.R. large, especially No. 13; charges too small. Deeper holes and probably 5 and 6 dynamite cartridges would have been necessary.
14	4 0	4	5	
15	4 6	4	5	Good.
16	4 6	3	4	Small L.L.R.; results average.
17	3 6	3	4	Good.
18	4 0	4	5	Large L.L.R.; very good.

Exact L.L.R.'s cannot be given, owing to situation of rock; they probably averaged 3 to 4 feet.

APPENDIX B.

EXTRACT FROM NOTES BY LIEUT. PAKENHAM-WALSH, R.E.

The second series of experiments was carried out on the same railway at Fern Hill, Ootacamund, on the 20th December, under arrangements made by Capt. Watson, 64th Pioneers, the object being, in this case, more for quarrying work, *i.e.*, to cut large blocks of stone suitable for masonry, rather than to break up masses of rock.

The details and results of these operations are given in the following Table.

Results of Shots Fired at Trials Conducted at Fern Hill, Ootacamund, with Ammonal Explosive No. 3, against Grey Granite.

Diameter of Bore-Holes.—1 inch.
Object.—Quarrying stone for use.

No. of Shot.	Depth of Holes.	Ammonal No. 3. No. of 2-oz. Cartridges actually used.	Corresponding No. of Dynamite Cartridges estimated necessary.	Result.
	′ ″	First	Quarry.	
1	4 0	3	3½	Fired electrically. Simultaneously Nos. 1 and 2 formed good cracks, extending for 5 feet in all directions. No. 3 shattered the rock.
2	3 0	3	3	
3	4 0	3	3½	
4	3 9	2	3	Fired electrically. Nos. 4 and 6 made good cracks, about 3 feet in all directions; 5 and 7 only cracked slightly in fissure and at bottom.
5	3 9	2	3	
6	1 6	1	1	
7	2 0	1	2	
8	In old hole of 5	3½	—	Fired electrically, and broke up rock well.
9	In old hole of 7	1½	—	
10	3 3	3	3½	Fired with time fuze; split rock.
		Second	Quarry.	
1	2 0	1	2	Fired consecutively by time fuze. The rock was split up excellently.
2	3 0	3	3	
3	4	4	4	
4	4 0	4	4	

Owing to the situation of the rock, the L.L.R.'s cannot be given, but the number of dynamite cartridges estimated gives a fair comparison.

In addition, a charge of 6 ozs. was made up in a waterproof tube, and fired successfully under water.

Photo 1 shows the second quarry after the charges were exploded; but much of the stone in the foreground had been previously cut, as may be seen by the tooling on it.

Photo 2 shows the two pieces of rock broken away above a bore hole, with the leads of the electric detonator passing through them still intact.

These experiments, however, were not of a nature to demonstrate its value for military purposes, and accordingly I arranged with the representative of the firm to carry out the following series of experiments, which was done at the Cordite Factory, Aruvankad, on the 27th December, in the presence of Major Babington, C.I.E., R.A., Superintendent, and nearly all the principal officials of the factory.

At Fern Hill, No. 3 ammonal was used, and at the factory No. 5; No. 7 detonators were used throughout, and time fuze in all the experiments on the 27th.

Experiment No. 1.

A tin containing 5 lbs. of ammonal was placed on a bank, and five rounds fired into it with a ·303 rifle at about 100 yards. The ammunition was Mark II., with a hollow-nosed bullet.

Three rounds passed through the tin and explosive, the first two without effect. The third exploded the charge, but the detonation was incomplete, the report being less loud; and some observers distinctly saw a large amount of flame, of which there is none when complete detonation takes place. This was a complete surprise to many present, as it was supposed that the material was insensitive to shock alone; I understand it has been tested in this way on several occasions before, and that this is the first time it has been exploded by a bullet. This result is important, and is referred to in the conclusions given above.

Experiment No. 2.

A piece of double bull-headed rail, weighing 65 lbs. per yard (web ¼ inch thick), 9 feet long, was placed loosely on the ground, on edge, in the position it would be in a line, but no steps were taken to fix it down.

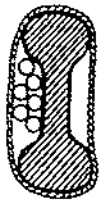
A charge of 8 ozs. (four cartridges) was lashed to the side against the web, in the same manner as guncotton would be, and fired, no tamping being used.

The result was distinctly curious. The rail was knocked over, and 9 inches of the web were completely removed, being apparently pulverized, as no trace could be found; but neither of the flanges was cut, though the upper one had a wide crack, extending nearly across it, and the rail was slightly bent. The whole effect was very local, hardly sufficient to derail a train, and the rail was unaffected at a distance of 6 inches on either side of the centre of the charge.

Experiment No. 3.

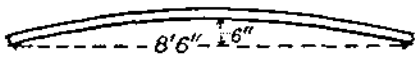
The same rail was again placed in position, and this time wedged firmly to represent as nearly as possible the conditions of a rail fixed to sleepers. The charge was placed at a reasonable distance from the previous damage, so that the latter should not affect the result, and was

12 ozs. (six cartridges).* These were tied together as in sketch, and lashed to the side of the rail in the usual way.



The result was that the web was again completely destroyed, apparently pulverized, for a distance of 8 inches, while the upper flange was removed for 12 inches. Something was heard crashing through some trees near by, and this is presumed to have been part of the flange, but it was not found.

The lower flange was again uninjured, and there was no sign of injury beyond the actual area destroyed; but the rail was bent as shown in sketch, a deflection of 6 inches in 8½ feet.



Both these experiments were carried out in a small passage about 2 feet 6 inches wide, behind a stop butt of earth riveted with poles about 7 feet high. The other side was a perpendicular bank in the solid earth about 10 feet high. No appreciable damage was done to either the stop butt or the bank. The effects on the rail are clearly shown in *Photos* 3 and 4. Note the crack in the top flange caused by experiment No. 2.

Experiment No. 4.

The remaining ammonal on the spot (50 ozs.) was put in one of its own 5-lb. tins and packed tightly up against one side with damp paper, the side with the explosive being placed nearest the firing point. In front of the tin was placed a ¾-inch board.

Nineteen rounds were then fired at a range of about 150 yards, with the following results:—

Series.	No. of Rounds Fired.	No. of Rounds Penetrating Tin.	Nature of Ammunition.
1	5	3	Mark II. hollow-nosed bullet.
2	4	1	" " "
3	5	4	Service ammunition.
4	5	5	" "

The one round in Series 2, which hit the tin, knocked it over. Before Series 4 the tin was turned so that it was end on to the firing point.

None of these rounds succeeded in detonating the explosive, though, as is shown, 13 of them passed through it, and the back of the tin was considerably torn about, and the powder leaking out.

As it was thought the wet paper might have affected the powder, a detonator was put in and the charge fired. This time the detonation was complete, there being no flame, as in experiment No. 1.

* The *Manual of Military Engineering* lays down one-third of a 1¾-lb. slab (*i.e.*, about 9½ ozs.) as the proper charge where guncotton is used.

NOTES ON FIELD EQUIPMENT OF ROYAL ENGINEERS.

By Lieut.-Colonel W. Baker Brown, R.E.

Introductory.

The reorganization of the Royal Engineers has at last crystallized in the form of *War Establishments*, 1907, and the various mobilization store tables (A.F. G.1098) of the same date.

This reorganization, which began before the end of the South African War, has been subject to many vicissitudes, owing to changes of army policy during the past seven years, and is probably, like all mundane affairs, open to improvement.

An attempt has, however, been made to maintain a consistent relation between men, stores, and transport, and while cutting off everything which is either redundant or luxurious, to include all improvements suggested by recent experience in South Africa and elsewhere.

The reorganization has also been applied simultaneously to all branches of the R.E.

The present is, therefore, a convenient opportunity to take stock of what has been done, and thus to establish a foundation on which any future changes and improvements can be built.

It is thought also that, as store tables are somewhat dry reading, many R.E. officers may be glad to have the essential points put before them in a concentrated form.

Summary of the Changes dealt with.

A considerable number of different changes, is embodied in the latest organization.

The most important are :—

1. Changes due to the experience of the war in South Africa, and recommendations embodied in the reports of the Engineer-in-Chief, Director of Telegraphs, and Director of Railways.
2. Changes recommended by the committee, under the presidency of Sir Evelyn Wood, in 1906.
3. Changes in the scale of transport for the Army recommended by the committee, of which Sir F. Stopford was president, in 1906.

4. Changes of organization of the Army from an army corps to a divisional system.
5. Changes in pattern of arms and accoutrements, and of harness.
6. Changes in patterns of other stores, including many changes of nomenclature embodied in the 1906 edition of the *Vocabulary of Stores.*

It would be tedious to follow each alteration through all the above stages, and it is only proposed to state shortly the present arrangements.

GENERAL CONSIDERATION OF FIELD EQUIPMENT.

The equipment of a unit may conveniently be considered under certain groups :—

1. *Equipment of "Personnel."*—(*a*), arms and accoutrements; (*b*), ammunition; (*c*), rations; (*d*), clothing and baggage; (*e*), camp equipment.

2. *Equipment of Animals.*—(*a*), harness or saddlery; (*b*), stable necessaries; (*c*), forage; (*d*), horseshoes.

3. *Vehicles and their Equipment.*—(*a*), vehicles and components; (*b*), wagon equipment, spare parts, and miscellaneous.

4. *Medical and Veterinary Stores.*

5. *General Tools and Materials.*—(*a*), saddlers; (*b*), farriers; (*c*), shoemakers.

6. *Tools for Military Purposes.*—(*a*), entrenching; (*b*), cutting; (*c*), mining.

7. *R.E. Artificers' Tools.*—(*a*), carpenters and wheelers; (*b*), smiths; (*c*), bricklayers and masons; (*d*), painters; (*e*), tinsmiths and plumbers; (*f*), grindstones.

8. *Materials.*—(*a*) to (*e*), for use with R.E. tools.

9. *Blocks and Cordage.*

10. *Stores for Water Supply.*

11. *Explosives.*

12. *Signalling Stores.*

13. *Survey Stores.*

14. *Special Technical Tools and Stores.*—(*a*), bridging; (*b*), telegraph; (*c*), ballooning; (*d*), electric lighting; (*e*), railway work.

15. *Miscellaneous.*—(*a*), office books; (*b*), stationery; (*c*), packages.

Of the above, the first five subheads may best be considered in their general application to all R.E. units; but the remainder must also be considered in their particular application to each class of unit.

In either case attention is directed to para. 7, Section 1, *War Establishments*, 1907, which states that the organization and equipment adopted is that required for a European war, and represents the normal equipment. Units actually serving in South Africa and elsewhere out of Europe are equipped on a special scale.

If any units equipped on a normal scale are ordered for service in a

non-European country, amendments suitable for the particular service will be made in their scales of transport and equipment.

The changes necessary for certain of these countries are kept worked out in tabular form at the War Office, but are not issued to units.

The scale of equipment authorized is controlled by Equipment Regulations, but for general convenience the scale applicable to each particular unit is worked out on an Army Form (G.1098) for each class of unit.

The scale of consumable stores and such details as boots, horse-shoes, etc., which was formerly based on a three months' supply, is now reduced to a fortnight's supply, on the understanding that under normal conditions such articles will be replenished by the Army Ordnance Department at short intervals.

1. EQUIPMENT OF "PERSONNEL."

(*a*). *Arms and Accoutrements.*—*Officers* carry the arms and accoutrements laid down in *War Establishments*, 1907, Table V. (*a*), Section II.

W.O.'s, N.C.O.'s, and men are all to be armed, in war, with the new short rifle and bandolier equipment, but the issue of arms to drivers may possibly be limited. N.C.O.'s and men of the dismounted branches will carry the bayonet, but the mounted branches will carry no sidearm. Pistols and swords will not be carried in the field by ranks below officer.

(*b*). *Ammunition.*—Each man will carry on his person 50 rounds; mounted branches carrying this in the bandolier, dismounted in bandolier or pouches. An additional 50 rounds will be carried in regimental reserve for each N.C.O. and man of the dismounted branches only.

(*c*). *Rations.*—The detail of rations, carried in the field by and for the soldier, is given in *War Establishments*, 1907, Table III., Section II. The weight of the one ration per head carried in regimental transport is taken at 2½ lbs. The rations are packed in wooden boxes, which will be used as firewood. The weight of wood carried in this way is taken at 1 lb. per head.

(*d*). *Clothing and Baggage.*—The details of the clothing for officers are laid down in *War Establishments*, 1907, Table V. (*a*), Section II. Each commanding officer is allowed 50 lbs. of baggage in regimental transport, and other officers 35 lbs. each. The details of the clothing of the men are given in *War Establishments*, 1907, Table V. (*b*) and (*c*), Section II. The only articles carried for the men in regimental transport are waterproof sheets, of which one, weighing 2 lbs. 9 ozs., is allowed for each man. Spare boots are carried by all units in the proportion of 3 per cent., with a minimum of six pairs per unit.

(*e*). *Camp Equipment.*—The camp equipment carried in the field comprises camp kettles and butchery implements. Kettles are provided in the proportion of one to every 3 officers, and one to every 24 men. Butchery implements are provided for each section into which a unit may be divided in the field. Tents do not form part of the normal equipment of the Army, and when they have to be provided, special arrangements must be made for their transport. Blankets are similarly dealt with, but, in this case, the special scale of transport required has been shown as an Appendix to Mobilization Store Tables, A.F. G.1098. Tools for camping will be drawn from the general equipment of each unit.

2. EQUIPMENT OF ANIMALS.

(*a*). *Harness or Saddlery.*—The patterns of harness are rather involved—owing to the peculiar nomenclature adopted in the *Vocabulary of Stores*—the terms A.S.C. and G.S. being used not only to describe sets, but also parts of sets, some of which are common to more than one pattern. But, speaking broadly, there are now only two patterns of harness in use by R.E. units for draught purposes—

Harness, A.S.C., wheel, double sets.
Harness, breast, pole draught, R.A., double sets.

The latter is used only for the technical vehicles on the limber principle, that is, at present, the double tool cart and the cable wagon; the former is used for all other vehicles. Both patterns are normally for driving from the horse, but a few pairs of driving reins and some long whips are included for driving from the box.

The pack saddlery, used by R.E., is "Pack saddlery, G.S.," with which are used "Bars, hanging," "Chests, pack transport, Clarkson," and "Racks, entrenching tool, R.E., wood, small." The saddlery used is "Saddlery, officers," "Saddlery, universal." Full details of the components of the various sets as used for R.E. units are given in tabular form in an appendix to each, A.F. G.1098.

(*b*). *Stable Necessaries.*—These comprise nosebags, brushes, rubbers and sponges (one set per horse), and buckets, water, canvas, one for two horses.

(*c*). *Forage.*—The scale of forage is laid down in *War Establishments*, 1907, Table IV., Section II. One day's ration of corn per horse (12 lbs.) is carried in regimental transport. One bale (82 lbs.) of compressed forage is carried in the locker of each G.S. or G.S. R.E. wagon. It is assumed that hay is available in the country.

(*d*). *Horseshoes.*—These are issued in sets of four shoes, with 60 nails per set. The allowance is one pair per shoe case, carried on the horses, and spare sets to the number of 15 per cent. of the establishment of horses, carried in vehicles.

3. VEHICLES.

The changes in patterns and details of vehicles have been numerous and important since the South African War. Nearly every pattern has been reconsidered.

(*a*). *Vehicles and Components.*—The following changes affect practically all existing vehicles:—

(1). *Pole draught* has been substituted for shafts in all cases except the balloon wagon and cable cart. This change has been made in both old and new patterns.

(2). *South African brakes* will be fitted to all vehicles except carts, tool, R.E., Mark II.; wagons, balloon, boat, cable, light spring, R.E. At present this change has only been effected in air-line, pontoon, and reservoir gas wagons on charge of units, and in new supplies of all patterns.

(3). The patterns of *axles* and *wheels* have been standardized, to reduce the number of different kinds in the Service.

Future patterns of R.E. vehicles will have mainly No. 165 fore axle and No. 199 hind axle, with Nos. 150 and 200 wheels. This change has been only applied to new supplies.

The following patterns of vehicles have been rendered obsolete for the reasons stated:—

(1). *Wagon, Tool, Field Troop, R.E., with Limber.*—Replaced by cart, tool, double (see L. of C., §13,763).

(2). *Wagon, Forge, R.E.*—This was a G.S. R.E. wagon, with special fittings for a forge and vice. These latter are now treated as separate stores, which can be carried in any vehicle. The forge wagon has been converted to G.S. R.E. (see L. of C., §13,420).

(3). *Lithograph Wagon.*—Abolished, as litho stores are now carried in cases or chests, which can be transported in a forage cart or other vehicle. This wagon will shortly be declared obsolete in L. of C.

Some new vehicles have been introduced, and there are now the following R.E. vehicles in the Service:—

(1). *Cart, Tool, R.E.*—A new pattern of this cart has been introduced, called Mark II., with a box body and other improvements, which will shortly be detailed in L. of C. The distinction between front and rear carts is abolished. Each cart is a separate item for store purposes. Two carts limbered up to form one vehicle are called a "double tool cart." Certain straps, to hold a few tools likely to be required on the line of march, are fixed on the outside, and can be used at the discretion of the officer in charge. Mark I. carts are being converted by the substitution of a body for the detachable tool boxes now carried. Both Marks are fitted for pole draught; the Mark I. has the South African pattern of brake, the Mark II. rear arm brake.

