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BRIDGING AT HARTY FERRY

BRIDGING OPERATIONS AT HARTY FERRY.

By MAJOR J. C. MATHESON, R.E.

DURING the Territorial Manœuvres last summer it was necessary to arrange for the crossing of troops over the Swale at Harty Ferry. The width from bank to bank was about 1,200 yards and there was not sufficient material to cover the whole, so that it was determined to run piers from either bank far enough out to be available for ferrying at all stages of the tide. The rise and fall averaged 14′, and the slope of the foreshore was very gradual so that long piers were required. The river bed was mud of the worst description.

The piers were of ordinary construction and call for little comment, but it was inevitable that in bridging operations of this magnitude a number of lessons should be learnt by the officers in charge, which may be of some service to others.

On the south bank the pier consisted of the following :—

(*a*). 108′ of approach ramp at 1 in 12 to get up to the top of the sea wall, carried on 8 lashed spar trestles.

(*b*). 108′ of pier starting from the sea wall, carried on 9 lashed spar trestles.

(*c*). 225′ on 14 pontoon trestles.

(*d*). 130′ on 13 barrel piers.

(*e*). 450′ on 30 pontoons.

(*f*). A pier head of double pontoons, giving 30′ by 15′ floor space.

On the north side there were 195′ of approach over uneven marshy ground, the transoms being carried on small cribs. Then the pier proper consisted of the following :—

(*a*). 96′ on 8 lashed spar trestles.

(*b*). 210′ on 13 pontoon trestles.

(*c*). 160′ on 17 barrel piers.

(*d*). 370′ on 24 pontoons.

(*e*). A pier head similar to that on the south side.

Including the approach on the north side, the length of the two piers was just two-fifths of a mile.

On the west side of the piers a narrow hard ran down to low-water mark on either side. This had to be left unobstructed for the use of horse boats and the ordinary traffic of the ferry.

The working party for the operations consisted of the three works companies of the Kent (Fortress) R.E. (T.) under Major Stephens, which furnished about 150 men for work, and, after two days, 100 men of the Training Battalion, R.E. The south pier was completed by the Kent (Fortress) R.E. (T.) who also made and placed the lashed spar trestles of the north pier, the remainder being done by the men of the Training Battalion. The whole of the bridging was in charge of the staff of the Fortification School, S.M.E., which furnished 3 officers and 5 Q.M.S. instructors.

The work was carried on in daylight only, in two reliefs of about six hours' actual work each. Excluding the time taken in unloading stores, the south pier took about 4,700 man-hours and the north 3,000.

The river crossing was made use of on August 2nd, when the 4th London Brigade and some details—about 2,000 strong altogether—with 30 wagons of all sorts and 140 horses were passed over the Swale from Harty to the Faversham shore. Most of the men were ferried between the pier heads in naval launches and cutters towed by picket boats. The remainder together with the horses and wagons were conveyed on pontoon transport rafts towed by W.D. steam launch or naval picket boats.

The day was fine but a strong S.W. wind was blowing raising a considerable sea. This prevented any use of the horse boats which had been provided, and very considerably hampered the embarkation at the north pier head as the cutters and picket boats were constantly getting driven on to the pontoons, and the wind and strong tide made it very difficult to get them off. For about two hours at low water practically no ferrying could be done as every steamer was aground. The only casualties that occurred were (i.) the couplings of a pontoon of a transport raft tore out, and (ii.) a pontoon trestle leg suddenly sank 3' under a specially heavy wagon. The first necessitated the replacement of the pontoon which took some time, the second was put right in 15 minutes.

The points of interest which arose may be classified under various heads.

I.—Lashed Spar Trestles.

(*a*). The inferiority of rope lashings as fastenings was again exemplified. Many lashings required wedging up after some days and others worked so loose that the bridge became distorted, necessitating strutting and in some cases re-making.

(*b*). The legs of the trestles were placed vertically. This was done because the height was not great and the ground was so irregular that separate sections were required for each line of legs. Time was pressing, and it was a simpler and quicker matter to take accurate sections in a vertical than in an inclined plane. At the same time vertical legs have the disadvantage that any racking of the frame causes one leg to lean outwards. This would probably only happen with doubtful fastenings like rope and when it has to be used it is better to keep to the sloping legs.

(*c*). On account of the mud, double ledgers were used with plank shoes nailed to the bottom of the legs and also lashed to the ledgers. This arrangement acted well.

(*d*). The longitudinal struts were butted against pieces of sheeting driven into the mud at low tide at right angles to the line of the strut.

II.—Pontoon Trestles.

(*a*). These again proved their efficiency and handiness. The new cupped shoes are distinctly preferable to the old wooden ones.

(*b*). A few of these trestles were raised from the ground at low tide, but the majority were put into bridge by the method described below, devised by Capt. Sankey, R.E.

A raft of pontoons at normal interval, with superstructure of baulks only, was brought alongside the hard which ran out on the west of the bridge. The raft had one more pontoon than the number of trestles to be raised. Then at low tide a trestle was placed in the centre of each bay and retained in a vertical position by guys on the pontoons, the transom, which was kept well down on the legs, resting on the baulks. The roadway of the trestles was then completed. When the tide rose, the raft was warped into position at the head of the bridge and the roadway connected up. Starting from the inshore trestle the legs were then lowered to take the ground, the transoms raised, and the pontoon raft dismantled piecemeal. Where conditions similar to those at Harty obtain, *i.e.* a number of trestles to be placed, available pontoons and a convenient place for loading the raft, this method would seem to be more expeditious than any other.