(2). *Cart, Cable.*—This cart is being superseded by a cable wagon on the limber principle (see L. of C., §13,770); it is fitted for shaft draught.

(3). *Wagon, Air-Line.*—Minor alterations have been made in this wagon, mainly by the use of pole draught and South African brakes (see L. of C., §12,463, 13,455, and 13,731).

(4). *Wagon, Balloon.*—This is a G.S. R.E. wagon, fitted with winding gear for controlling the balloon. It will probably be replaced by a new wagon on the limber principle. It has shaft draught.

(5). *Wagon, G.S. R.E.*—This wagon, which was formerly used by all R.E. units, is now retained only for use by telegraph units, whose instruments must be carried in a vehicle with springs. In other units it will eventually be replaced by wagons G.S. Mark VIII. or later patterns. For the present, to use up stock, several units retain G.S. R.E. wagons. G.S. R.E. wagons, having springs, give an easier draught than the springless G.S. wagons, but have a tare load of 5 cwt. in excess of the latter. Wagons G.S. R.E. have pole draught and South African brakes.

(6). *Wagon, Printing.*—This is retained for use with the printing equipment in the field. Some alterations of pattern are being considered.

(7). *Wagon, Pontoon.*—Numerous minor improvements, based on South African experience, have been introduced into this vehicle. The width of track has been reduced from 5 ft. 10 ins. to 5 ft. 6 ins., to bring this vehicle more into line with other vehicles. It has pole draught and South African brakes.

(8). *Wagon, Reservoir, Gas.*—This is retained to carry tubes of hydrogen gas for balloon units. It has been strengthened by the substitution of the fore carriage of the G.S. R.E. wagon for the old fore carriage. It has pole draught and South African brakes.

The following are new vehicles:—

(9). *Wagon, Cable.*—This has superseded the cable cart. It is on the limber principle. The body carries eight miles of field cable on four drums, and is fitted with winding-up gear and seats for two men of the detachment. The limber is fitted with a complete third-class office set (vibrator and telephone receiver), and there is also space for a few tools and stores. It has pole draught and front arm brakes (see L. of C., §13,770).

(10). *Wagon, Light Spring.*—This has been introduced mainly for use by telegraph units to carry small loads or detachments in attendance on cable wagons. It will carry 1,500 lbs. load, or 10 men for short distances. It is of especially light construction, with four wheels, pole draught, and front lever brake (see L. of C., §13,256).

(11). *Wagon, Boat.*—This has been introduced to carry a collapsible boat equipment with field troops. It will take two boats

and superstructure for one raft. It has pole draught and front lever brakes (see L. of C., §13,383).

(12). *Wagon, Ambulance.*—Some Mark V. wagons of this type are being converted for transporting the men of field troops. The new nomenclature is not yet settled. They can carry 10 men each, with small stores or tools. They have pole draught and brakes of the lever type.

(13). *Wagon, Wireless Telegraphy.*—Is being designed on the limber principle to carry one complete set of instruments with aerial. The body will contain the machinery for the electrical power, the limber the receiving and sending instruments.

(14). Special vehicles for field search lights have been designed, but this equipment is still only in the experimental stage. In addition to the special R.E. vehicles, the following army vehicles are included in R.E. equipment :—

(15). *Cart Forage.*—Two-wheeled, shaft draught, South African brake. Used for carriage of tools, stores, or supplies, and for many purposes in camp and on the march.

(16). *Cart, Maltese.*—Two-wheeled, shaft draught, South African brake, with springs. Used for medical instruments and supplies.

(17). *Cart, Water.*—These are supplied and driven by A.S.C. The latest mark is of the tank pattern, carrying 118 gallons of water, and is being fitted with a filtering apparatus, which includes a pump.

(18). *Wagon, G.S.*—This is the ordinary type of four-wheeled wagon used throughout the Service. It has pole draught and no springs. The patterns of brakes are :—Mark VIII., front lever brake ; Mark VIII.*, front lever brake coupled with screw at rear ; Mark VIII.**, front lever brake with independent S.A. brake ; later patterns, S.A. brake combined with front lever brake.

(19). *Wagon, Limbered G.S.*—This is a small vehicle of limber type, recently introduced for the carriage of S.A. ammunition and tools, but has not yet been included in R.E. equipment. A Table is attached, giving the most important details of the above vehicles.

TABLE GIVING DETAILS OF VEHICLES USED IN R.E. EQUIPMENT.

Vehicles.	Pattern of Pole.	Pattern of Shaft.	Pattern of Axletrees.	Pattern of Wheels	Pattern of Brake.	Weight. Stripped.	Weight. Complete, with Spare Parts, Accessories, & Vehicle Equipment.	Width. Over-all.	Width. Of Track.	Length, Over-all (including Pole or Shaft except where otherwise stated).	Remarks.
						lbs.	lbs.	′ ″	′ ″	′ ″	
Carts, Cable:—											
Mark I....	—	Nos. 67 & 68	3rd Cl. B, No. 166	3rd Cl. B, No. 146	S.A.	1176	1194	6 0	5 2	13 10	(*a*). Including outrigger.
,, II.	—					1325	1343			15 0	(*b*). With pole extended.
Carts, Forage:—											(*c*). With pole used as a perch.
Mark I.	—	Nos. 43 & 44	3rd Cl. B, No. 157	3rd Cl. B, No. 158	—	910	953	6 3 (*a*)	5 2	15 6	(*d*). With 2nd Class hind wheels
,, II....	—				S.A.	938	981				(*e*). With 3rd Class hind wheels.
Carts, Maltese:—											(*f*). With pole.
Mark II.	—	Nos. 63 & 64	3rd Cl. A, No. 146	3rd Cl. B, No. 158	—	728	805	6 1	5 2	13 1	(*g*) Without pole.
,, III.	—				—						
,, IV.	—		3rd Cl. B, No. 157		—						
,, V.	—				—						
,, V.*	—				S.A.	763	840			13 5	
Carts, Tool, R.E.:—											
Mark I.	Draught No. 14	—	3rd Cl. B, No. 176, Mk. II.	3rd Cl. B, No. 144	S.A.	1134†	1168	6 0	5 2	15 1 (*b*)	
,, II.	,, No. 20	—	2nd Cl. C, No. 200	2nd ,, C, ,, 200	Rear arm brake	1120†	1146	6 2		8 10 (*c*)	
										16 0 (*b*)	
										10 9 (*e*)	
Carts, Water Tank:—											
Mark I.	—	Nos. 63 & 64	3rd Cl. B, No. 157	3rd Cl. B, No. 158	—	1054	1072	6 1	5 2	—	
,, I.*	—				S.A.	1025	1043				
,, II.	—				S.A.						
Wagons, Air-Line:—											
Mark I. (*d*)	Draught No. 7A.	—	3rd Cl B, No. 168 (fore) 2nd ,, C. ,, 199 (hind)	3rd Cl. B, No. 150 (fore) 2nd ,, C. ,, 200 (hind)	—	2352	2382	6 2	5 2	25 4½	
,, I. (*e*)		—	3rd ,, B, ,, 165 (fore) 3rd ,, B, ,, 166 (hind)	3rd ,, B, ,, 150 (fore) 3rd ,, B, ,, 145 (hind)	—			6 1			
,, II.		—	3rd ,, B, ,, 165 (fore) 2nd ,, C. ,, 199 (hind)	3rd ,, B, ,, 150 (fore) 2nd ,, C. ,, 200 (hind)	S.A.			6 2			
Wagon, Balloon, R.E. .	—	No. 100	3rd Cl. B, No. 165 (fore) 2nd ,, C. ,, 199 (hind)	3rd Cl. B, No 150 (fore) 2nd ,, C. ,, 200 (hind)	—	2653	2793	6 2	5 2	21 9	
Wagon, Boat	Draught No. 7A	—	3rd Cl. B, No. 177 (fore) 2nd ,, C. ,, 199 (hind)	3rd Cl. B, No. 150 (fore) 2nd ,, C. ,, 200 (hind)	Front lever br'ke	1736	1766	6 2⅝	5 3	21 2	
Wagon, Cable:—											
Limber	Draught No. 17, Mark III.	—	2nd Cl. C, No. 198	2nd Cl. C, No. 200	Front arm brake	921	2055	6 2½	—	13 10 (*f*)	
Body		...	,, ,, C, ,, 38			1101				8 3 (*g*)	
Limber and body ...		—	—	—	—	2030		6 2	5 3	11 8	
										24 7½ (*f*)	
										16 1 (*g*)	

† Single Carts.

Vehicles.	Pattern of Pole.	Pattern of Shaft.	Pattern of Axletree.	Pattern of Wheels.	Pattern of Brake.	Weight. Stripped.	Weight. Complete, with Spare Parts, Accessories, & Vehicle Equipment.	Width. Over-all.	Width. Of Track.	Length Over-all (including Pole or Shaft except where otherwise stated).	Remarks.
						lbs.	lbs.	′ ″	′ ″	′ ″	
Wagons, G.S. :—											
Mark VIII.	Draught No. 7A.	—	3rd Cl. B, No. 159 (fore) 2nd Cl. C, No. 200 (hind)	3rd Cl. B, No. 159 (fore) 2nd ,, C, ,, 200 (hind)	Front lever brake	1792	1909	6 2	5 2	22 8	(*d*). With 2nd Class hind wheels. (*e*). With 3rd Class hind wheels.
,, VIII.*		—			Front lever br'ke coupled with screw at rear	1904	2021				
,, VIII.**		—			Front lever br'ke with independent S.A. brake	1954	2071				
,, IX.		—			S.A. brake combined with front lever brake	1848	1965				
,, X.		—				1792	1909			23 0	
,, X*		—		3rd Cl. B, No. 159A (fore) 2nd ,, C, ,, 200A (hind		1792	1911	6 4			
Wagons, G.S., R.E. :—											
Mark I. (*d*)	Draught No. 7A.	—	3rd Cl. B, No. 165 (fore) 2nd ,, C, ,, 199 (hind)	3rd Cl. B, No. 150 (fore) 2nd ,, C, ,, 200 (hind)	—	2464	2604	6 2	5 2	20 8	
,, I. (*e*)		—	3rd ,, B, ,, 165 (fore) 3rd ,, B, ,, 166 (hind)	3rd ,, B, ,, 150 (fore) 3rd ,, B, ,, 145 (hind)				6 1			
,, II.		—	3rd ,, B, ,, 165 (fore) 2nd ,, C, ,, 199 (hind)	3rd ,, B, ,, 150 (fore) 2nd ,, C, ,, 200 (hind)	S.A. brake			6 2		21 9	
Wagon, Light Spring, R.E.	Draught No. 8	—	3rd Cl. B, No. 215 (fore) 2nd ,, C, ,, 200 (hind)	3rd Cl. B, No. 143 (fore) 2nd ,, C, ,, 199 (hind)	Front lever br'ke	1064	1120	6 2½	5 2	19 10	
Wagons, Pontoon :—											
Mark IV.	Draught No. 7A.	—	3rd Cl. B, No. 167 (fore) 2nd ,, C, ,, 88 (hind)	3rd Cl. B, No. 150 (fore) 2nd ,, C, ,, 200 (hind)	S.A. brake	2100	2129	6 10½	5 10	26 4½	
,, IV.*		—						6 7	5 6½		
Wagon :—											
Lithograph, Mark II.	Draught No. 7A	—	3rd Cl. B, No. 165 (fore) 2nd ,, C, ,, 199 (hind)	3rd Cl. B, No. 150 (fore 2nd ,, C, ,, 200 (hind)	S.A. brake	—	—	6 2	5 2	21 9	Obsolete.
Wagon, Printing ...	Draught No. 7A	—	3rd Cl. B, No. 165 (fore) 2nd ,, C, ,, 199 (hind)	3rd Cl. B, No. 150 (fore) 2nd ,, C, ,, 200 (hind)	S.A. brake	2800	2830	6 2	5 2	21 9	
Wagon, Reservoir, Gas : Mark I.... ... ... ,, II.	Draught No. 7A	—	3rd Cl. B, No. 51B (fore) 2nd ,, C, ,, 45 (hind)	3rd Cl. B, No. 150 (fore) 2nd ,, C, ,, 200 (hind)	S.A. brake	1820	1850	6 0	5 2	20 8½	
Wagon, Limbered, G.S. : Fore, Mark I ...	Draught No. 17, Mark III.	—	2nd Cl. C, No. 141	2nd Cl. C, No. 198	—	616	1297	6 4	5 2	13 11 with pole. 4 10 without pole.	Length over all limbered up :— 9 1 with perch. 22 10 with pole. 5 4 without perch. 13 9 without pole.
Hind, ,, I....		—	,, ,, ,,	,, ,, ,,	S.A. brake	588					

(*b*). *Wagon Equipment and Spare Parts.*—The components of each vehicle, with a list of accessories, spare parts, and wagon equipment, are shown in Army Form G.1096. The components form part of the vehicle for store purposes, but accessories, spare parts, and wagon equipment are held on separate charge.

The wagon equipment of ordinary vehicles includes a few tools—such as pickaxe, shovel, and hammer—so as to make a convoy of wagons self-contained as regards camp duties or small casualties on the line of march. Such tools always remain with the vehicles, and are not available for other purposes.

For ordinary transport vehicles this arrangement is convenient, but for technical vehicles, which carry tools for their technical duties, the arrangement is not convenient, so the cart or wagon equipment of R.E. vehicles now only includes such articles as buckets, or inventory boards, which are always with the vehicles. Any tools required for camping, etc., will be taken from the general equipment of the unit. The accessories are mainly such articles as covers and seats.

The spare parts now carried by each vehicle are reduced to a few spare pins and washers. The amount of spare parts, carried in the field, as wheels, axles, and poles, has been much reduced on the understanding that the general army organization will arrange for periodical issue of such parts by the A.O.D. Spare poles in the proportion of 25 per cent. of the vehicles are included in the equipment of most units.

4. MEDICAL AND VETERINARY STORES.

Medical officers are no longer attached to each R.E. unit, but are distributed as under :—

One with headquarters of divisional Engineers.

One with each bridging train.

Each medical officer is accompanied by a Maltese cart, driven by one of his orderlies. The cart and harness are included in the equipment of the above units. The medical equipment, consisting of one medical companion, one surgical haversack, two field panniers, is brought to the place of mobilization by the medical officer. A similar arrangement is made for veterinary duties, except that the veterinary equipment of one 84-lb. and two 25-lb. chests is carried on a pack animal.

In addition certain 25-lb. chests or wallets of veterinary stores are carried as under :—

	25-lb. Chests.	Wallets.
Balloon companies	—	1
Bridging trains	—	2
Cable telegraph companies	1	4
Wireless „ „	—	1
Air-line „ „	2	4
Field troops	1	1
Field companies	1	2

5. GENERAL TOOLS AND MATERIALS.

(*a*). *Saddlers' Tools* are issued in filled holdalls, weighing 13¼ lbs. One or two of these are issued to units, according to size. A small quantity of suitable materials for repair of harness is carried by each unit, except divisional telegraph companies and headquarters of divisional Engineers.

(*b*). *Farriers' Tools* are issued in filled tool bags, weighing 14½ lbs. each. They are issued one to each section and one to the headquarters of each unit.

(*c*). *Shoemakers' Tools and Materials* are carried in a filled bag, weighing 25 lbs. One or two bags are issued to each unit, according to size.

6. TOOLS FOR MILITARY PURPOSES.

The numbers of these carried by each R.E. unit necessarily varies with the probable work to be done and with the details of packing. This is best considered when discussing the equipment of each class of unit.

The following is approximately the proportion of tools of this class carried by a field company, and may be useful as a guide when making up improvised equipments. It is, of course, intended for an ordinary European cultivated country, with a due proportion of trenching and cutting. For each 20 non-commissioned officers and men (dismounted branch) allow :—

Shovels, R.E.	12	Hand axes	3
Pickaxes (9 with 4½-lb. heads and 3 with 8-lb. heads)	12	Billhooks	4
		Handsaws	3
Spades	2	Crowbars (4 ft. 6 in.)	1
Felling axes	4		

The pattern of shovel and pickaxe carried by R.E. has been much discussed ; the latest pattern of shovel is special to R.E. and weighs 5 lbs. 2 ozs. The pickaxe for general use has a 4½-lb. head with the helve shod with a metal sheave, making the total weight of metal 5½ lbs. To provide for heavy work 25 per cent. of the pickaxes carried by field companies, and also those carried in pontoon wagons, have an 8-lb. head with an unshod helve.

7. R.E. ARTIFICERS' TOOLS.

The tools actually carried in the field have been reduced to the lowest possible amount. If a force remains stationary for any time and much R.E. work has to be done additional tools must be drawn from the A.O.D. or obtained locally. For details see the notes on organization of reserves.

The sets of tools in filled chests include many articles which are not essential for active service. Special sets applicable to field

service have been selected, and are shown in detail in Army Form G.1098.

Tool chests are only carried in a few units. In other cases the tools are packed in Clarkson's chests, which are also available for pack transport, in leather holdalls (holdall, tool artificers, L. of C. §4,916), in bags, carpenters', or in sandbags.