(*c*). As these trestles formed part of a tidal ramp the transoms had to be raised and lowered frequently. When the tide was up, some difficulty was found in manipulating the clamping arrangements of the straps, as there is no place for a man to stand or sit where he can get conveniently at the strap ends. A boat if available can be used, but it might be possible to sling or fix permanently a seat or step on the outside of the leg at the convenient height. On this occasion a horizontal spar was lashed to uprights driven into the river bed parallel to the bridge and about 18″ from it. The spar was a little below the level of the grip-strap, and extended alongside the trestles which most frequently had to be adjusted.

III.—BARREL PIERS.

(*a*). It is noteworthy that most of the barrel piers made in the ordinary manner were in use for 20 days, and no difficulty was experienced from the slings or braces getting slack. None of them were adjusted during the operations.

(*b*). Several composite piers were used, made up as shown on *Military Engineering*, Part III., Pl. 43, *Fig.* 5. In every case these were most unsatisfactory and became so loose that they almost broke up. When composite piers of small casks have to be made up, and small casks are far more likely to be found than large ones, it is much better to place them as shown on *Fig.* 4 of the Plate referred to above.

IV.—PONTOONS.

(*a*). All the pontoons were service pattern except 3 experimental steel ones. They received a fairly severe trial. In the journeys from and to Upnor they were towed 50 miles well loaded with stores. During the rough weather of August 2nd some of those at the heads of the piers, especially on the north side, received repeated blows from cutters and picket-boats. At low tide many of them had to take the load when grounded on the mud. It was fortunately soft and of even surface. In spite of these adverse conditions the amount of damage and leakage was very small. All the pontoons performed the return journey in the water except two, namely the one damaged in the transport raft, and a very old one which sprang a bad leak.

(*b*). For conveyance from Upnor to Harty all the pontoons and casks were divided between two rafts made in the manner shown in the figure on p. 180, Part III., *Military Engineering*. The number of boats placed side by side was six, a spar was placed across the bows of the first six pontoons and lashed there, and the raft was towed on a bridle. As a precautionary measure, in case the weight of the raft proved too much for the front pontoons, a central wire hawser was prepared to which each set of pontoons was secured separately. It was not however found necessary to use this hawser. The length of the rafts made them somewhat unmanageable at times especially in shooting the narrow opening of the Kingsferry Bridge over the Swale (where both rafts bumped), but as the number of tugs was limited, it was unavoidable. On the return journey, as the bridge was broken up gradually, it was found possible and more convenient to make up rafts of six pontoons, three boats in line.

(*c*). The pontoon rafts for the transport of horses and wagons were made up in the way described in *Military Engineering*, Part III., para. 285, namely 3-boat rafts of double pontoons giving a deck space of 30′ by 30′. But this was not found to be a good plan as the centre pier naturally gets twice the load on it that the outside ones do. At Harty, during the passage of the horses, it was impossible to put up screens round the rafts on account of the wind, and the animals could not be prevented from crowding towards the centre of the deck. This reduced the freeboard of the centre pier to a very small margin and in the rough water a great deal was shipped. In one journey the strain proved too much for the bottom couplings of one pontoon, which pulled away from the side and put the pontoon *hors de combat*, necessitating that raft going out of action until the damaged pontoon could be replaced.

In cases where a larger raft than a 2-boat is required, it would be better to make it up of two 2-boat rafts side by side, and in rough water even to make the pontoons touch each other throughout the width of the raft. This will probably give large excess buoyancy, but it will destroy the wash of the waves underneath the deck and prevent water being shipped except on the outside.

V.—Pier Heads.

The pier heads were made of 2-boat rafts of double pontoons. To facilitate loading and unloading the transport rafts, three sets of cut-baulks were put on the outside of each pier head. There was just room to fit these in, but the back light saddles had to be removed. Thus three easily removable roadways were provided on to the rafts. Large fenders were required when the picket boats and heavy launches were brought alongside.

To avoid getting cables round propellers, no buoys should be used with the outside anchors and the cables should be splayed inwards. At Harty three cables got foul of propellers and caused considerable loss of time and temper.

VI.—Anchors.

The anchoring arrangements required special attention as the mud was very bad holding ground. The 112-lb. anchors had chesses lashed to their crowns perpendicular to the line of the flukes, and this arrangement undoubtedly increased the holding power. The cables were naturally made as long as possible. On the west of the piers, to avoid blocking the hard, small piles were used in place of anchors as far as low-water mark.

Photo No. 1 shows the completed south pier. *Photo* No. 2 shows nine pontoon trestles being warped into place on a pontoon raft, and No. 3 shows a loaded transport raft coming alongside a pier head.

NOTES ON THE EMBARKATION AND DIS-EMBARKATION OF MULES.

By Lieut. T. A. Swinburne, R.E.

The following notes on embarking and disembarking mules were made by the writer whilst on an expedition to the Persian Gulf last year, and may prove of use to the readers of the *Journal.*

At Bombay the mules are walked down a gangway on to a large lighter, where they stand about in considerable disorder as there are no facilities for tying them up. The lighters are towed out to the ship and the mules are hoisted aboard by the ship's derricks. On arrival at their destination the mules are slung overboard by derricks and lowered into boats. The boats are then towed by a steam cutter as close as possible to the shore, where the beach party take charge of them, get them broadside on to land and tilt them up. The mules jump out. When the mules have to be re-embarked, they will, with a little persuasion, jump straight in if the beach is steep and the boats can get close in.

If however the water inshore is shallow and the 3′ line (to which boats can come) is far out, rafts must be used and these are constructed as follows:—

Construction.

The frame consists of 3″ staging lashed across 2″ planks. In order to give the necessary stiffness these planks must be doubled. Four of the floor boards out of the mule stalls on the ship are then lashed above the staging. The ribs on these boards, which will run at right angles to the length of the raft, assist the mules to get a good foothold, and it was found of some use to nail matting on to the boards, as, when wet, the latter get very slippery.

The planks are 15′ long, the staging 8′. Empty water breakers such as are carried by ship's boats are lashed along the sides of the raft to give buoyancy. Two more of these are fastened under the bows, to prevent them sinking as they are apt to do when the raft is towed through surf.

All breakers must be placed bungs on top, as otherwise—no matter how tightly they are plugged—water will certainly get in and render them water-logged and useless. A stout towing rope is fastened to the bows.

USE.

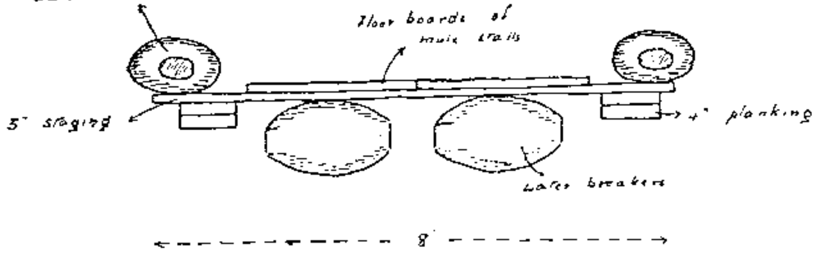
The raft may be brought alongside the ship's cutter, broadside to broadside. The mule is then walked on and made to jump in. But in order to lessen this jump and to give the animal more "run," it is better to hitch the towing rope round the thwart of the boat and slightly raise the bows of the raft, thus forming a kind of gangway. Thick mats should be hung over the gunwale of the cutter to save the mule's knees. Sapper drivers must always go with their mules in the boats.

There must be a beach party to catch the animals as they jump out. Mules on each side of the centre thwart must face opposite ways to trim the boat, as a mule always presses his hind-quarters up against the side.

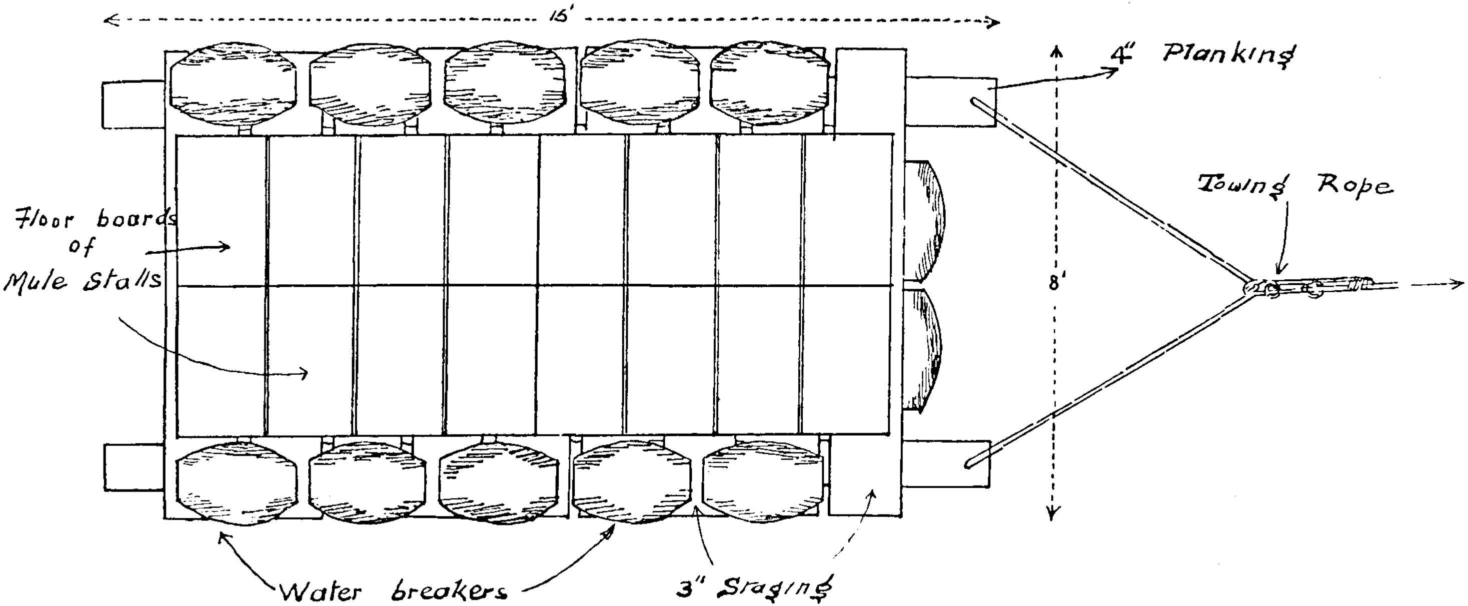
A boat can be cleared of 10 mules in 40 seconds, and loaded with the same in 5 to 10 minutes. Mules can be hoisted on deck (not into hold as well) at the rate of one per minute. On one occasion 130 mules were embarked (using rafts) in 4 hours. This included $\frac{3}{4}$-mile tow, with two lifeboats and only one steam cutter.

The following are the details of the plan and elevation of the raft. The details of men and materials are also given.

END ELEVATION. (No Lashings are shown).