The forges carried are :—

Forge, pack saddle for field troops and bridging trains.
„ double bellows for field companies.

But it is probable that the forge, field, G.S., which can be carried on a pack saddle, will supersede the above. A very small amount of fuel for forges is carried, and must be supplemented by local supplies.

Grindstones are required not only for artificers' but for other cutting tools. The present sizes are 10-inch and 18-inch (measuring by the diameter of the stone), but an intermediate size of 14-inch is being introduced for field companies and bridging trains, in lieu of the 10-inch, which is rather too light.

8. MATERIALS.

The amount of materials carried has been limited to that absolutely required for small repairs to equipment and vehicles. It must be supplemented by supplies obtained locally or from the A.O.D.

9. BLOCKS AND CORDAGE.

After some years of discussion and experiment the old patterns of wooden blocks have been superseded by a series made of malleable steel (see L. of C., 13,716). Each block is identified by the size of cordage with which it is used and the number of sheaves. The usual sizes carried are the single and double for 1½-inch or 2½-inch cordage.

White hemp cordage being stronger and more pliable than tarred, the former is included in equipment for all tackles. Tarred cordage is carried for certain bridging services and other special uses. Breast lines and cables, etc., for bridging services are issued in bulk as cordage, and cut to the required lengths when taken into use.

10. STORES FOR WATER SUPPLY.

For field use, a pump (lift and force, to lift 60 feet) with hose is carried on each tool cart of the field troops and field companies. For each pump there is carried in 2nd line transport a 600-gallon waterproof trough, with pickets and the necessary cordage. (*Military Engineering*, Part V., Miscellaneous, *Fig.* 3, *Plate* XXII.).

In addition to above, some water carts are being fitted with a filter apparatus, which includes a pump in its components.

11. EXPLOSIVES.

The patterns of guncotton hitherto used in the field have been unnecessarily complicated.

R.E. units at present carry the T slab of wet guncotton (1½-lb.) with both F (2-oz.) and H (1-oz.) primers.

Cavalry carry the V slab (14-oz.) and the F primer, each slab being enclosed in a special tin case.

There are also varieties of packages and cylinders, and there is the further complication that the official weight of wet guncotton is the weight of the guncotton when dry, that is before any water is added.

It is intended in future to limit the guncotton carried in the field by all units to one pattern of slab and one pattern of primer. The slab will be a modified V, 15 ozs. in weight, 6″ × 3″ × 1⅜″, with one perforation for primer. The primer will be a modified H, 1 oz. in weight. Both primer and perforation in the slab will be slightly coned, so that the primer when pressed home will fit tightly. The slab and primer together will thus weigh 1 lb., so that the number of slabs will in practice be the number of pounds in the charge.

Wet guncotton will be held on charge by slabs, instead of by weight. The wet guncotton for R.E. units and general service will be carried in the field in "boxes, guncotton, wet, field," to hold 14 slabs, but cavalry will retain their special tin cases for one slab. The dry guncotton will be carried in cylinders to hold 10 primers, the top being closed with a bayonet joint. Six cylinders are issued in a wooden case.

For firing charges R.E. units carry both electrical and ignition appliances.

The electrical appliances include a magneto generator, lengths of D 15 cable, and detonators No. 13.

The ignition appliances are No. 9 safety fuze, Vesuvian matches, and detonators No. 8. The matches and detonators are carried in special tin boxes.

Instantaneous fuze is not carried in the equipment, as it is mainly useful for firing charges simultaneously, or for mines or long bore holes, for all of which the electrical gear can be used.

12. SIGNALLING STORES.

A small signalling equipment of helios, lamps, and flags is carried by each field company; other units carry flags only.

13. SURVEY STORES.

Small sets of the usual military sketching and drawing instruments are carried in all units except telegraph units.

14. SPECIAL TECHNICAL TOOLS AND STORES.

These will be dealt with when discussing the details of each class of unit.

15. MISCELLANEOUS.

(*a*). *Office Books.*

(*b*). *Stationery.*—Each unit carries one box stationery, field, filled. Units which exist in peace hold the boxes on peace charge, and for units which do not exist in peace the boxes are included in the mobilization equipment of the unit. The details of the contents are shown in the tables of books, army forms, and stationery issued with A.O. dated December, 1899, but this list now requires amendment as regards R.E. units.

(*c*). *Packages.*—The packages used for carriage of tools and materials have been already referred to. Where no special holdall or case is provided, tools must be packed direct into vehicles, sandbags or similar articles being used as packing.

IMPERIAL DEFENCE.

By Lieut. W. G. S. Dobbie, R.E.

With reference to Major Harrison's article in the February number of the *R.E. Journal*, entitled "Military and Naval Home Defence," there seems to be another aspect of the case which has not been touched upon.

One of the chief dogmas of the Blue Water School is, that invasion is impossible so long as we maintain the command of the sea. The word "invasion" is taken to mean the landing of a force large enough to maintain itself in our country, and does not refer to raids by comparatively small bodies of troops; in fact, to land an "invading" army will take a very considerable time, even supposing the enemy is free of interruption both from the weather and any force we may be able to bring against him.

As to the exact length of time the enemy will be likely to have free from interference by our fleet, it is not possible to speak with any certainty; but it seems difficult to imagine that more than three days, at the very outside, could elapse before our fleets are on the spot in sufficient strength to overwhelm the invading ships. The Channel Fleet never cruises very far, and the Home Fleet, which, though a heterogeneous collection of ships, comprises a good many very powerful units, could easily mobilize in less than the time mentioned. In the three days it would not be possible to transport and land any force larger than 20,000 men, a number far too small for any effective operations in a hostile country. Further, this raiding force would know that it could not possibly return whence it came, as its retreat would very speedily be cut off by our fleet, a thought which would hardly be conducive to the peace of mind of the members comprising it. It would, therefore, seem that it is necessary for the British fleet to be placed *hors de combat* before a force, sufficiently large to invade England, could be landed on her shores. The next point for consideration is what would happen supposing we did lose command of the sea. This would certainly give our enemies the chance of invading our land if they wanted to. But it is very doubtful if they would do so, for the simple reason that there would be no necessity should the English fleet cease to exist.

The people of England are almost entirely dependent for their food on that which is brought into the country from our oversea possessions or from foreign countries. The same applies, though in a lesser degree, to raw materials. If, then, we lose command of the sea, it would be no difficult matter for the enemy's ships to stop this supply of food from reaching our coasts. The end would not be long delayed. We would have to accept whatever terms were offered. To sum up the foregoing remarks, invasion is impossible so long as we retain command of the sea; but if we lose that, invasion is unnecessary. It will then be asked—what is the object of having an army? The answer is twofold—1st, to take the offensive, and so to bring our enemy to his knees; 2nd, to protect our colonies which have a land frontier.

As regards the first, it will not be sufficient to keep the enemy's fleet blockaded in his ports. We cannot bring him to terms until we land an army in his territory, and so render it impossible for him to ignore our demands. It is not suggested that it would be possible to land an army, say in France or Germany, large enough to take Paris or Berlin, but we could invade and overrun the enemy's colonial possessions, a plan of operation which would in time produce the desired result.

Conversely our colonies would be a very convenient object of attack if they happened to adjoin the territories of our enemies. The most striking examples of this are Canada and India. To protect these possessions a large number of troops will be required. In the case of India they already exist, but in Canada the number of troops now available is totally inadequate in view of the immense length of frontier to be protected. Nor does its population admit of sufficient expansion of its peace army without interfering with its industries. It is here that a considerable portion of the regular army could with great advantage be stationed, thus strengthening what would otherwise be a very weak point in the defence of the Empire.

The troops at home would then consist of:—

(*a*). Garrisons of our big naval ports.

(*b*). The striking force.

The regular troops might be supplemented by a well-trained militia, which would make good the wastage of a campaign; but no reliance must be placed on this or any other military force to resist invasion. That is a duty that the Navy, and the Navy alone, must perform.

As regards the protection of our commerce, the fact that the bulk of our armoured ships are in home waters does not really constitute a danger, as these ships would not be used for commerce protection. No enemy would dare to detach any of his armoured ships for the

purpose of raiding our commerce. It would, therefore, follow that armoured ships are not required for its protection, but protected cruisers, which have the advantage of being cheap, and therefore numerous. If the enemy's fleet is blockaded efficiently, there is theoretically no need for commerce protection at all. It is only because some of the enemy's ships may slip through the blockading force that the necessity for commerce protection arises.

To sum up:—For the reasons given above the Navy should be considered the defensive weapon, and the Army the offensive. It is a waste of time and money to try and make the Army do the Navy's work, and it is equally impossible for the Navy to do that of the Army.

MILITARY v. NAVAL HOME DEFENCE.

By COLONEL E. H. BETHELL, D.S.O., *p.s.c.*, LATE R.E.

IN the February number of the *R.E. Journal* Major W. A. Harrison raises some important points and makes some important assumptions.

I venture to consider the former and to make some criticisms on the latter.

Major Harrison assumes that in the very early stages of a war, and before the naval forces engaged have had time to establish a superiority on one side or the other, an invasion on a large scale may be launched against us; he considers that some foreign complication, such as the recent Turkish move towards Egypt, might draw away so much of the strength of our available squadrons to distant waters as to make it possible for an enemy to obtain temporary command—say for six clear days—of the waters over which the invading force was to be thrown.

Having made this assumption, Major Harrison proceeds to base upon it an argument concerning our military forces; he says that admittedly our Territorial Force will not be fit to meet a properly trained enemy during the first months of war, and that therefore it can only be auxiliary to our home defence army; that the latter must be raised to the number required for home defence under every condition, irrespectively of the Territorial Forces; but that it may "include the striking force, which is apparently considered of such primary importance."

I think such a scheme of the requirements of a home defence army, irrespective of the Territorial Forces, is for all practical purposes an impossible scheme; Major Harrison's hostile transports are going to have six clear days of transporting troops, and, therefore, an invasion on a large scale is evidently intended, when the large quantity of shipping available, *e.g.*, in Germany, is considered. I suppose that with the three clear days of preparation Major Harrison will expect the enemy to get *at least* five army corps, say 150,000 men, across; perhaps, having regard to the enclosed nature of the country to be traversed, these corps would not be of normal composition—they might contain an abnormal proportion of infantry, and total up to 200,000 men.

This being so, his home defence army, "irrespective of the Territorial army," will, I suppose, consist of at least 200,000 men, with a due proportion of all arms.

The country is to pay for a two-power standard fleet, a regular colonial army, a territorial army, and finally for this large home defence army.

Proceeding to criticize this programme, I would observe that it seems to me very unlikely that in the very early stages of a war, before the respective naval forces had found their level or taken each other's measure, and while our striking force was still at home, such an invasion would be projected; if, however, there were a reasonable probability of such an attempt, then the obvious reply would surely be better training of the territorial army.

In any solid programme of defence industrial conditions cannot be ignored; war has got to be one function of a nation's organic whole, and preparation for it must not make impossible its other and equally necessary functions.

Consistently with this condition I think we cannot hope for more, and we ought not to be content with less than a territorial army trained approximately on the Swiss model; our streak of silver sea still gives us, in all human probability, time for preparation; if Germany is able to launch half a million men within a week against France, then France must be able to mobilize about the same number in the same time. In our case it is unlikely that, at any rate, under present naval conditions, we shall be invaded by even 150,000 men within a week of a declaration of war; our striking force is sure to be at home in the early stage of a war; it behoves us so to organize, equip, and train our territorial army that we may be able to mobilize it at once, and proceed without delay to more thorough training than we have been able to give it in peace time.

Whether such a standard can ever be attained on any other basis than that of universal training and liability to serve may well be doubted, in spite of the experiment now being made. What additional motives are we bringing to bear on our wished-for recruits to the Territorial army other than those which have always operated on Volunteers? County rivalry—nothing else tangible. The essentially defective justice of any scheme, which is intended to saddle the patriotic part of the community with the sole liability to duties which are more and more recognized to be incumbent on all young men who exercise the rights of citizenship, must, I believe, in the long run make every such scheme comparatively unfruitful.

The Chancellor of the Exchequer would indeed be in an evil plight if he were compelled to rely for the collection of taxes on considerations similar to those so eloquently brought forward by the Secretary of State for War, with a view to induce recruits to join.

Having, however, got our territorial army, it seems to me that the further question of the extent to which permanent fortification should be called in to strengthen the coast defence of the country is one which can only be settled by considering each individual case, bearing

in mind that permanent fortifications are immovable, and may never be used, while the force of armed men can be concentrated and used where it is wanted.

I think a few "staff rides," dealing with coast-defence problems, show one how great the resources of defence are in many parts of our coasts, and how greatly they are increased by full consideration beforehand.

Finally, I suppose, from Major Harrison's expression "the striking force, which is apparently considered of such primary importance," that Major Harrison does not consider it is of primary importance. To me it seems vital and primary in the highest degree. The idea that in these days, when war means the subordination of every other function of a nation during war to the requirements of war, when it means the concentration of national energy on war, 44 millions of people are to take no part in it, leaving everything to be settled by its comparatively few sailors, is not, I think, tenable.

There is a limit to the damage that fleets can do; moreover, it is certain that we cannot hope to survive without alliances, and it is certain that some promising alliances with us will lose much of their value to our ally, if that ally doubts our will and ability to despatch an army to its assistance—an army of which sea power will double the value—when required.

Therefore, a powerful striking force we must have, and what is more, a reserve of trained men sufficient to enable it to keep the field in modern war.

Who shall say that Lord Roberts's million of trained and partly trained men is an excessive estimate for all purposes; or who will maintain that such a reservoir of trained men can be obtained without ruining the country by any other means than the means adopted by every country which has had to consider the situation practically, viz., by universal service of some kind?

There is the comparatively expensive kind which circumstances have forced on Germany and France, with its comparatively protracted training—and there is the cheaper kind, which is good enough for Switzerland, which has only to make its neutrality respected, and which is probably good enough for us, who have the advantage of time for preparation, and who have to pay for a two-power standard fleet and a colonial army.

Certainly, Germany seems to have solved the combined military and industrial problem in a way which smashes the croaking critics of 25 years ago; for she has got the army she wants, and yet with a birth rate 50% greater than ours, and an emigration which is a small fraction of ours, her industrial position is very strong.

REPORT ON AN IMPROVISED SEARCH LIGHT ON BOARD THE R.I.M.S. "MINTO."

By Major W. P. Brett, R.E.

General Conditions.—During the 1907 manœuvres in Aden, an experiment was made to see whether field search lights could be improvised from material available at the station, but the difficulties of obtaining proper generating plant were too great to allow of their being fitted up in time of peace. The General Officer Commanding, therefore, gave orders to fit up a search light on board the R.I.M.S. *Minto*, which was at the time at Aden, and she was then moored in such a position that the search light could be used with effect.

Projector, Construction of, etc.—No projector was available, but there was the base (complete) of a Mark III. projector in store. The remainder had to be constructed in the workshops, and, as time was of great importance, it was made as light as possible. *Fig.* 1 shows the general construction of the projector.

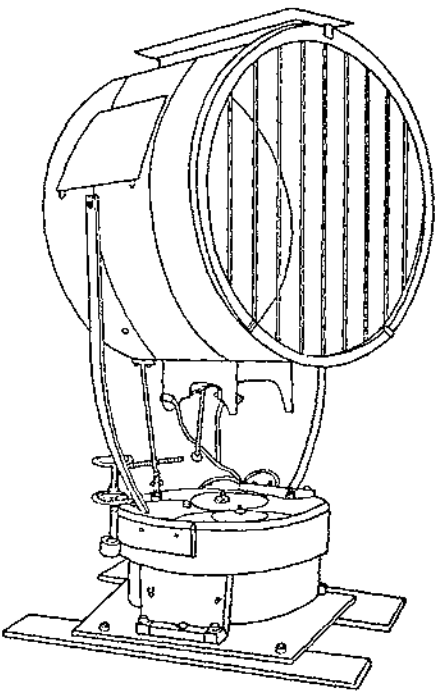


Fig. 1.

A palladium reflector without its case was used, as being the most convenient.

Ten round iron rods, $\frac{5}{8}$ inch in diameter, were then bolted to the mirror, as shown in *Fig.* 2, and a ring of flat iron was bolted to the other ends of the rods. This completed the frame.

The frame was stiffened by binding the rods together, near their middle, with stout iron wire (see *Fig.* 2).

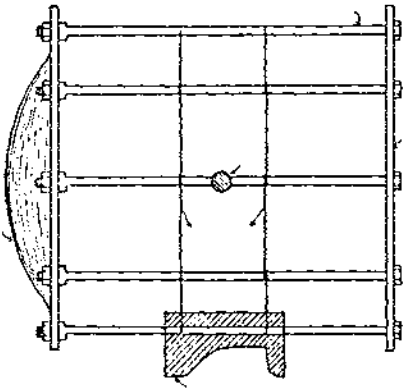


FIG. 2.

Lamp.—A hand lamp was used with an adapter, the adapter being fixed to the two lower rods in a position to allow of the arc being central to the reflector. The adapter also allowed the lamp to be adjusted backwards, or forwards, for focus.