PLAN.



(No Lashings have been shown).

Finally 12 men will make a raft in 2 hours and the materials required are :—

2" planks, 15' long	4
3" „ 8' „	8
Floor boards out of stalls	4
Water breakers	12
3" rope, 20' long	1
1" or $1\frac{1}{2}$" lashings	40

TERRITORIAL TRAINING OF ENGINEERS UNDER THE COMPULSORY SYSTEM IN NEW ZEALAND.

By CAPT. J. E. DUIGAN, *N.Z. Headquarters Staff.*

OFFICERS of the Royal Engineers will no doubt be interested in the manner that the Territorial Engineers of the New Zealand forces are to be trained under the Compulsory System of Training.

Subject to the provisions of the Defence Act, 1909, and Amendments, 1910, all male inhabitants of New Zealand who have resided therein for six months, and are British subjects are liable to be trained as follows:—

Age.	Where to Serve.	Training Prescribed.
12 to 14 years........	Junior Cadets......	120 hours per annum.
14 „ 18 „	Senior Cadets......	Equivalent to 16 days.
18 „ 19 „	Territorial Force (Recruits).	14 days, 8 of which must be in camp. In addition
19 „ 25 „	Territorial Force (Trained Men).	home training which for Engineers is 20 half-days, or their equivalent.

All men on passing through the various stages of training and on reaching the age of 25 will be passed to the reserve. It will thus be seen that the system introduced although compulsory will not be any great hardship on the citizens of the Dominion.

The training in the reserve will be two muster parades per annum. It will be readily seen that under this compulsory system of training our Engineer companies will have a full trade establishment. The establishment will be based on that of the Royal Engineers, and we shall have some of the finest material in the world to work on, as pointed out by Lord Kitchener.

The system to be followed in regard to procuring men with trades will be on the following lines:—(1). They will be required to produce a certificate of competency in a list of one of the trades laid down in General Regulations. (2). Or will be tested in one of the workshops at the headquarters of the unit by a competent officer.

One of the most difficult questions that yet requires to be solved is the supply of officers for the various companies. As we have only four field companies the number of officers required will be few, and in my opinion the only way to ensure that the companies are well officered, is to provide in the General Regulations that only gentlemen with technical qualifications will be given commissions in the Engineers.

The peace establishment of a field company is 212, and it remains to be seen whether so high a peace establishment can be run by our Territorial officers. The only regular staff that each company will have will be a staff sergeant-major. It should be however remembered that the Colonial learns quickly, is very adaptable, and is not so hard to discipline as some people think.

The home training will be looked on as the individual training period and the annual training in camp will be looked on as the collective training period. During the latter period of training the theoretical work learnt will be put into practice and the various companies will carry out their duties in conjunction with other branches of the service. The following is the syllabus of training laid down for field companies, and it should be noticed that the syllabus is divided into 1st, 2nd, and 3rd year subjects. Taking the organization of a field company as a headquarters and four sections, the system to be adopted is as follows :—

(1). Recruits and men with under one year's service in the Territorials will be drafted to No. 4 Section and will remain in that section until after the individual training period.

(2). Men with one year's service and less than two years' service in the Territorials will be drafted to No. 3 Section and will remain in that section until after the individual training period.

(3). Men with two years' and under three years' service in the Territorials will be drafted to No. 2 Section and will remain in that section until after the individual training period.

(4). Men who have been fully trained will be drafted to Headquarters and No. 1 Section.

The N.C.O.'s of the company will be men who have been fully trained and passed the prescribed examination. The above system will only hold good for individual training. On mobilization and for annual training trained men and recruits will be distributed between the sections.

The training of each section will be as follows :—

No. 1 Section and Headquarters.—General work and instructional duties.
No. 2 Section.—Third year subjects of Training Syllabus.
No. 3 Section.—Second year subjects of Training Syllabus.
No. 4 Section.—First year subjects of Training Syllabus.

Each O.C. unit will decide after the annual examination if men are to be moved up to a higher grade for the next season's training.

It will be seen that all men are put through an examination annually.

SYLLABUS OF TRAINING.

1st Year Subjects.—(1). Field geometry. (2). Brushwood and revetments. (3). Hasty fieldworks and earthworks generally. (4). Defence of buildings, villages, woods and improving cover. (5). Defence of posts and camps. (6). Knotting, splicing and lashings. (7). Obstacles. (8). Use of spars and hoisting gear. (9). Blocks and tackles.

2nd Year Subjects.—(10). Explosives. (11). Hasty and deliberate demolitions. Land mines. Auto. flares, etc. (12). Principles of bridging. (13). Trestle and frame bridges. (14). Pontoon and flying bridges. (15). Water supply and camping arrangements. (16). Boning and levelling. Temporary roads, etc.

3rd Year Subjects.—(17). Siege trenches, magazines. (18). Sapping and mining. (19). Defence of fortresses. (20). Preparing and firing mines. (21). Topography.

Semaphore signalling is taught during training with senior cadets.

As drivers will be procured from men who carry out those duties in their ordinary civil occupations, it is not necessary to spread their course of training over one year. The following is the syllabus for drivers :—(1). Riding and driving. (2). Field movements, limber and two horses. (3). Wagon drill. (4). Knotting, lashing and splicing. (5). Care of harness and fittings. (6). Horse management. (7). Stable duties. (8). Foot drill. (9). Semaphore signalling. (10). Physical drill.

The age of retirement of officers and N.C.O.'s is as under :—Majors, 50 years ; captains, 45 years ; subalterns, 40 years ; warrant officers and sergeants, 50 years.

The syllabus for home training is made out by O.C. units and forwarded to the Director of Training for his perusal and revision if considered necessary. Lectures are given periodically by officers on discipline, on the lines adopted by the Japanese, *i.e.* by appealing to the man's honour, sense of duty, and higher nature. He is taught patriotism and the objects of defence. Every sapper joining a company has issued to him a book of drills and questions and answers, the Q. & A. method of instruction having been found to give excellent results.

Having shortly described the system adopted of training in N.Z. for a field company, I think it may be fairly assumed that, when it is in full swing, the Engineer units of the Dominion will be found capable of carrying out their duties in a satisfactory manner, and fit to take the field when called upon for Imperial Defence.

A SIMPLE FORMULA FOR CALCULATING THE STRENGTH OF REINFORCED CONCRETE BEAMS.

By CAPT. T. E. KELSALL, R.E.

IN the *R.E. Journal* for February, 1909, the following formula for concrete beams with single reinforcement was quoted from *Application of Reinforced Concrete*, by Major Stokes-Roberts, R.E.

$$bd^2 = \frac{WL}{X}$$

where b = breadth of beam in inches.

d = effective depth of beam in inches (*i.e.* from top to centre of tensile reinforcement).

W = total safe distributed load in lbs., including the weight of the beam itself.

L = length of beam in feet, the ends being supported.

X = a variable, depending on the percentage of tensile reinforcement to effective area of cross section of the beam (bd), and having values as under when mild steel bars are used.

Percentage of Tensile Reinforcement.	Corresponding Value of X.
$\frac{1}{2}$	45
$\frac{3}{4}$	57
1	73
$1\frac{1}{2}$	100
2	130

The values of X appear to be obtained by equating the maximum bending moment of a uniformly loaded beam supported at the ends, with the moment of resistance of the beam for each percentage of reinforcement.

For example, taking the tensile reinforcement as 1 per cent., to find the corresponding value of X.

Working on the method given on pp. 17 to 19 of *Reinforced Concrete*, by Capt. J. G. Fleming, R.E., 1910, and adopting the values given on p. 19 for strength, etc., of steel and concrete, the formula

$$k = \sqrt{2\,pm + p^2m^2} - pm$$

gives the distance of the neutral axis from the top of the beam as $\cdot 42d$.

Since 1 per cent. is more than the economical ratio of tensile reinforcement, the formula used to obtain the moment of resistance of the beam is

$$M_r = \tfrac{1}{2}kcbd^2\left(1-\frac{k}{3}\right)$$

which gives $110{\cdot}9bd^2$ inch-lbs. as its value.

The greatest bending moment for the beam, when uniformly loaded, and supported at the ends, is $\frac{WL \times 12}{8}$ inch-lbs. (since L is in feet and W in lbs.).

Equating, $$110{\cdot}9bd^2 = \frac{WL \times 12}{8}$$

$$\therefore bd^2 = \frac{WL}{73{\cdot}9}$$

i.e. for 1 per cent. tensile reinforcement, $X = 73{\cdot}9$.

Working out values of X, to the nearest whole number, for various percentages of mild steel tensile reinforcement, the following results are obtained.

Percentage of Tensile Reinforcement.	Corresponding Value of X.
$\frac{1}{4}$	25
$\frac{1}{2}$	47
$\frac{3}{4}$	65
1	74
$1\frac{1}{4}$	78
$1\frac{1}{2}$	82
$1\frac{3}{4}$	85
2	87

From the above it would appear that the values of X, given with the original formula for percentages of reinforcement over 1 per cent., are much too high.

If wrought iron is used as the reinforcing material instead of mild steel, the following results are obtained.

Taking the safe tensile strength of wrought iron as 11,000 lbs. per square inch and

$$\frac{\text{modulus of elasticity of wrought iron}}{\text{modulus of elasticity of concrete}} = \frac{24{,}000{,}000}{2{,}000{,}000} = 12$$

the economical ratio of reinforcement is found to be ·0107 (just over 1 per cent.), and the distance of the neutral axis from the top of the beam $= {\cdot}39d$.

The values of X are as under.

Percentage of Tensile Reinforcement.						Corresponding Value of X.
$\frac{1}{4}$	...	...	...	...	...	17
$\frac{1}{2}$	...	...	...	...	...	33
$\frac{3}{4}$	...	...	...	...	...	49
1	...	...	...	...	...	64
$1\frac{1}{4}$	...	...	...	...	...	72
$1\frac{1}{2}$	...	...	...	...	...	76
$1\frac{3}{4}$	...	...	...	...	...	79
2	...	...	...	...	...	82

The same formula can be used for doubly reinforced beams, if the relative proportions of compressive and tensile reinforcement are fixed. The formula

$$p' = \frac{3(2pt - kc)}{4(m-1)c}$$

on p. 21 of Capt. Fleming's book gives the amount of compressive* reinforcement necessary to cause the tensile reinforcement to be fully stressed, when in excess of the economical ratio.

The moment of resistance is then obtained from the formula

$$M_r = pbd^2t\left(1 - \frac{k}{3}\right),$$

k being taken as $\cdot36d$ and $\cdot39d$ for mild steel and wrought iron respectively, *i.e.* the same as in singly reinforced beams with the economical ratio of reinforcement.

Values for X can then be found as before, and are as follows.

Mild Steel.