Trunnions.—The trunnions were formed by two pieces of iron, made in the form of an ordinary lathe carrier, thus being adjustable backwards or forwards, their position being fixed by trial before the outer case was fixed on (see *Fig.* 3).

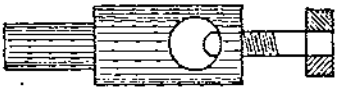


FIG. 3.

Outer Case, etc.—The outer case was made of sheet iron, obtained from empty kerosene tins. Each tin, when cut, makes a strip about 1 foot wide and $3\frac{1}{2}$ feet long. These strips were placed round the frame, and bound to the rods and to each other with iron wire. An inspection door at each side and a ventilator at the top were made of the same material.

A glass door, at the front of the projector, was made with a framework of wood, and fixed on by iron clips.

The legs were formed of two heavy pieces of flat iron bolted to the base.

Elevation and depression were worked by means of a long screw, with wooden hand wheel, working in a nut fixed to the back of the projector.

Plant on the "Minto."—On board the R.I.M.S. *Minto* were two dynamos, driven by vertical steam engines, each of which was capable of 100 ampères, at 100 volts pressure.

Special arrangements were, therefore, necessary to reduce the voltage, and to guard against too great a current being taken by the lamps on closing carbons.

Fig. 4 shows the connections and resistances used.

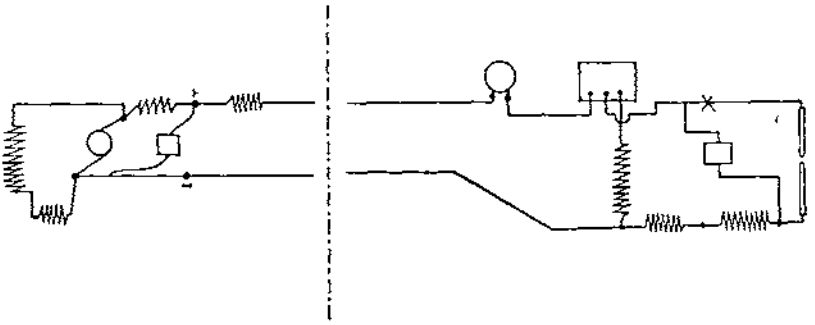


FIG. 4.

Three ohms in adjustable resistance, reduced volts at dynamo to 80. Volts at lamp were 50, and current 75 ampères.

After a trial run, it was found that only one of the ·25 ohm resistances was required.

The running of the lamp was very satisfactory in every way; no hitch occurred.

The R.E. engine drivers and electricians took charge of, and ran all the machinery.

To test the efficiency of the beam, a company of the 2nd Battalion Suffolk Regiment advanced over some broken ground within range of the beam.

The beam was found to be very efficient up to 800 yards. This is not so great as might have been expected, but, with a better reflector and a little more experience in handling the beam, better results would probably be obtained.

The General Officer Commanding expressed himself as satisfied with the results.

R.E. CORPS LIBRARIES AND PUBLICATIONS.

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

NOTHING could more clearly indicate the intellectual awakening effected in the Corps by the Royal Engineer Establishment at Chatham, than the fact that a professional library was started within a year of the issue of Pasley's first order as director of the establishment.

The library was started at a general meeting of R.E. officers stationed at Chatham, held on the 3rd November, 1813. Colonel Robert D'Arcy, C.B., was president of the meeting, being, doubtless, the senior R.E. officer stationed at Chatham at the time.

During the next five years similar libraries were established at other stations both at home and abroad. "The object of such libraries," says Pasley, "is to enable officers of Engineers to study their profession in any part of the world to which they may be ordered, without the trouble and expense of moving private libraries, which would exceed the means of any individual. None but books of deserved reputation are admitted; and of the most useful works several copies are provided, in order that more than one subscriber may read such works at the same time. The expenses are entirely defrayed by a small monthly subscription of members present only, no entrance being charged."*

This library was kept in the office of the clerk of works at Chatham, a non-commissioned officer being employed as librarian, in addition to his other duties as assistant to the clerk of works. This librarian received, besides his ordinary pay, "one day's extra allowance in each week" from the officers who were members of the library.

Company libraries were soon afterwards started by Colonel Pasley. These libraries consisted of a few selected books of geometry, mechanics, or of a military nature likely to prove instructive to the N.C.O.'s and men. They were purchased by them by voluntary subscription, and were carried in a box when the company moved. "It is desired," writes Pasley, "that the captains of companies will patronize this measure if they should be requested so to do by the men under their command; but without using any influence to induce non-subscribers to come forward."†

* Pasley's *Standing Orders for the R.E. Establishment, 1818*, p. 259.
† Pasley's *Standing Orders*, p. 260.

The first company library on this principle, was established by the 7th Company, 1st Battalion, early in 1816.

The Corps Library established at Chatham in 1813 is still in existence, but it is now generally known as the S.M.E. Library. It is managed by a committee of officers at the station, under the Commandant of the S.M.E.

The other libraries, with the exception of one started at Dublin in 1825, appear to have gradually died out, until the idea was resuscitated by Lieut.-Colonel R. C. Alderson in 1845. The present central Corps Library is situated at the Horse Guards, London.*

Branch libraries exist at most R.E. stations of any importance. Two of these—viz., those at Esquimalt, B.C., and at Halifax, N.S.—were handed over by the officers of the Royal Engineers to their successors, the Royal Canadian Engineers, in 1906, in which year the Dominion Government took over from the Imperial Government the duty of garrisoning these fortresses. These libraries will, it is hoped, form a visible link connecting the Royal Canadian Engineers, who were organized in 1903, with the parent Corps.

The R.E. Corps libraries have, since 1877, been managed by the R.E. Institute Committee.

The various R.E. Corps publications may be divided up under four heads :—

(1). S.M.E. text books.
(2). *R.E. Professional Papers.*
(3). The *R.E. Journal*—an officers' periodical.
(4). The *Sapper*—a rank and file paper.

S.M.E. Text Books.

Pasley's earliest text book, the *Course of Instruction in Practical Geometry*, was published by John Murray in 1814. The two succeeding volumes of the *Course* were published by the same house in 1817.

Pasley's *Exercise of the New Double Pontoons*, 1821, *Escalading*, 1821, and many other books of instruction, were, however, lithographed at the R.E. Establishment, Brompton Barracks ; and, from that day to the present time, nearly all the R.E. text books have been either lithographed or printed at the S.M.E. Although the *R.E. Professional Papers* were for the first thirty-eight years of their existence—from 1837 to 1875—published away from Chatham, since the latter date not only the *Professional Papers*, but also the *R.E. Journal* and the *Sapper*, have all been published at Chatham, and are all closely connected with the S.M.E.

Professional Papers.

Lieut. W. D. Denison started the *Professional Papers* in 1837, as mentioned by Major-General Harness, C.B., in a memoir he wrote on him in 1872. He writes : "In 1837, while a subaltern in the Corps, the officer to whom these passing tributes of respect and affection are

* For a history of the R.E. Corps libraries from 1845 see the preface to the *Catalogue of the London Library.*

paid succeeded in establishing the *Professional Papers*, and in so doing has, with the single exception of the founder of our School at Chatham, done more to increase the interest of his brother officers in their profession, and to diffuse through the Corps the experience of its individual members, than any of his predecessors or contemporaries."*

In 1837 Lieut. Denison was quartered at Woolwich, at that time the headquarters of the Royal Sappers & Miners. He succeeded in interesting several of his brother officers in the question of publishing papers on professional subjects, pointing out the desirability of the publication of a professional work, in which should be embodied the experience of individuals. Such a work, he maintained, being circulated among the officers of the Corps at large, would serve, in some measure, to remedy the inconveniences which arise from their being scattered all over the world, and consequently unable to take advantage of that freedom of intercourse and interchange of information which would otherwise take place amongst them.†

A meeting of several officers was held, at the Royal Engineer Office, Woolwich, for the purpose of considering the details of a plan proposed by Lieut. Denison for the attainment of this object, and entirely concurred in the opinion expressed in the prospectus he laid before them. Resolutions were passed asking him to take charge of the proposed publication, and when these had been approved by the Inspector-General of Fortifications, Lieut. Denison at once entered upon his duties as editor.

In his introduction to the first volume, published by J. Barker, of Fleet Street, in 1837, Denison prefixed a few introductory remarks, in which he clearly set forth the object of the *Papers*, viz., to collect and arrange the large amount of professional information disseminated throughout the Corps, and to enable officers to benefit by the experience of all engaged in engineering work by combining it with that derived from other sources. Several attempts had already been made to start such papers, but had hitherto failed, and, as Denison pointed out, it was only by co-operation and by every individual contributing, that the experiment could be made to succeed. If this were not done, the existence of the *Papers* might indeed be prolonged for a few years, by drawing upon stores of knowledge that had already been accumulated ; but when these were exhausted, the common routine duties of the Corps would hardly afford material for an annual volume. He added that the materials could be found both in the numerous experiments and investigations of subjects connected with both the military and civil branches of our profession, and also in the study and application of sciences which not only are both useful and interesting, but also tend to draw closer the bonds which

* *R.E. Professional Papers* for 1872, Vol. XX., New Series.

† *Professional Papers of the Corps of R.E.*, Vol. I., Preface, p. iii.

unite us to other scientific bodies. Denison then points to the unfavourable way in which the military academies of this country compared, as places of scientific instruction, with those of other countries, and ends the introduction in the following words:—"Labour and study will be requisite to enable them (*i.e.*, young officers) to perform satisfactorily their ordinary duties, and this should be their first consideration; but this labour and study brings with it its own reward, not only as it enables them to perform their duties efficiently, but as it is the stepping stone to the cultivation of those sciences which open a wider range to the intellect, extend their sphere of usefulness, and which, by occupying the mind and improving the faculties, tend eventually to make them better officers and men."

Denison edited the first eight volumes of the *Professional Papers*, and on resigning the editorship, on his appointment to the Lieut.-Governorship of Tasmania, he was succeeded by Capt. Henry James, who edited the ninth volume.

In the preface of this volume, dated 8th March, 1847, Capt. James writes: "I feel assured that it will be gratifying to the Corps, and to the officers who have subscribed to the *Professional Papers*, to learn that, at the meeting which was held in September last, the officers there assembled voted as from themselves only (they were not authorized to represent the Corps in this matter) a piece of plate to Sir W. Denison, on which the following inscription was engraved:—"Presented by his brother officers who attended the meeting of the 23rd September, 1846, to Capt. Sir William Denison, Royal Engineers, as a token of grateful remembrance that to him alone they are indebted for having originated the diffusion of individual experience by means of *Professional Papers*, which he has continued to conduct for a period of 10 years, until he was appointed to the Government of Van Diemen's Land."

During the early seventies the inadequacy of the machinery for producing the *Professional Papers* appears to have begun to make itself felt. Amongst other things, the editor had to carry out his ordinary Corps duties concurrently with the work of editing the *Papers*. Capt. C. S. Hutchinson, for instance, was Professor of Mathematics at the Royal Military Academy, Woolwich, and was afterwards employed in the Railway Department of the Board of Trade for the 13 years (1862–1875) during which he acted as editor.

The work had become too heavy for one officer to carry out efficiently in addition to his other duties. An association of officers, destined eventually to include practically the whole of the Corps, was accordingly projected on the lines of the R.A. Institution at Woolwich. This association, which was, and is still, known as the R.E. Institute, came into being in 1875. In addition to taking over the publications enumerated above, the R.E. Institute carries out a large amount of other useful work. The Council administers

all the Trust Funds incorporated in the Memorials Maintenance Fund, edits, prints, and issues annually, the whole of the Corps Funds Reports—including a verbatim report of the Corps Meeting—and keeps its members supplied with books, maps, etc. It is, in fact, more or less a general agency, and is frequently made use of by Government departments both at home and abroad, rarely, if ever, refusing to carry out a request within reason made by a member.

An officer has hitherto been appointed every five years to act as secretary of the Institute, the work of editing the *Professional Papers* constituting one of his duties.

Meanwhile, during the last years of Capt. Hutchinson's editorship, individual enterprise as well as combined effort had begun to supplement the work of the overburdened editor of the *Professional Papers*.

In 1870 the *R.E. Journal*—of which a short description will be given later—was launched by a resolution at the annual Corps Meeting; and in 1874 Colonel Wilbraham Lennox, V.C., started on his own account a series of translations of a confidential nature from foreign works on military engineering.

The duties connected with the editing of the *R.E. Journal*, as well as with the continuation of Colonel Lennox's confidential series, and the management of the Corps libraries, were eventually taken over by the Secretary of the R.E. Institute, in addition to the work of editing the *Professional Papers*.

The Institute building at Chatham, designed by Lieut. M. F. Ommaney,* was commenced in 1871 and completed in 1875.

Since 1875, members of the Institute have received the *Professional Papers* and other Institute publications free, as they pay a *pro rata* subscription to the Institute itself.

The affairs of the R.E. Institute are managed by a Council, elected at the annual Corps Meeting in London. Up to 1904 the Inspector-General of Fortifications was president of the Institute Council, but since the abolition of that office in 1904 the senior officer on the active list present at any meeting has acted as chairman.

R.E. Journal. The idea of starting a paper which should contain a list of the Corps, and such information from the various stations as might be thought interesting, was proposed by Major Richard Harrison at the annual Corps Meeting held on the 27th May, 1870. The proposition was strongly supported by Colonel W. O. Lennox, V.C., C.B., and was carried by a large majority.

From that day to this the *Pick-Axe*, as the *R.E. Journal* is familiarly called, has become indispensable to every R.E. officer.

Capt. Robert Home, who shortly afterwards brought out his well-known *Précis of Modern Tactics*, was the first editor of the *Journal*.

* Lieut. Ommaney was awarded the Fowke Medal for the design.

2nd Capt. V. G. Clayton succeeded him as editor in 1871, and kept it going until he handed it over to Major W. H. Collins, acting Secretary of the R.E. Institute, in 1876. From this date the editorship has constituted one of the duties of the Secretary, R.E. Institute. The *Journal* was originally foolscap folio, and contained professional matter, regimental and social news, and a list of officers and stations of the Corps.

From January, 1873, the list was printed separately, and called the *Supplement to R.E. Journal.* In January, 1905, the title of this *Supplement* was altered to *R.E. Monthly List.* At the same time the size of the *Journal* was changed to royal 8vo, and its contents limited to professional matter (including much of what had hitherto been published in the *R.E. Professional Papers*) and memoirs; regimental and social news being printed in a new *Supplement* of the same size.

Capt. R. H. Vetch, who has since done so much historical work for the Corps by his biographies of Sir Gerald Graham and Sir Andrew Clarke, and by his articles on military engineers in the *Dictionary of National Biography* and in the *Encyclopædia Britannica*, was the first official Secretary of the R.E. Institute, Major Collins having carried on the work temporarily, pending the appointment of a permanent secretary.

Since 1882 publications other than the *Professional Papers* and the *R.E. Journal* have been undertaken by the R.E. Institute.

For instance, Major W. R. Slacke's *Notes on Drains and Drainage*—the first English text book on the subject—was published by the R.E. Institute in 1885; Colonel H. Tovey's *Notes on Military Law* was published in 1886; and Sir Douglas Galton's *Army Sanitation* in 1887.

The *Dictionary of Explosives* by Major J. P. Cundill, R.A., was published in 1889. Major J. F. Lewis' *Permanent Fortification for English Engineers*, 1890, Major E. C. S. Moore's *Notes on Sanitary Engineering*, 1892, and Sir Guilford Molesworth's *Railway Construction*, 1895, are all well-known text books in their various lines.

Between 1894 and 1898 Major G. K. Scott-Moncrieff published several useful handbooks. The first edition of his *R.E. Field-Service Pocket-Book* was brought out in 1894. Captain R. F. Edwards brought out a second edition of this handy little work in 1902. Major Scott-Moncrieff's other books, *Water Supply of Barracks and Cantonments*, 1896, and *Principles of Structural Design*, 1897, have already been referred to in the chapter on the Construction Course.

Perhaps the most monumental work ever brought out by the R.E. Institute, and certainly the most valuable from the historical point of view, is Capt. R. F. Edwards' *Roll of Officers of the Corps of Royal Engineers from 1660 to 1898.* This was mainly compiled from MS. rolls of the late Capt. T. W. J. Connolly—the Herodotus of the Corps—and brought up to date. In addition, references were made

to the British Museum, Record Office, War Office, and other sources public and private. To all historians of the Corps this work is, and must always continue to be, of paramount importance. It is to be hoped that it will be kept up in the future, as is being done at the present time.

The *Sapper*.

The idea of running a monthly periodical for the rank and file of the Corps originated in the minds of three corporals—Piggott, Avis, and Beaumont—in the early part of 1895.

The matter would, however, probably have dropped had it not been taken in hand by Engineer Clerk Sergeant S. W. Hurst, who, with the assistance of the three corporals, prepared in manuscript the first copy of the periodical, which it was proposed should be called the *Sapper*.

This was laid before the Assistant Commandant, Colonel W. G. Morris, who was so well satisfied with it that he straightway convened a committee of officers to consider the desirability of publishing such a periodical. It was unanimously agreed that it would be an excellent thing for the Corps at large.