Percentage of Tensile Reinforcement of Effective Area.			Corresponding Percentage of Compressive Reinforcement of Effective Area.			Corresponding Value of X.
$\frac{3}{4}$	...	...	$\frac{1}{4}$	...	...	70
1	...	...	1	...	...	94
$1\frac{1}{4}$	...	...	$1\frac{1}{2}$	...	...	117
$1\frac{1}{2}$	...	...	$2\frac{1}{4}$	...	...	141
$1\frac{3}{4}$	...	...	3	...	...	164
2	...	...	$3\frac{3}{4}$	...	...	188
$2\frac{1}{4}$	...	...	$4\frac{1}{2}$	...	...	211
$2\frac{1}{2}$	...	...	$5\frac{1}{4}$	...	...	235
$2\frac{3}{4}$	...	...	6	...	...	258
3	...	...	$6\frac{3}{4}$	...	...	282

* Not *tensile* reinforcement as stated in the book: apparently this is a clerical error.

Wrought Iron.

Percentage of Tensile Reinforcement of Effective Area.	Corresponding Percentage of Compressive Reinforcement of Effective Area.	Corresponding Value of X.
$1\frac{1}{4}$	$\frac{1}{2}$	80
$1\frac{1}{2}$	1	96
$1\frac{3}{4}$	$1\frac{3}{4}$	112
2	$2\frac{1}{4}$	128
$2\frac{1}{4}$	3	144
$2\frac{1}{2}$	$3\frac{1}{2}$	160
$2\frac{3}{4}$	$4\frac{1}{4}$	176
3	$4\frac{3}{4}$	191

It must be remembered that all the values of X given above are for a uniformly loaded beam supported at the ends. Consequently if the formula is used for other beams, changes must be made in the values of X inversely proportional to the changes in the bending moment.

The proper distribution of the reinforcement when the bending moment changes from $-$ to $+$, as in the case of a beam fixed at the ends, must of course be arranged for, as well as provision against failure by shear.

As the writer lays no claim to be an expert in the subject of reinforced concrete, any criticisms on the above article will be welcomed by him.

WORKS FINANCE.

By S. Dannreuther, Esq.

From a Lecture delivered at the S.M.E. on 10th November, 1910.

Some time ago the late Commandant of the S.M.E. suggested that, as a supplement to a professional lecture on Trade Accounts and the general principles of all accounting, a further lecture should be given dealing with the special features of Army Accounts and Army Finance, and for this purpose he sought the assistance of a military officer of the late Army Accounts Department, who should have had experience of work both at the Headquarters of a Command and at the War Office. No volunteer was, however, forthcoming; and I was then asked if I would undertake the task. I can lay no claim to the requisite qualifications; but as I happen for the moment to be in charge of the Works Finance branch of the War Office, it occurred to me that, although I could not deal exhaustively with the whole subject, my experience of the financial administration of the Works Vote might enable me to offer a few remarks on that part of the subject which is, or will be, of special interest to those, on whom sooner or later will devolve the important duties of a Division Officer or a Commanding Royal Engineer.

It is, no doubt, true that Works Services are for the most part peace services. When you take the field, bricks and mortar give way largely to canvas; and it is not for Works Services proper, that is to say, the designing, erection and maintenance of buildings, that the Corps of Royal Engineers primarily exists. It may well be, therefore, that many junior officers regard Works as of secondary importance, although it is, I believe, generally considered that they form an excellent preparation for Engineer work in war. They must recollect, however, that their highest functions, so important in time of war, are to a great extent in abeyance in time of peace; and as peace is the rule and war the exception, the majority will probably find a considerable portion of their future careers devoted to Works. In any case, it is almost exclusively in this direction that they will come to close quarters with Army Finance and Accounts. I shall, therefore, after a general survey of the sphere of Army Finance, practically confine myself to the financial and accounting aspects of Works Services; and it is to officers who will before long be Division Officers that my remarks are more especially addressed. If any have already a craving for financial responsibility, it may interest them to learn that to them, a very small body of officers when compared with the grand total of combatant officers of the Army, such responsibility will attach in a far greater measure than to any other class of officers. On Engineer officers, or rather on those of them who may be engaged on Works, will devolve the duty of expending annually, in the best interests of the State, a sum of from £1,000,000 to £1,500,000 on behalf of the War Department alone: (if we include India and Egypt, the annual aggregate will amount to £3,000,000): and they will have unique opportunities of effecting economies in designs of buildings, types of construction, employment and supervision of labour, and in other directions. Larger sums may be disbursed by others in paying, feeding and clothing the troops; but such payments are for the most part made in accordance with definite rates and scales, and do not involve responsibility commensurate with that which will fall on Engineer officers.

Now, in the first place, I must endeavour to give a brief sketch of the system of Army Accounts and the sphere of Army Finance. In the outside world of commerce, including therein the activities of County Councils and other municipal bodies, the term "finance" is usually applied to such operations as the raising of capital and other funds, and the buying and selling of stocks and shares. With such finance we in the War Office have nothing to do. Whatever funds are allotted to the Army by Parliament are raised, whether by taxation or from other sources, by the Chancellor of the Exchequer, and placed in the hands of the Paymaster-General from whom we draw cash in accordance with our requirements, up to the total amount allotted to us. By Army Finance must be understood such rational control as is exercised by the Army Council over estimates and expenditure. How difficult a matter it is to exercise an effective control will be more apparent when the somewhat anomalous system of Army accounting is thoroughly understood.