Certain rules were drawn up, which, together with the proposed composition of the committee, were forwarded to the War Office for approval. The committee is divided into two branches, the Committee of Control and the Working Committee. The Committee of Control consists of officers stationed at the S.M.E., and is presided over by the Commandant.

The Working Committee consists of warrant and non-commissioned officers. In addition to the editor, this committee consists of a publishing secretary, a treasurer, and an auditor.

The first copy of the *Sapper* was published on the 1st August, 1895. 3,000 copies were printed, and within a week of the date of publication not a single copy was to be obtained. Since then it has come out regularly every month.

The following warrant and non-commissioned officers have acted as editors of the *Sapper* since the start of the paper :—

Engineer Clerk Sergeant S. W. Hurst, August and September, 1895.

Engineer Clerk Q.M.S. F. Bone, October, 1895—February, 1900.

Superintending Clerk S. W. Hurst, March, 1900–

The first few numbers of the *Sapper* were printed in the S.M.E. Printing School. Since January, 1896, the printing has been done by Messrs. Mackay & Co., Ltd., Chatham.

All the notes and sketches which appear in the *Sapper* are contributed by the warrant, N.C.O.'s, and sappers of the Corps; and there can be no doubt that, amongst the many agencies which keep alive R.E. *esprit de corps*, not the least valuable is the *Sapper*—the only regimental paper in the Army which is kept going entirely by the rank and file.

TRANSCRIPT.

GERMAN CAVALRY STEEL BRIDGE EQUIPMENT.*

By MAJOR E. HARTMANN.

INTRODUCTION.

FOR its proper employment in war cavalry must be self-contained and independent of other units. During the course of its numerous duties, and particularly when reconnoitring, water will be met with—either unbridged, or with all bridges over it destroyed. Horses will have to swim across, with the help of existing or improvised floating equipment, *e.g.*, steel or collapsible boats, canoes, rowboats, rafts, floats, etc.; or else be transported on rafts or floating bridges, constructed out of regular equipment carried by the troops or improvised on the spot.

A cavalry regiment carries, as regular equipment, either four steel half-boats on two "bridge wagons," or two collapsible boats on one "collapsible boat" wagon.

The *Cavalry Fieldworks Instructions* were replaced, on the 24th October, 1907, by new and comprehensive regulations, entitled *Cavalry Pioneer Instructions.*†

These instructions give full information as to the use of collapsible boats. The new collapsible boat, instead of consisting of a centre piece and two bow pieces, is formed by only two bow pieces, a much simpler arrangement. Four saddle beams of equal length replace the three long and two short saddle beams of the old equipment.

The rest of the equipment is the same in both cases. The collapsible boat wagon has six horses, instead of four, in order to be able to keep up with the regiment on the march, and to be at hand when wanted.

The extensive experience gained in the long use of the old equipment showed that it did not fulfil requirements. The collapsible boats were found to be too flimsy, the canvas being easily damaged. In addition, the wagons were too heavy and unstable over rough ground. The problem was, therefore, to design a lighter and stronger metal boat to replace the canvas one.

Aluminium was first thought of, but it was found that it did not withstand the action of water, and was, therefore, in spite of its lightness, unsuitable for boat-building. This led to the choice of sheet steel as the most suitable material.

* From *Kriegstechnische Zeitschrift.* No. II. 1908.

† These instructions contain also information on demolition and reconstruction work by cavalry in the field.

Extensive and very thorough experiments were carried out with these new steel boats by the Guard Corps in 1897—1898, and by the 3rd Army Corps in 1899; these experiments showed this type of boat to be eminently suited for its purpose. Some further improvements were, however, introduced, and the improved boats were then handed over to the 15th Army Corps.

The experiments, carried out at Strasbourg from 1900—1902, proved so satisfactory, that the steel boat was finally adopted for the cavalry bridge equipment.

The following are the chief points of difference between the old and the new equipment:—

(i.). The 6-horse "collapsible boat" wagon has been replaced by two 4-horse bridge wagons.
(ii.). The bi-partite collapsible boats have been replaced by half-boats, made of galvanized Martin mild cast steel.
(iii.). A fixed "chess table" replaces the loose chesses.
(iv.). Superstructure is carried for eight bays instead of six.
(v.). The whole equipment has been strengthened, not only by larger scantlings for the individual parts, but also (in the bridge for all arms) by the addition of strong intermediate supports for the "chess tables."

The chief advantages claimed are:—

(i.). Greater mobility and stability of the wagon.
(ii.). A very marked increase of strength in the steel boats.
(iii.). Increased buoyancy and adaptability to use under varying circumstances.

1. Description of the Steel Boat Bridge Equipment.

The cavalry bridge equipment, introduced by Army Order of the 19th June, 1903, was called "Steel Boat Bridge Equipment," so as to distinguish it from the "Collapsible Boat Equipment."

The equipment consists of nine distinct main parts, noticeable by the simplicity of their construction.

(*a*). *Cavalry Half-Boat.*—The half-boat (*Fig.* 1), of galvanized sheet steel, is 3·45 mètres long, 1·58 mètres broad, and ·565 mètres deep, in the clear.

The boat has a pointed bow and square stern.

The framework of the boat is formed of wrought-iron ribs, to which the steel skin is riveted.

The gunwale is perforated for the reception of the saddle beam, or crutches, at the bow and stern.

The centre batten, at the bottom of the boat, is of wood, and has two cleats, one near each end, for belaying cables when the boat is in bridge.

On each side of the centre batten there are two other wooden battens, and on the outside there are three wooden battens for protecting the bottom of the boat.

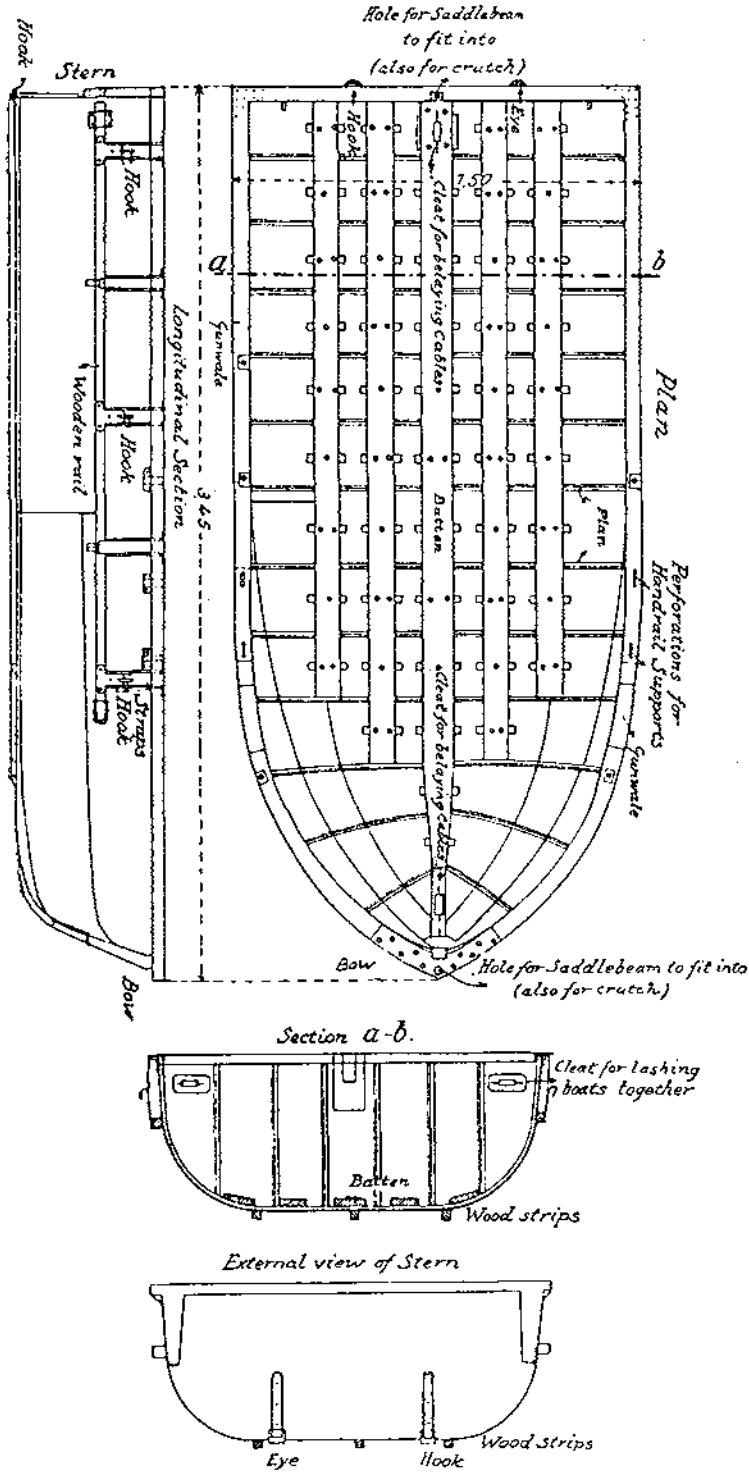

Hole for Saddlebeam
to fit into
(also for crutch)
Hook
Stern
Hook
Hook
Hook
Hook
Wooden rail
Longitudinal Section.
3.45
Gunwale
a
b
Hook
Eye
1.50
Cleat for belaying cables
Batten
Cleat for belaying cables
Plan.
Plan
Perforations for Handrail Supports
Gunwale
Bow
Hole for Saddlebeam to fit into
(also for crutch)
Bow
Section a-b.
Cleat for lashing boats together
Batten
Wood strips
External view of Stern
Eye
Hook
Wood strips

Fig. 1.

The sides of the boat are protected by a continuous wooden rail. When packed on the wagon, the half-boats are placed one over the other, upside down, the upper boat resting on the continuous wooden rail of the lower one. This rail is supported by straps fastened to the gunwale. These straps are provided with hooks, which are used during transport "for lashing" the boats to the wagons, and during bridging for lashing the "chess tables" to the boats.

With two such half-boats, a complete boat can be formed by lashing them together by the sterns, for which purpose there are belaying pins at the top, and hooks and eyes at the bottom (*Fig.* 2).

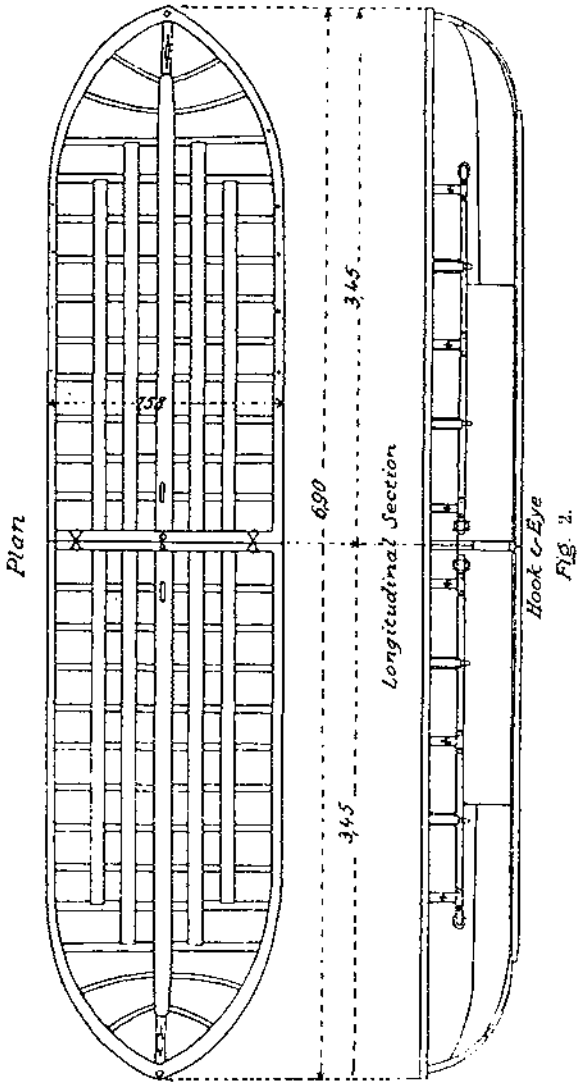


Fig. 2.

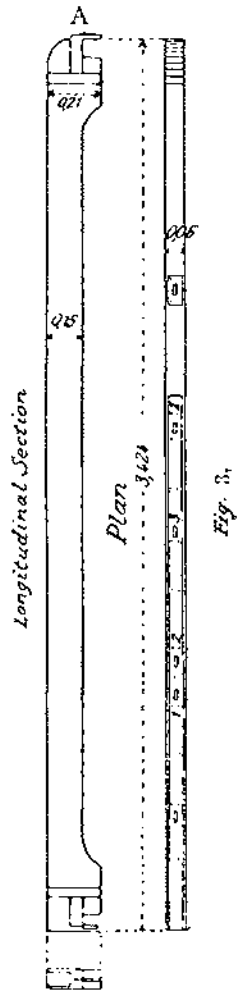


Fig. 3.

The forming of these two half-boats into one can be done either on land or in the water. The latter method is generally preferable, the half-boats (which weigh approximately 132 kg.) being more easily handled on shore than the whole boat, and moreover are easily joined together in the water.

(*b*). *The Saddle Beam.*—The saddle beam (*Fig.* 3) is made of pine, and serves as a support for the superstructure, which consists of "chess tables." Its length is 3·424 mètres, its width ·06 mètre, and its depth ·15 mètre, except at the ends, where the depth is increased to ·21 mètre.

The curved end A fits into the hole at the bow, the other end going into the hole at the stern, thus forming a fixed and firm support along the length of the boat. Several perforations will be noticed along the upper surface of the saddle beam. These are for the reception of the handrail supports, which occupy different positions, according to the different widths of the bridge. That marked (i.) is used in the light foot-bridge, whilst (ii.) is for the two "chess table" bridge, and (iii.) for the three "chess table" bridge.

The two unnumbered perforations are for the supports when the "chess tables" are used with the half-boat.

The weight of the saddle beam is about 20 kg. It can also be used as a shore transom, being sunk slightly into the ground, and made fast to six pickets.

(*c*). *The "Chess Table."*—The pine "chess table" (*Fig.* 4) forms the superstructure. It is made in such a way as to dispense with the necessity of ribands, and is 4 mètres long, 1 mètre broad, and consists of three ·14-mètre × ·04-mètre road-bearers, with chesses screwed on. The chesses are of pine, ·02 mètre thick. The weight of the table is about 92 kg. The two outer road-bearers fit on to the saddle beam with claws, and the centre one with an iron attachment. When used in raft, the claws fit on to the gunwales of the boat. When two or more "chess tables" are alongside each other, the centre road-bearer is clamped to the saddle beam by means of the eyes on the iron attachment. The chesses are screwed to the road-bearers, as nails are liable to drop out.

(*d*). *The Intermediate Support.*—The intermediate support (*Fig.* 5) is used, in two and three "chess table" bridges, for fastening them together and bracing the road-bearers. It is made of pinewood, is 3·15 mètres long, 1·08 mètres deep at the middle, ·06 mètre at the ends, and ·065 mètre wide. For fixing it to the "chess table" there are two single and two double hooks. The hooks grip the top of the "chess table," and are tightened up by means of bolts with wing nuts. Accidental unscrewing is guarded against by means of a ring clip. The weight of the support is about 44½ kg.

(*e*). *Handrail Support.*—The handrail support (*Fig.* 6) is made of ash. It is 1·19 mètres long, 1·3 mètres to the end of the iron shoe, and is ·05 mètre square. At its upper end it is provided with an iron ring for threading or fixing the handrail, whilst at the lower end the iron shoe is pointed, and fits into holes in the saddle beam. In a raft it fits into holes in the gunwale, and its weight is approximately 1·75 kg.

(*f*). *Anchor.*—The anchor weighs about 30 kg., and consists of two

flukes, and a movable stock fixed at right angles to the shank, so as to prevent the flukes from resting flat on the ground without getting any hold.

The anchor is used for keeping the floating piers in position. Its weight, although slight compared to that of the bridge train anchors, is, however, sufficient, under ordinary circumstances, for the light steel boats. If a heavier anchor is required in exceptionally swift-flowing waters, two

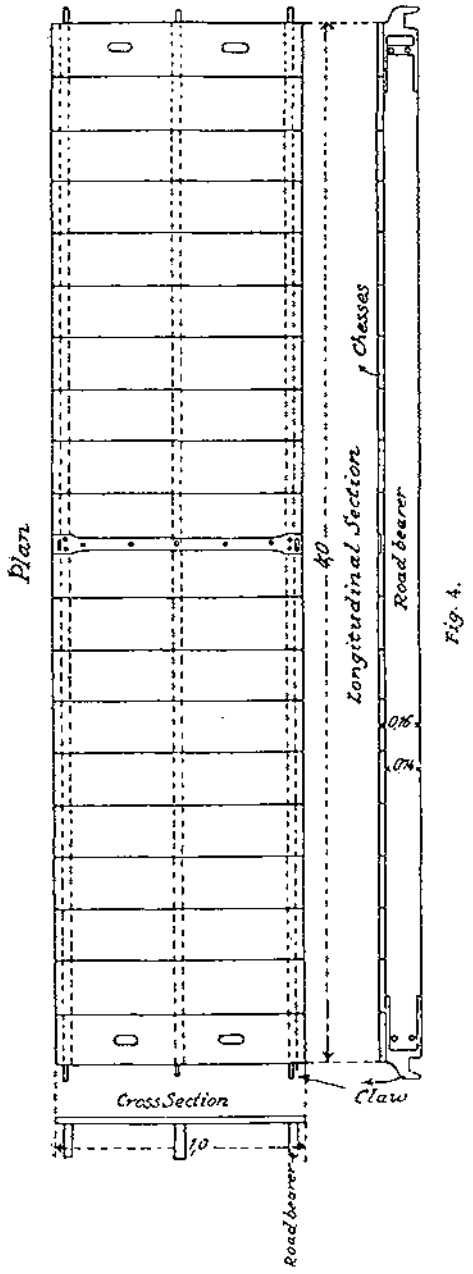


Fig. 4.

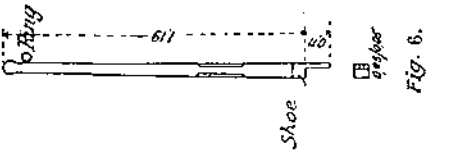


Fig. 6.

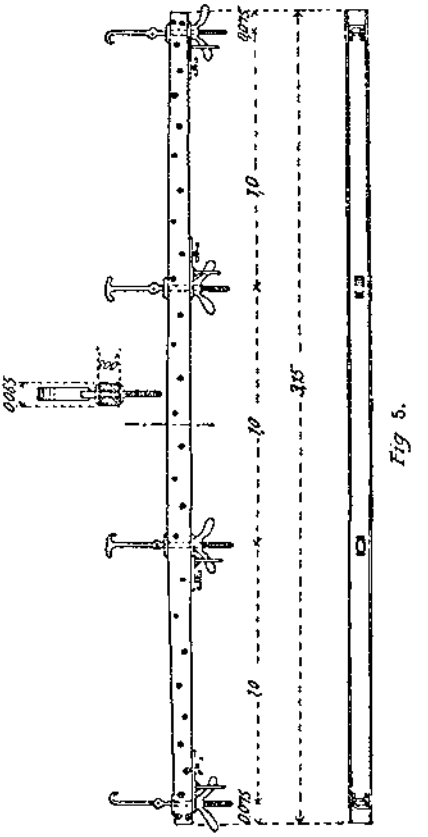


Fig 5.

anchors can be coupled together. The anchor of the collapsible boat equipment only weighed 22 kg., but dragged continually.

(*g*). *Cordage.*—The anchor cables, 35 mètres long, are only half the length of the collapsible boat cables. The size of the ropes has not been altered, and is ·015 mètre. The weight is 6·6 kg., *i.e.*, only 2·8 kg. less than the collapsible boat equipment cables. The reason for this is that the new cables are more tightly spun, and contain a greater quantity of hemp.

The ropes, used for the handrails and for lashing the boats together, are 6·5 mètres long, and ·01 mètre in diameter, and each weighs 5 kg. The remaining lashings are of rope ·008 mètre in diameter, cut in lengths of 2·5 mètres, and weighing ·16 kg. These lashings formed no part of the collapsible boat equipment.

(*h*). *Oars, etc.*—The oar is made of fir, and is in one piece. It is 3 mètres in length, embracing handle, boom, and blade—the latter being shod with a brass band on its rounded end. The oars weigh about 4 kg.

The iron crutch has a cylindrical stem and two prongs—weight about 4 kg.

A fir pole, 4·2 mètres long, is carried. Its mean diameter is ·05 mètre, and it has one blunted iron-shod end. It is divided into ·25-mètre intervals for measurement purposes, and its weight is about 35 kg. No boathook is provided, and the pole cannot be used as such.

(*i*). *Shore Picket.*—The shore picket is made of ash, and is 5 mètres long, and ·006 mètre in diameter. It is pointed and shod with iron at one end, and the other end has an iron ring let in. Its weight is about 5 kg.

2. PACKING OF THE STEEL BOAT EQUIPMENT.

Special 4-horsed wagons are used (*Figs.* 7 and 8) for carrying the equipment. A cavalry regiment is equipped with two of these wagons, loaded with :—

4 steel half-boats.	12 shore pickets.
8 chess tables.	6 saddle beams.
6 handrail supports.	4 intermediate supports.
12 oars.	2 anchors.
8 poles.	12 crutches.
16 handrail and connecting lashings.	4 cables.
	8 short lashings.

Figs. 7 and 8 show how these stores are carried. It should be specially noticed how accessible everything is; any portion of the equipment can be got out without any great dislocation of the remainder. The stores carried are as under :—

In the fore-carriage recess "A"...	Wagon equipment and stores.
In the space "B"	Bridge equipment.
In the well "C" behind the axle...	Half the demolition equipment, bridge and boat small gear.
Under the box seat "D"	A large forage sack with four 1-day's rations.

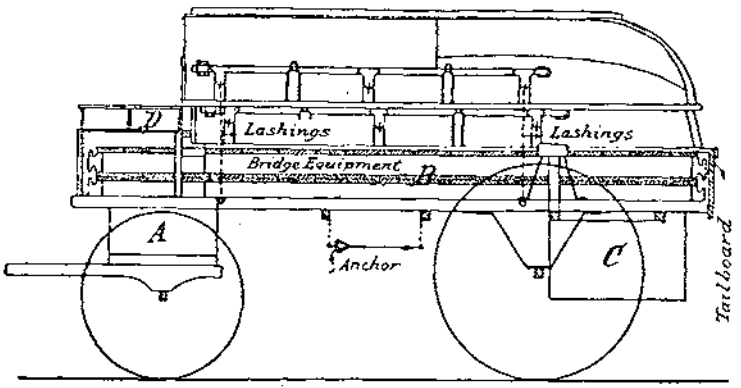


Fig. 7.

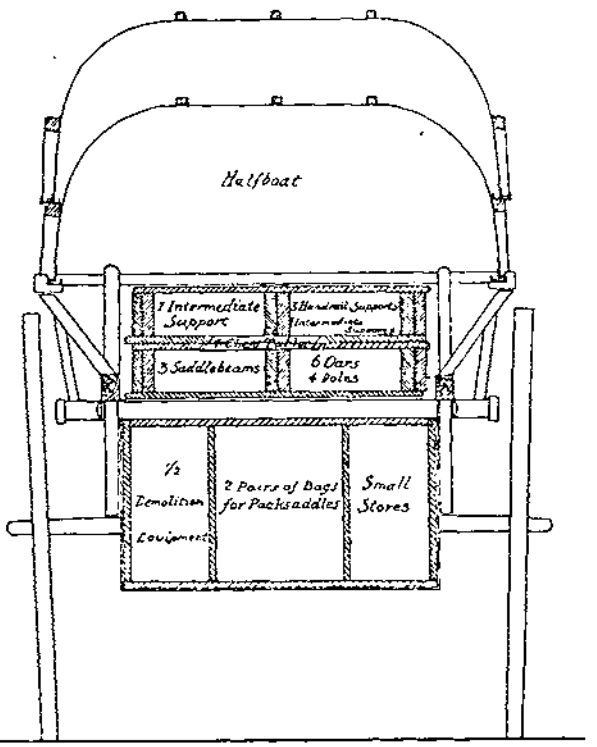


Fig. 8.

In cases where the site or type of bridge have not been fully determined, a depôt* should be established on the bank at the water's edge near the probable site (*Fig.* 9). The stores are unpacked, and for this purpose two

* The author in a footnote objects to the use of a foreign word like "depôt" in an official German publication, and suggests several words that might have been adopted without borrowing.—*Translator.*

detachments are told off. One detachment, consisting of one N.C.O. and eight men, unloads the boats, boat and anchor gear, and saddle beams. The second detachment, of one N.C.O. and four men, unloads the rest of the bridge equipment. The boats are at once placed in the water, and made fast to the shore. The requisite number of chess tables and intermediate supports are placed upstream of the line of bridge, and the remaining stores are placed downstream. The same order of laying out the stores should be always strictly adhered to, to facilitate work when darkness has set in.

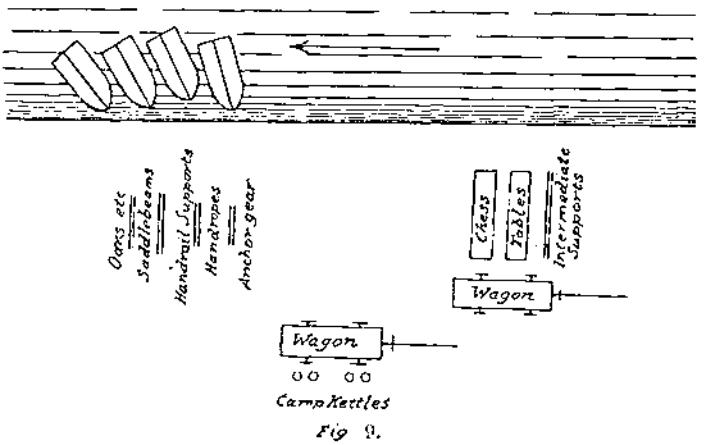


Fig 9.

If a bridge is to be thrown across immediately, the wagons, on their arrival at the site, should be brought up facing upstream, and no special depôt need be formed. The stores, to be used in the bridge or raft, are then unloaded by the bridge detachment, and it is unnecessary to tell off special unpacking detachments. No unnecessary stores are to be unpacked.

Before a bridge or raft is broken up, the wagons must be transported across to the far bank. As, in unpacking, the boats were the first to be taken off, so, in packing, they are loaded last. The wagons should be placed facing downstream, and the half-boats are placed over each other as soon as they are brought out of the water, and before they are placed on the wagon.

3. METHOD OF ANCHORING STEEL BRIDGES.

A good anchorage is essential, so as to furnish the necessary rigidity of a steel boat bridge against both current and wind. The method adopted depends on width of stream, velocity of current, and nature of river bed. *Fig.* 10 shows a way of anchoring a short footbridge, the cables being fixed on shore. *Fig.* 11 shows how a long three chess table bridge can be anchored. This bridge absorbs the equipment of six cavalry regiments, *i.e.*, a cavalry division. The main anchorage of this bridge is in the water, and each boat is attached to an upstream and a downstream cable. In order to cross such a bridge as rapidly as

possible, it is recommended that the horses be swum alongside the bridge. If this is done, the downstream anchor cables must be removed. If, however, the wind is strong, in comparison to the current, so that there is a danger of the bridge bulging on the upstream side, the horses had better not be swum.

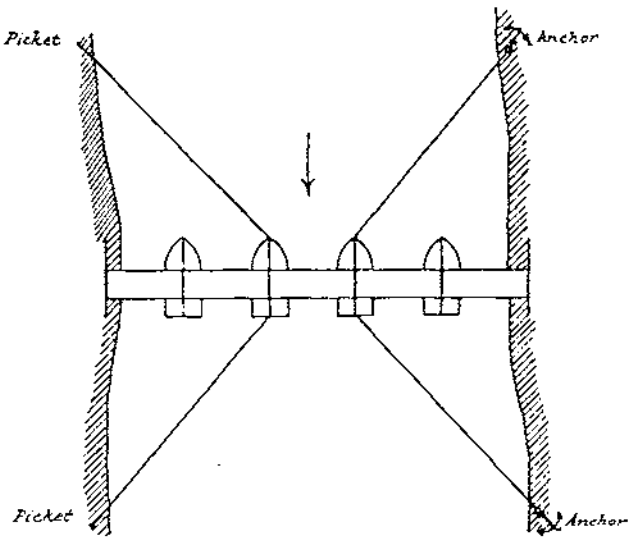


Fig. 10.

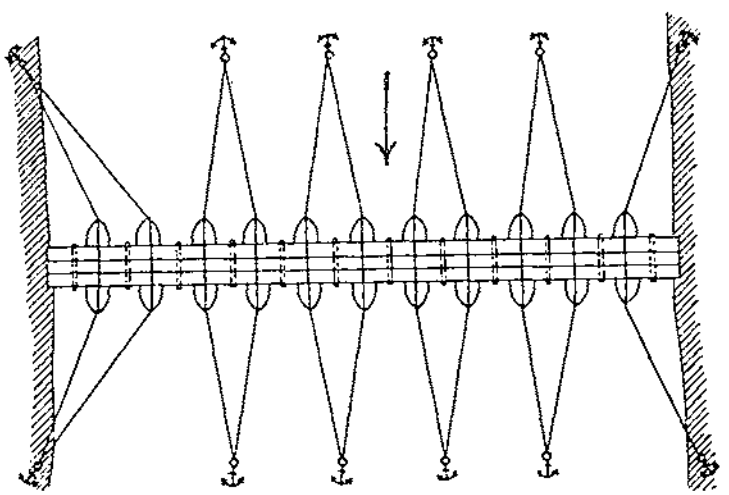


Fig. 11.

Experience has shown that the dragging of anchors, on account of the flukes not getting a sufficiently firm hold of the bed, is not solely due to lack of weight of the anchor, nor does such dragging happen to the upstream anchors only. It is more often the case that, in the gravelly beds of streams with strong currents, the whole bed is shifted bodily

downstream, taking the anchor with it. Dragging of the anchor can always be noticed by the slackening of the cable, and this must be carefully watched for.

Cables can be fixed to a picket on shore, instead of making use of an anchor.

4. DIFFERENT FORMS OF BRIDGE.

(*a*). *Footbridge* (*One Chess Table*).—The light footbridge (*Fig.* 10) is used for transporting the men with their saddlery and kit, horses being swum across, guided by a lance, close to the bridge on the downstream side.

This is accomplished as follows:—The arm band is placed between the two upper pennon rings, and then fixed on to the throat lash ring of the halter, so that the point of the lance projects about ·2 mètre beyond the side of the horse's head, thus avoiding risk of injury to the latter. When swimming horses in this manner, two men in the water must lead the horse into the water until it no longer offers resistance to the man with the lance. The man with the lance must conform to the movement of the horse, and a judicious use of the whip from the bank will appreciably expedite the operation. This form of bridge is, as a rule, only applicable in slow-flowing streams, and only half-boats are used. The bearing* is 4 mètres, and is the same in all bridges, being regulated by the length of the chess table. Before being put into bridge, every half-boat is equipped with one oar, one crutch, one handrail support and line, and the saddle beam is placed in position as support for the chess tables.

With the regulation bearing of 4 mètres, a cavalry regiment can, therefore, with its four half-boats, form a bridge 20 mètres long, using five chess tables and the half-boats as piers.

With the above form of bridge a special shore transom is not necessary, the shore ends of the chess table being stuck in the ground.

When, owing to the depth of the water, all four boats cannot be used, or such a length of bridge is required as to use all eight chess tables, *i.e.*, 32 mètres, improvised piers must be constructed. For this purpose piles of the simplest nature are sufficient, and two piles, driven into the ground 1·8 mètres apart, will fulfil all purposes. A saw-cut is made in the head of each pile, as shown in *Fig.* 12, and the saddle beam placed in the notches and lashed.

(N.B.—This bridge would require seven saddle beams, whereas only six are carried.—*Translator*).

The use of iron bands, for fixing the saddle beam on to the head of the piles, is not recommended, as they tend to damage and shorten its life.

The bracing of the piles is to be done in as simple a manner as possible (*Fig.* 13). They must, however, be braced, in order to prevent swaying of the bridge during the passage of the troops. These improvised piers must be 4 mètres apart.

Additional work may sometimes be required on marshy banks, involving the laying of chesses, or even bridging with small trestles or cribs.

* The expression bearing has been used according to the latest instructions instead of span. Bearing is accordingly the distance between the centre of the supports.

(*b*). *Bridge with Two Chess Tables.*—The bridge in *Fig.* 14 can be constructed with three floating piers, *i.e.*, one half-boat, one complete boat, one half-boat, and eight chess tables, *i.e.*, the equipment of one regiment. This bridge is 16 mètres long and 2 mètres wide. Led horses can cross the bridge in single file with intervals; men in file breaking step; and light unloaded vehicles can be drawn over by hand.

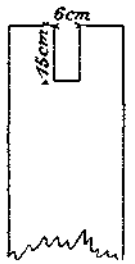


Fig. 12.

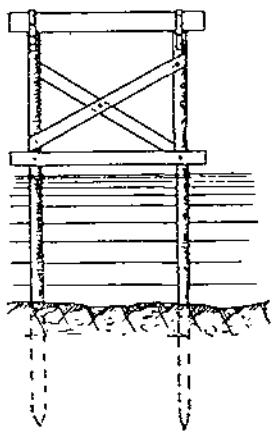


Fig. 13.

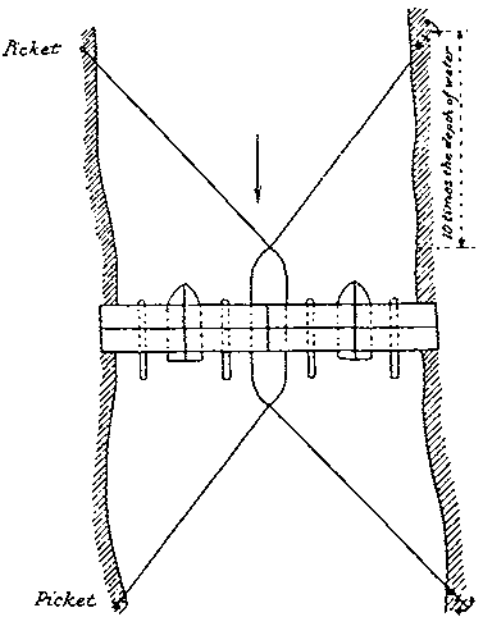


Fig. 14.