That system dates from the Revolution of 1688, or rather from the definite establishment of the principle, embodied in 1689 in the Bill of Rights, that "the raising or keeping of a standing army in time of peace, unless it be with the consent of Parliament, is against law;"—words which are repeated every year in the Preamble of the Annual Army Act. The compact then made between the Crown and Parliament provided that a standing army should be kept at such strength as Parliament might authorize, and that, while the command should vest in the Crown, the money should be provided by the House of Commons. In the long constitutional struggle this was a great victory for the Commons; but there was still no guarantee that the money so provided by them would not be misappropriated, and history shows that such misappropriations were not infrequent. By misappropriation I do not mean merely malversation, peculation, or any similar offence, but also the technical offence of expending the supplies granted by Parliament on other objects than those specified by Parliament. It was mainly to guard against the latter offence that a special form of accounts was devised and public auditors were appointed. The accounts, called Appropriation Accounts are, as their name implies, primarily intended to show that the money spent has been correctly appropriated to the specific purposes for which the various grants to the King have been made, and they are the only accounts demanded by Parliament. The scope of the public audit was gradually extended; and the powers and duties of the Comptroller of His Majesty's Exchequer and of the Commissioners for auditing the Public Accounts were finally consolidated by the Audit Act of 1866. The Comptroller and Auditor-General is a public official in an exceptional position in that he is directly responsible to the House of Commons, and is not dismissible by the Government. He reports to the Public Accounts Committee of the House, a distinguishing feature of which Committee is the fact that its Chairman and the majority of its members are drawn from the Opposition.

The settlement of 1688 still holds good in its main principles, though in practice the constitutional claims of the Crown have, through disuse, suffered considerable abatement. The Sovereign retains supreme command of the Army, but exercises his control through the Secretary of State for War, who is responsible to Parliament for his own acts and for the advice he gives. Real executive authority resides now, in theory, in the Privy Council—in fact, in the Prime Minister and his Cabinet.

Now to turn to the form of Army Estimates and of the corresponding Appropriation Accounts. I advise those who have never studied them to get specimen copies of each: a first glance will be sufficient to show how markedly they bear the impress of that principle of "appropriation" by which in former days the people's representatives set such store.

In the forefront of Army Estimates appears Vote A: this is not a money vote, but deals with the numbers of officers and men on the Home and Colonial Establishments. It owes its origin to the settlement of 1688, under which the King was authorized to keep a standing army at such strength as Parliament might approve; and the vote must be taken every year in Parliament to make it lawful to maintain any standing army at all.

Vote A is followed by the money votes, at present 15 in number, those numbered 1 to 12 dealing with effective services, and the last three, numbered 13 to 15, dealing with the non-effective charges for officers, for men, and for Civil Servants and other civilian subordinates.

The votes for the non-effective services do not call for any particular comment: the rates or scales of pension, etc., are more or less definitely laid down in the Royal Warrant for Pay or in Acts of Parliament, and the procedure in regard to these votes is, to a great extent, automatic. The annual aggregate net expenditure under them amounts, however, to nearly £4,000,000; and in considering the financial aspect of any new proposal, care has to be taken not to omit from the calculation any future so-called "non-effective" charges.

The 12 "effective" votes provide successively for the following services:—Pay of the Army (including, by the way, the cost of the Establishment of the School of Military Engineering); Medical Establishment; Special Reserves; Territorial Forces; Establishments for Military Education; Quartering, Transport, and Remounts; Supplies and Clothing; Ordnance Department Establishments and General Stores; Armaments and Engineer Stores; Works and Buildings; Miscellaneous Effective Services; and, finally, the War Office.

Each of the money votes is divided into a number of subheads, of which there are in all nearly 200; and these subheads are generally further subdivided into innumerable items. The important point to notice is that each vote and each subhead of a vote deals with expenditure of a particular nature, and not with expenditure directed to a particular object. For instance, there is in the Supplies Vote a subhead to provide for the cost of fuel and light—and so, if we buy anything in the nature of fuel it can only be charged to this particular subhead, though the use to which it will ultimately be put may be, in one case, to cook the soldiers' food, in another to heat a copper for washing, in another to produce steam for driving machinery, and so on. It may be taken as a general rule, to which there are only a few minor exceptions, that Army Estimates ignore purpose, and are based on classification in accordance with the immediate character of the expenditure.

The Appropriation Accounts follow the estimates in every detail of form (it would perhaps be nearer the truth to say that the estimates follow the accounts, as it is the necessity for presenting Appropriation Accounts that conditions the form of the estimates). The total of every class of expenditure, vote by vote, subhead by subhead, and in some cases item by item, is shown in direct comparison with the estimate, *i.e.* with the specific grant of money voted by Parliament. I need hardly point out that the system has one obvious advantage from a book-keeping point of view. There is not much room for doubt as to the immediate nature of any item of expenditure; it can therefore readily be charged to the correct vote and subhead, without the delay and uncertainty that would arise if in each case the ulterior object had to be ascertained.

No excess on the total of Army Votes is permissible; if any occurs, it must be met by a Supplementary Estimate. An excess on one vote may only be met by a saving on another vote with the provisional sanction of the Treasury, subject to ratification by Parliament itself by means of a clause in the Annual Appropriation Act. Within the confines of a single vote none but a trifling excess on any subhead may be incurred without the sanction of the Treasury; and the same rule applies occasionally even to individual items under a subhead.

Such is the system of control devised by Parliament, a control rigidly exercised with the aid of the Exchequer and Audit Department. It may be summed up in the one word "Appropriation." There is an important corollary to which I have not yet alluded. The Parliamentary grants are made for expenditure on particular objects during the particular year, and the appropriation of the money granted is shown in the accounts for that year. It follows from this that, if the Parliamentary control, such as it is, is not to be impaired, no carry-over can be allowed. It is in fact a cardinal point in our national system of finance that, except in the case of loans for which special provision is made by Acts of Parliament, the expenses of any one financial year (from the 1st April to the following 31st March) must be met from the revenues of that year; any unspent balances being surrendered to the Exchequer and normally applied to the reduction of the National Debt. Liabilities incurred must be discharged in the year in which they mature from the funds voted by Parliament for that year. In short, every financial year is a water-tight compartment.