The two rows of chess tables are joined together, in each bay, with an intermediate support. As in the light bridge, no shore transom is required, but six shore pickets must be driven against the end of the chess table to keep it in position.

(*c*). *Strengthened Bridge* (*Three Chess Tables*).—In building the strengthened bridge (*Fig.* 11) only complete boats are to be employed. Ridden horses, in single file, can cross this bridge, also infantry in fours at double interval and breaking step. Also a field gun, ammunition wagon, S.A.A. carts, and light baggage carts can cross. All vehicles to be at 10-pace intervals, and limbered vehicles to be unlimbered.

It is only by strictest compliance with these instructions that the full utility of the bridge will be preserved. It is true that the carrying capacity is sufficient to support a heavier load for a short time, but a slight gain of time, enjoyed by the first troops, would be more than counteracted by the lack of stability of the bridge later on.

It is in crossing these bridges that the impetuosity of the cavalry soldier must be checked by wise moderation, for, the more quietly the operation is carried out, the greater will be the order, and the quicker the passage.

The superstructure consists of three rows of chess tables, kept together by intermediate supports. The more complicated the bridge, the more the various parts are apt to shake loose, if the greatest order is not preserved while crossing. In exceptional cases the bridge equipment of a regiment can be used for building "three chess table" bridges, 8 and 12 mètres long (*Figs.* 15 and 16).

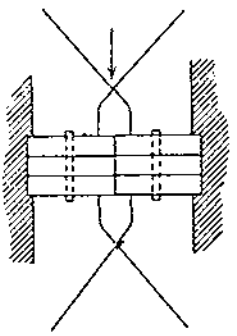


Fig. 15.

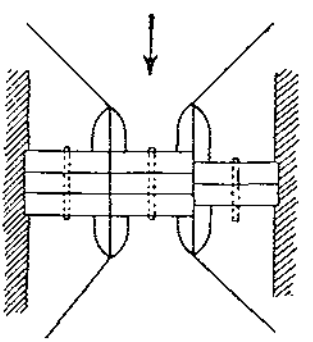


Fig. 16.

In the 12-mètre bridge, one shore bay is formed of two chess tables only, laid with their intermediate support centrally to the bridge. In a similar manner, when the equipment of several regiments is used, should there be an insufficient number of chess tables, the two shore bays can be formed with two chess tables.

Such bridges can be used by cavalry and infantry as two chess table bridges, and as strengthened bridges for vehicles.

Very often the bridge equipment can be used to advantage for crossing broad ditches with steep sides or soft bottoms.

A cavalry division has sufficient equipment to construct

120-mètre light foot bridge,
96-mètre two "chess table" bridge,
or 48-mètre strengthened bridge;

but only the last of these gives full security along the whole length.

A 120-mètre bridge can be built, but it is not well adapted for the passage of troops on account of its great swaying, since its design presupposes a sluggish stream. In a moderate current so long a bridge would simply capsize, owing to want of rigidity. Even the 96-mètre bridge calls for the greatest caution.

The question of only using complete boats, and of making up the other piers out of trestles, depends on circumstances, such as the supply of local material.

(N.B.—The maximum measurements given above are difficult to reconcile with the equipment carried.—*Translator*).

5. RAFTS.

In forming rafts with the equipment, only complete boats are to be used, the superstructure consisting of four chess tables and the saddle beams being dispensed with. Each complete boat is equipped with one pole, three oars, three crutches, two handrail supports, two handrail lines, and four lashings.

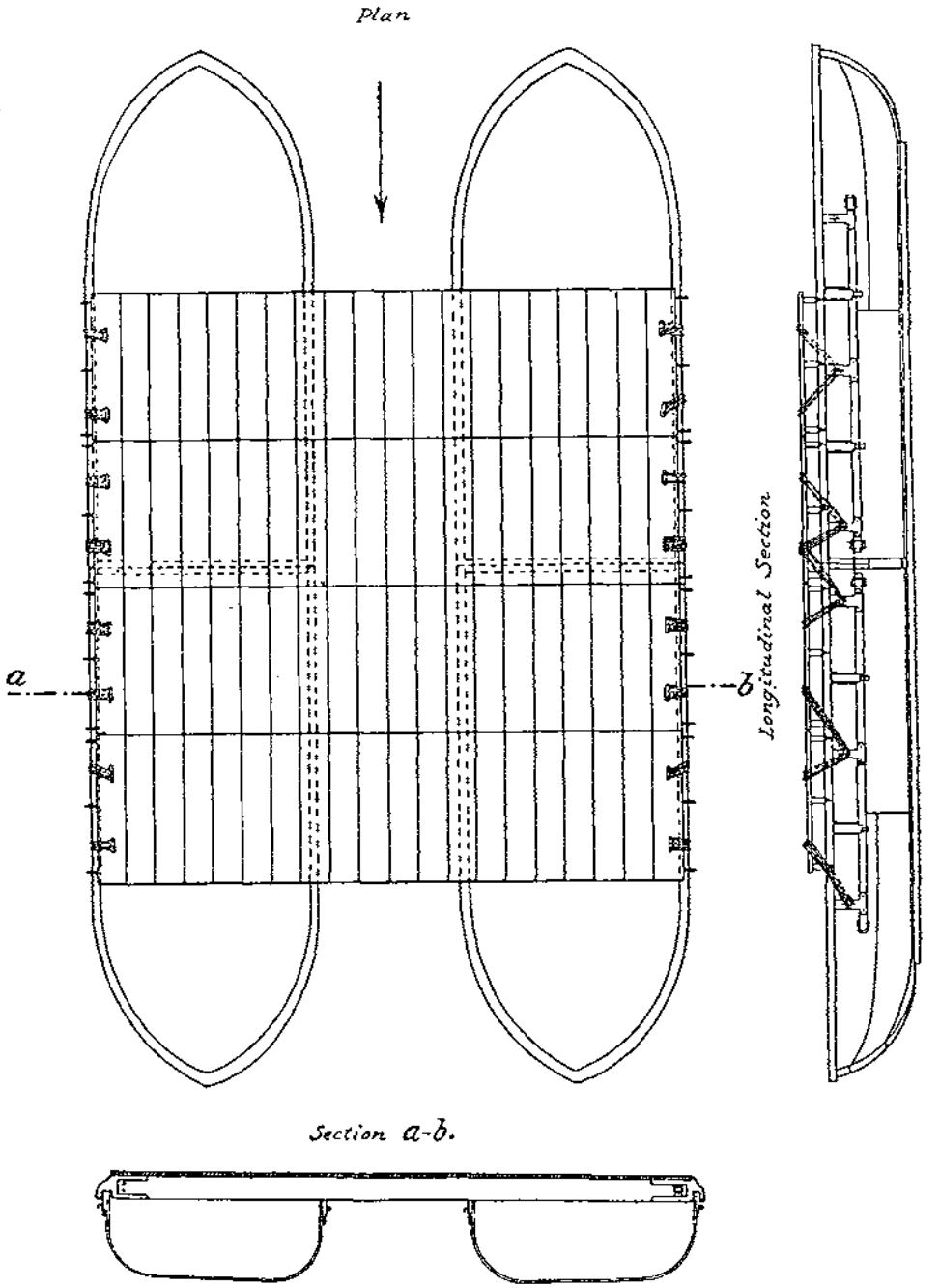


Fig. 17.

The chess tables are lashed (through the hand holes in the outer chesses) to the hooks on the outside of the boats. The outer bearer of the centre upstream chess table fits over the gunwale of the downstream half-boat (*Fig.* 17).

The lashing must be done with the greatest care, as the whole stability of the raft depends on it, and the lashings must be frequently looked to, and any slack immediately taken up. As a rule, a special landing stage is not required, that is to say, when only a horse and its rider are dealt with, but where guns or wheeled traffic have to be off-loaded, a gangway has to be constructed out of the surplus chess tables.

In this case the chess tables are fixed on to a saddle beam on shore, and the off-shore ends hooked on to the shore gunwale of the raft on arrival.

The gangway chess tables are joined together by an intermediate support (*Fig.* 18).

A cavalry regiment has sufficient equipment for one raft, and the construction of a two chess table gangway on each bank.

If the equipment of several regiments is available, and the raft cannot approach sufficiently close inshore on account of want of water, a floating pier will have to be constructed out of the surplus bridge equipment (*Fig.* 19). In calm water rafts can be got across by means of the poles or oars, but if there is a sufficient current, the raft can be used as a flying bridge, necessitating a transverse cable, the current supplying the necessary power. This is done as follows:—

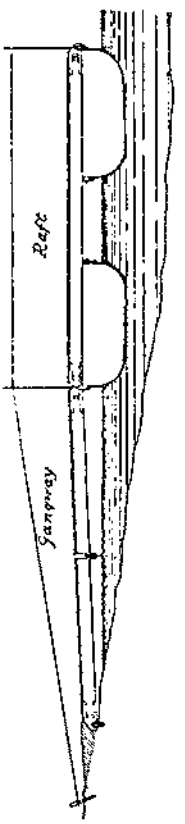


Fig. 18.

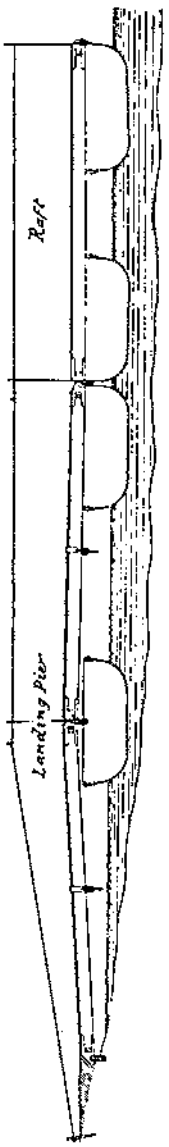


Fig. 19.

If a raft, attached to a cable crossing a stream, is kept at an angle to the direction of the current, the raft will move straight across the river in the direction of the bows of the upstream boat. The motion is caused by the pressure of the current on the sides of the raft, as long as it

remains in its proper position. This position is maintained either by steering with the oars, or by means of double ropes. These ropes are attached to the cable with a running noose, and held, by hand, in the bows of the boats. By drawing in or letting out these ropes, the raft is kept at the correct inclination.

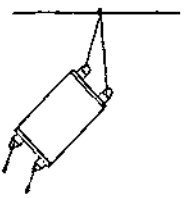


Fig. 20.

With the steel boat bridge equipment, a rope is stretched taut over the river and firmly fastened, on each bank, to a tree or stout picket, care being taken to keep it as taut as possible. The raft, at the correct inclination to the current, is moved across the stream either by direct pull or by means of a roller on the rope and bridle reins (*Fig.* 20). The use of the raft, as a simple ferry, is only possible in very weak currents, and the raft is then pulled across the stream by men on either bank.

6. Organization of Work.

For building the light bridge, the working parties are detailed as follows:—To each half-boat a crew of two, or one N.C.O. and eight men for the equipment of a regiment. In addition, a carrying detachment (for the equipment of one to three regiments) of one N.C.O. and four men is required.

When orders are given to construct the bridge in double time, the carrying detachments are to be increased, and special unpacking detachments added. An adequate reserve is also to be provided whenever special works have to be carried out, such as the formation of approaches and the erection of trestles.

In the case of the two chess table bridge, the men are told off as follows:—

A crew of two men to every half and complete boat, and consequently for a complete regiment one N.C.O. and six men (*Fig.* 14).

Two carrying detachments, four men each (for the equipment of one to three regiments), and a suitable reserve for special work.

For strengthened bridge, the crew for each boat is also two men, consequently one N.C.O. and four men per regiment. Three carrying detachments, four men each (for the equipment of one to three regiments), and a reserve for special work. In building an 8 or 12-mètre strengthened bridge (*Figs.* 15 and 16), 20 minutes should be allowed, and one hour is sufficient, if the whole equipment of a cavalry division is utilized, in forming a similar bridge, 48 mètres in length.

The quicker the wagons can be unpacked, the quicker will be the bridge completed. The time should, however, not be underestimated, as frequently the approaches, etc., take up more time than building the bridge itself.

In this respect an officer's patrol sent ahead to reconnoitre the point of passage is of considerable advantage.

7. CAPACITY OF THE EQUIPMENT.

The buoyancy of a complete boat is sufficient for 10 infantry soldiers with equipment, or eight cavalrymen with saddlery and equipment.

(a). Complete Boat Bridge.

Equipment of ? Regiments.	No. of Complete Boats.	Buoyancy.		Remarks.
		Infantry with Equipment.	Cavalry with Saddlery and Equipment.	
1	2	20	16	(1) Crew (1 coxswain, 2 rowers) not included.
2	4	40	32	(2) With strong wind and rough water these numbers are to be reduced.
3	6	60	48	
4	8	80	64	
5	10	100	80	
6	12	120	96	

(b). Rafts.

Equipment of ? Regiments.	No. of Rafts.	Buoyancy.				Remarks.
		Infantry with Equipment.	Horses and Horseholders.	Saddle Equipment of Cavalrymen.	Guns and Gun Numbers or Transport Vehicles.	
1	1	30	4	50	1	(1) Crew (1—2 coxswains and 4 men for each raft) not included.
2	2	60	8	100	2	(2) With strong wind and rough water these numbers are to be reduced.
3	3	90	12	150	3	(3) For the construction of landing stages each regiment has 4 chess tables and 6 saddle beams available. If boats are required for landing piers, then the number of rafts has to be decreased.
4	4	120	16	200	4	
5	5	150	20	250	5	(4) Horses are only to be put on rafts as quite an exceptional measure.
6	6	180	24	300	6	

(c). Lengths of Bridges.

Equipment of ? Regiments.	Light Foot Bridge.		Two Chess Tables.		Strengthened Bridge.			Remarks.
	Floating Piers only.	Employment of all Chess Tables with Trestles added.	Floating Piers only.	Employment of all Chess Tables with Trestles added.	Floating Piers only.	Employment of all Chess Tables with Trestles added; all Bays 3 mètres wide.	Employment of all Chess Tables with Trestles added, with one or both Shore Bays 2 mètres wide.	
	Mètres.	Mètres.	Mètres.	Mètres.	Mètres.	Mètres.	Mètres.	
1	20	32	16	16	8(2)	8	12	(1) One half-boat not used.
2	36	64	24(1)	32	20(3)	20	24	(2) Complete boat not used.
3	52	96	36	48	28(3)	32	32	(3) The length of the bridge is reduced by 4 mètres if a complete boat is used as an anchor boat or for protec ive and salvage work.
4	68	128	48	64	36(3)	40	44	
5	84	160	56(1)	80	44(3)	52	56	
6	100	192	68	96	52(3)	64	64	

"Cavalry far ahead—Reconnaissance!" With these four striking words our great Moltke emphasized the first duty of cavalry in war; and this exhortation applies not so much at the beginning of, but rather for the whole campaign. To fulfil this duty the cavalry is called upon to act independently of other units, and must, therefore, be self-contained. To accomplish this, the whole equipment of cavalry must be as far reaching as its weapons. But it can never successfully fulfil its *rôle* in the domain of war if it lacks a comprehensive technical training, enabling it to carry out its allotted task in the field, pre-eminent amongst which is the crossing of rivers by means of regular or improvised equipment.

The new steel boat equipment has presented the German cavalry with an incomparable weapon for accomplishing this object, excelling all other field equipments by the simplicity of its construction. Its weight is insignificant, its stability unimpaired, and it is undoubtedly superior to the collapsible boat.

The whole equipment of the steel boat bridges is not only more durable and easier to transport, but it is more easily handled. These facts are firmly established when the steel boat is compared with the collapsible one.

May our cavalry only do full justice to the new equipment.

G. H. Fowke.

NOTICES OF MAGAZINES.

Memorial de Ingenieros.

September, 1907.

Sappers and Miners: The Fourth Arm.—By Major D. Ricardo Burguete.—The Japanese were the first to make use of their engineer troops as a true fourth arm. Even before the war in Manchuria one battalion of engineers was attached to each division, a proof of the importance they attached to the use of this arm. The corps played its part in this campaign with the greatest success, and the author of this article desires to point out the still greater part it is destined to play in the future, not merely in the defence, but also on the offensive.

In the attack, the engineers have two duties to perform:—(*a*). To prepare the infantry assault in that zone in which the artillery is unable to co-operate, and (*b*) with the aid of mines, after the assault has been delivered, to confer offensive power on those sections of the position which, for topographical or tactical reasons, are considered to be weak.

With regard to (*a*), when the time has come to assault the enemy's position, and the attacker has come to such close quarters with the defence that his artillery is no longer able to assist him, he is in need of something to help him in crossing the last few yards, and this assistance can be given him by the engineers, who will hurl explosives against the enemy's position.

With regard to (*b*), weak flanks may easily be made strong by the use of mines, and points in the line of battle, which are subject to such heavy fire that it is dangerous to assemble many troops upon them, may be strengthened in the same manner.

Ground taken from the enemy may be mined, and then abandoned, with the intention of blowing him up when he again reoccupies it.

The author considers that the Spanish race is specially well adapted to supply sufficient sappers with the nerve and daring necessary for taking an active share in the attack, and, though an infantry officer himself, he seems to have the highest opinion of the corps and of its future.

The Ministry of War in the Madrid Industrial Exhibition (*concluded*).—The General Staff exhibited an interesting and varied collection of maps and plans, which included Claudius Ptolemy's *Eight Books of Geography*, published at Rome in 1535, and several rare seventeenth century maps of the West Indies and America, as well as the $\frac{1}{200000}$ Military Itinerary Map of Spain, which is not yet completed, the new $\frac{1}{5000}$ map of the Pyrenees reduced to a scale of $\frac{1}{200000}$, a reduced

map of the Campo de Gibraltar, 14 sheets of the new map of Morocco, with plans of Marrakesh, Mepnes, Larache, Tangier, and various Riff Kábilas.

The Artillery Museum, which possesses one of the finest collections of arms in Europe, made a good exhibit, over 80 in number.

The Corps of Engineers exhibited models of various fortresses, such as Bilbao, Gerona, and Melilla, and of the Danish bridge train which has been recently adopted in the Spanish service, and which has the reputation of being amongst the best in the world.

THE AUTOMOBILE SERVICE IN OUR ARMY.—By Capt. D. Ricardo Goytre.—The first motor cars in the Spanish Army were a 12 and 24-h.p. Peugeot, which the Marqués de Puerto Seguro presented to the 2nd Regiment of Sappers and Miners in September, 1903. The first of these was made in 1898, and took part in the Paris-Ostend race in 1899, in which it took first place. Though of so early a type, it is still running well. The 24-h.p. machine was made in 1900, and at that date was considered a very powerful car; owing, however, to faults in the design, it was always breaking down, and was never so reliable as the earlier model. The present article, which is to be continued, contains pictures and diagrams of both cars, which are of some interest to those who care for the archæology of motorism.

MILITARY REVIEW.—Opinions of Capt. Mahan and Mr. S. Sims on war vessels and marine artillery, deduced from the Russo-Japanese War. This is a summary of articles which appeared lately in the *Proceedings of the United States Naval Institute*. Capt. Mahan's opinion is that the superiority of the Japanese resulted from their choice of their position in respect to the presumed objective of the enemy, and not to the superior speed of their ships, which speed does not constitute an essential advantage either from the tactical or the strategical point of view. By this he does not mean that speed is valueless, but that it is not to be aimed at at the expense of armament. He further considers that the suppression of guns of medium calibre is a retrograde step.

Mr. Sims, who is the United States inspector of artillery, combats both these views, and is a vigorous upholder of the fast, one-calibre battleship of the *Dreadnought* type.

'M.'

REVUE DU GÉNIE MILITAIRE.

January, 1908.

THE INFLUENCE OF THE SIEGE OF PORT ARTHUR ON THE CONSTRUCTION OF FORTS.—*A continuation of the previous articles.*—The proper *rôle* for a fort is to defend both itself and the intervals on either side of it. It should be regarded as a point of support, which enables the garrison of the fortress

to manœuvre and make counter-attacks in its vicinity. In order that a fort may fulfil its destiny, it should be able to command, with its guns, the obstacles on its front and flanks, and, in addition, obstacles, guns, and garrison, should be so shielded that the enemy cannot destroy them with his artillery. The advent of the gorge caponier, from which the intervals on either side may be flanked by infantry and machine-gun fire, marks an epoch in fortress warfare.

It is a great mistake to provide a fort with guns heavy enough to engage the besieger's artillery. Where heavy guns are mounted in a fort, the besieger can bombard them day and night, with the satisfaction of knowing that even if he is not harming the guns, he is inflicting losses on the infantry garrison. By mounting the heavy guns outside the forts, it is possible to conceal their positions.

The writer discusses the design of Ehrlong Fort, and its defects. Four large guns were mounted in a battery in the centre of the fort. These guns offered an easy target, and the Japanese were consequently able to silence them whenever they pleased. The right flank of the fort was enfiladed from Takushan, and the left from Wolf Hill. To obviate these defects, traverses were constructed along the flanks at intervals of 12 feet, and finally the spaces between were roofed in with boards covered with earth. The interior of the fort was not drained; consequently the rain-water ran into the counterscarp gallery through the tunnel under the ditch. The only exit from the gallery then lay through some very narrow embrasures.

The casemates, which were built under the gorge parapet, had been designed for a company at peace strength. The garrison consisted of a company at war strength, and was often reinforced by a second one. Caponiers, counterscarp galleries, and gun shelters had then to be used as barracks. There were no means of lighting or ventilating the galleries and casemates, and the whole condition of the fort was most insanitary. There were no officers' quarters.

A defect, which was very severely felt, was the absence of a covered passage from the gorge casemates to the front parapet. When the fort was under fire, the garrison of the front parapet were completely cut off from their food and water supplies. Finally, it became necessary to dig a zigzag communication trench from the gorge to the front parapet, and even this gave only indifferent cover. The exit, from the gorge casemates into the fort, was not properly defiladed, and many losses occurred at this point.

Another defect, that made itself apparent, was the absence of proper shelters for the guns destined to repel assaults. Two such shelters existed, but the ramps leading out of them were too steep (1 in 4); consequently the guns were always left in position, and the shelters were handed over to the infantry. The shelters should be on approximately the same level as the guns, and as close to them as possible.

The artillery armament of a fort should consist entirely of guns to repel assaults. These should be small calibre—1½ inches is big enough—quick-firing guns of the latest pattern. Their duty should be to destroy bullet-proof shields and any hasty cover that the enemy may erect. In

addition there should be a large number of machine guns. These are particularly useful for flanking ditches and the intervals between the forts. Each machine gun should have an observer allotted to it.

The proper position of the casemates for the garrison is under the gorge parapet. The casemates should each have two exits into the fort, and two into the gorge ditch. At Ehrlong—where there was only one exit into the fort and one into the ditch—both became blocked at the same moment, and the whole garrison was thus captured. In addition, there should be an underground passage, connecting the gorge casemates with the shelters under the front parapet, also an underground passage leading out of the fort; and the mouth of this passage should be thoroughly defiladed from the enemy's fire. During the bombardment of Ehrlong, the ground in rear was so swept by the enemy's fire, that it was impossible for messengers to enter or leave the fort, and when reserves were despatched to reinforce the garrison, the majority of them never reached the fort at all.

A bombproof shelter for the relief on duty must be provided under the centre of the front parapet. It should be similar to, but smaller than, the gorge casemates. An exit into the fort must be provided, and, in addition, there must be galleries connecting the shelter with the gun shelters. In the roofs of these galleries openings covered with metal shields should be provided, through which the garrison can reach the banquette.

All parts of the fort should be connected by telephones, the most important connection being that between the look-out stations on the parapet and the casemates. There should also be electric bells fitted in all the casemates and shelters, which can be rung from the look-out stations, so that the alarm may be given without delay. The exterior telephonic connections have been discussed already.

At Port Arthur the thickness of all concrete roofs was 3 feet. They were intended to be proof against 6-inch shells, and events showed that they were so. The first shell would produce a crater 4 to $5\frac{1}{4}$ inches in depth and diameter; a second falling in the same place would increase the depth by $1\frac{1}{4}$ to 2 inches, and the diameter to 2 feet; it would also detach flakes of concrete, 1 to $1\frac{1}{2}$ inches thick, from the inside of the roof. More shells aggravated the damage, and produced fine cracks in the concrete. The most serious damage occurred at the edges and corners of the concrete structures. Pieces of concrete, $\frac{1}{2}$ inch wide and $1\frac{1}{2}$ to 2 feet long, came away at each concussion. This damage could not be repaired. On the other hand, the repairs to concrete roofs and surfaces were easily carried out, generally by covering the damaged portion with earth.

The 11-inch shells, however, pierced the 3-foot concrete roofs with ease, sometimes even without bursting. The Russians attributed this to the bad quality of the concrete, but there is no reason to suppose that this was so.

The writer calculates that where concrete is directly exposed, a thickness of 9 feet will be required to resist modern siege artillery. When an earth covering can be added, the thickness may be reduced. The effect of an earth covering is illustrated by the following examples:—

1. At Ehrlong a 3-foot concrete roof was covered with 3 feet of earth. An 11-inch shell produced a crater only 11 inches deep, and some fine cracks in the concrete.

2. Over the covered passage at Ehrlong was a thickness of 3½ feet of earth, and over this again a bed of flints and rubbish, 6 inches thick. The 11-inch shells never reached, or damaged, the concrete. On one occasion a 6-inch shell burst in the crater formed by an 11-inch shell, but even then no damage was done.

The adoption of 12-inch and 18-inch howitzers by various European nations is likely to necessitate a further large increase in the thickness of concrete structures.

Experience at Port Arthur has shown that the most serious obstacle, to an assault, is a deep and wide ditch, with perpendicular sides. When such a ditch is flanked efficiently, it becomes impassable. Even the Japanese never attempted to make an assault across ditches of this nature. Where the ditches had been cut in rocky soil, the besieger's artillery was unable to do any appreciable damage to the escarp. There can be no doubt that the modern V-shaped ditch and steel railing is a very inferior obstacle. Even if the enemy's artillery does not destroy the railing altogether, it buries it in the *débris* brought down from the escarp and parapet.

Lieut.-Colonel von Schwartz considers that vertical escarps and counterscarps are a necessity. The escarp wall should be of concrete, and made especially thick at the top, where the enemy's shells can reach it. The ditch should be 30 feet wide, the bottom being 9 feet deeper at the foot of the escarp than at the foot of the counterscarp.—*To be continued.*

INCLINED AXES IN TELEPHOTOGRAPHY.—A discussion of the errors produced by assuming that the optical axis of the camera is horizontal, when it is actually inclined, and the limits within which such errors are negligible.

ARTIFICIAL STONE.—Some cavalry barracks and a military hospital have been built of artificial stone at Châlons-sur-Marne. The composition was 770 lbs. of Portland cement to 14 cubic feet of sharp sand and 28 cubic feet of gravel, or broken stone. For cornices the proportion of cement was increased to 880 lbs. The cost, including laying, came to 55 francs per cubic mètre, as compared with 89 to 106 francs per cubic mètre for similar work in stone.

J. E. E. CRASTER.

THE ELECTRICIAN.

January 3rd, 1908.

STREET LIGHTING BY ARC LAMPS IN THE CITY OF LONDON.—Street lighting by flame arc lamps has made great progress, the most interesting example being the experimental lighting in the City of London. Here installations of up-to-date arc lighting are being run to show the great advance that

has been made since the days when the open type arc lamps, still in use, were first installed.

In Cannon Street, Oliver and Gilbert flame arc lamps, 28 feet high and 38 yards apart, have been used respectively for alternate lamps, and have been suspended by means of span wires, so as to hang over the centre of the street. This is undoubtedly the correct position for the lamps, both as regards efficiency and appearance, and it is likely to be adopted for future lighting.

The lamps are suspended by four span wires arranged in X form, and so designed that the failure of any one wire still allows a factor of safety of 7 on the remaining wire on the same side of the street. This means that ordinarily a factor of safety of 14 is adopted, and is sufficient to show that any fears as to the security of the lamps are groundless.

The four span wires are of steel, and two of them, which are insulated with rubber covered with a preservative braiding as a protection against the weather, serve to conduct the current to and from each lamp. All four span wires pass round insulators both at the lamps and at the supporting bolts fixed in the buildings. This provides insulation even in the case of wires which do not carry current, and it is so arranged that the breakage of an insulator does not take the stress off any wire.

The mean hemispherical candle-power of one of these lamps is 1,400. Current is obtained from the distributor mains, and the ordinary method adopted would be to run 10 lamps in series across 400 volts.

It is found that by placing the lamps at a high level, although the illumination in their immediate vicinity is somewhat reduced, the distribution of light is greatly improved. The minimum illumination in Cannon Street is very good, and surpasses that of any other street in London. The price—£17 10s. 0d. per flame arc lamp per annum—is cheaper than the present mode of gas lighting.

January 17th, 1908.

WIRELESS TELEPHONY IN THE U.S. NAVY.—Each of the battleships and torpedo boats, now cruising to the Pacific, possesses an installation of wireless telephones by the De Forest Radio-Telephone Co. During the preliminary trials at Fort Monroe, under the personal supervision of Dr. De Forest, messages were exchanged up to a distance of 15 miles, and, when the fleet sailed from Fort Monroe, communication was maintained up to 30 miles. Subsequent reports state that the apparatus was fulfilling expectations, and that the various orders between the vessels of the fleet were being transmitted by this means.

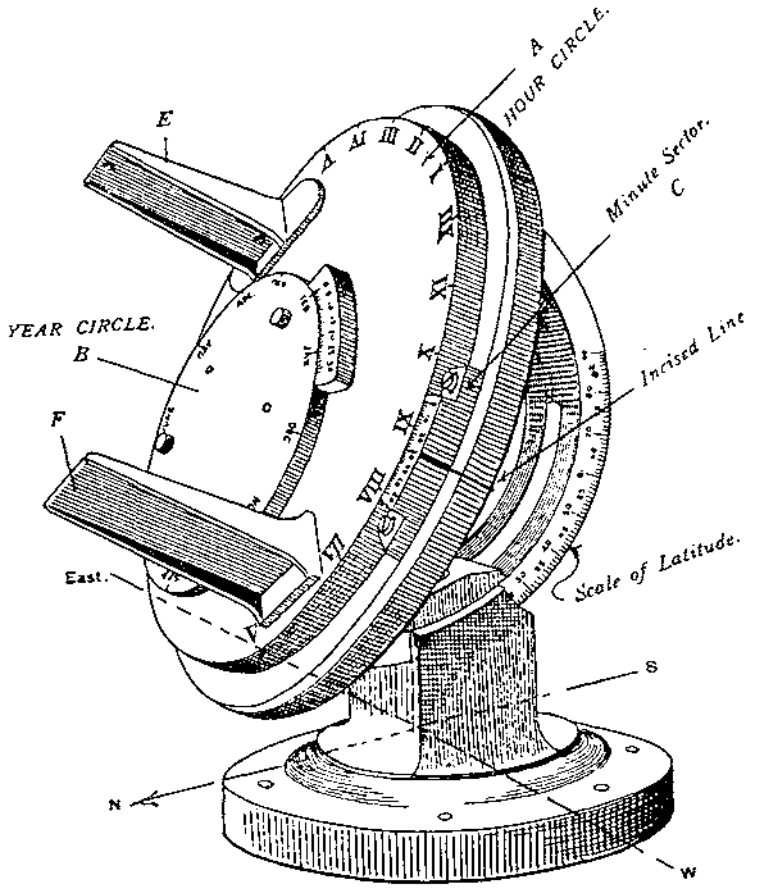
R. C. HAMMOND.

CORRESPONDENCE.

THE HELIO-CHRONOMETER.

SIR,

I beg that you will allow me, through the medium of the *R.E. Journal*, to bring to the notice of the Corps, and of your other numerous readers, a recent invention of the most interesting kind, which I have tried myself, and know to be entirely satisfactory.



It is nothing less than a sundial, which, when once set correctly, can be depended upon to give mean time correctly throughout the year whenever the sun shines (for ordinary work, of course, not for astronomical).

The sundial in ordinary use, as is well known, does not give the "mean" time of daily life. This (the helio-chronometer) does, and, moreover, if anyone should wish to know the time of day at any distant place where a friend is, a second "minute" sector, fixed with due allowance for longitude, will enable him to read off the friend's time without any calculation.

I enclose a drawing of the instrument, and directions for adjustment can be obtained from the makers. These require little to be added by way of explanation, but I would say that the base plate shown on the sketch of the instrument must be looked upon as double, the lower part being referred to as the G.R.G. plate of the instructions; this must be first levelled and fixed firmly—the upper part is a mere collar.

The six screws pass through the upper plate into holes prepared in the lower fixed plate.

Until the screws are driven home, the instrument can be turned bodily all round the compass. When the right position is found, then screw home, and your helio-chronometer will be your comfort for ever, if you care to have your clocks keep time.

I may as well add that the upright E is the gnomon of the ordinary sundial, but instead of working with shadow, the sun passes through one of the small holes shown on it, casting a miniature of itself upon F, in the centre of which is a line, and when the spot of light is bisected by the line, the time read off from the minute sector is the correct time.

The upright or gnomon E is movable, and herein is the secret of the accurate mean time. By the studs on the year circle you move it round so as not only to bring the month under the sector 1—31, but the mark of the month under the very day. This movement shifts E also slightly, and thus the compensation is provided which ensures the mean time.

It is a beautiful instrument, highest cost at present only £10 10s. 0d., much cheaper than a chronometer, and never wants winding up, and will stand all weathers, and easily true to half a minute.

The makers are Messrs. Pilkington & Gibbs, 7, Lune Street, Preston.

Your obedient servant,

E. D. MALCOLM,

Colonel, late R.E.

The Editor, *R.E. Journal.*

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