There are administrative difficulties due to this restriction. They are especially prominent in the case of Works which can rarely be executed in their entirety within the limits of any one financial year. But the restriction is, I think, inherent in, and inseparable from, the existing system of Parliamentary Estimates and Accounts.

Critics of the system are not wanting, even among those who are aware of the difficulty of finding any satisfactory alternative. Here, for instance, is a recent comment of an ex-Cabinet Minister:— "Operations have to be terminated or postponed, surpluses surrendered, deficits avoided, quite irrespective of the business aspect of the transaction, to fit in with the pedantry of Appropriation Bills and other antiquated methods of supervising expenditure." Moreover I must point out, what indeed is obvious, that the system, while affording an adequate safeguard against misappropriation, in both its natural and its technical sense, and at the same time admitting of simplicity in the matter of book-keeping, is incomplete in that the accounts do not, like commercial accounts, afford any direct evidence of economy in administration, nor is the form of the estimates such as to enable the House of Commons to exercise any efficient check on extravagance.

"How unbusinesslike!" the reader may exclaim. "Shall we never have ordinary business methods introduced into the financial administration of the Army, one of the largest, if not the very largest, business concerns in the British Empire?"

A very plausible complaint—but I must point out, in the first place, that the limited nature of Parliamentary control does not imply that there is not an adequate departmental control; and, secondly, that ordinary business methods (that is to say, commercial methods) are in reality inapplicable, at least in their essential features. I do not mean to say that we cannot, and do not, follow such business methods in our commercial transactions—as, for example, in the management of our factories or in our administration of contracts—but all such transactions are only incidental to the real business of the War Office, which is to maintain and add to the efficiency of the nation's fighting machine.

Now in business, as it is understood in the world of commerce, the one primary object in view is to obtain, for a given cash expenditure, a greater cash return; and the success of an undertaking is gauged by the proportion that the return bears to the expenditure. The central pivot in the controlling mechanism is the Profit and Loss Account. If a satisfactory profit can be assured, further funds will readily be forthcoming; and the concern and its capital may continue to grow, almost indefinitely. As with the whole, so with its parts: in any branch, however small, an increase of expenditure will be welcomed, provided that the rate of profit be not diminished; and considerable freedom of initiative can be allowed to a manager, however subordinate, provided always that its exercise result in a satisfactory cash return—and of this there is a never-failing index in the accounts. Liability to be called to account must always attach to true responsibility; and where there is true responsibility, decentralization presents few difficulties.

Turn now to the business of the Army. There is a steady demand for cash expenditure—but the return that we have to look for is not in cash, but in that somewhat intangible commodity, military efficiency. This efficiency is to a certain extent a matter of opinion; the only real test that can be applied to it is the test of war, and, happily, that test is rarely applied. There is no accurate index-meter in the shape of a Profit and Loss Account.

Although we can say that, provided there is no waste, a greater expenditure may lead to greater efficiency, there is obviously a limit to the amount that any nation can afford to spend on the maintenance of its security in time of peace. Within that limit there is only one way of attaining the maximum of efficiency, and that is by practising rigid economy. Therein lies the true function of Army Finance.

I should like in this connection to quote the happily expressed opinion—not of a civilian, whom some might think prejudiced, but—of a distinguished member of the Royal Engineers, the late Commander-in-Chief in India. "A modern army," he recently said, "is simply an insurance against national disaster; and the expenditure incurred on it is strictly comparable with private expenditure on similar precautionary measures. The first business condition necessary to justify our military expenditure is that the army maintained should be in a thoroughly efficient state. . . . Expenditure of money on an inefficient army can no more be defended than the payment of premia to an insolvent company. . . . But the application of business methods to Army administration means more than this. It means that we must never for one moment lose sight of the fact that the efficiency of an army maintained as the ultimate guarantee of public security must be purchased at the lowest possible price. Therefore every existing source of Army expenditure has to be periodically scrutinized, and be shown to contribute towards that security or be discontinued; and the cost, as well as the utility, of every proposal for new expenditure must be most carefully considered before it is accepted."

In this consideration—in the pursuit of economy—lies, as I have said, the function of Army Finance. It is not confined to the Finance Department, but is the constant preoccupation of the Army Council and its subordinate officers.

From what we have seen of the structure of Army Estimates and of the form of the accounts there is no difficulty in realizing that it is no easy matter to ascertain the exact financial effect of any new proposal for increased expenditure. The prime charge on the vote immediately concerned may not be difficult to calculate; but there are nearly always indirect effects on other votes which cannot easily be disentangled by anyone who has not acquired a familiar knowledge of estimates and accounts. It is the special duty of the Finance Department—the main permanent element of the War Office—to acquire such familiar knowledge, with the power of criticism which it bestows, and to place it at all times at the disposal of the members of the Army Council and their Military Directors, so as to enable them to exercise a rational control.

Hitherto my references to Army Estimates have been to them in their Parliamentary form. We must now go back to their earlier stage, the stage of preparation before they are presented to the House of Commons. The first step towards their preparation is to ascertain the total amount of money that will be available for expenditure on the Army during the course of the year. That total is fixed by the Cabinet. After making allowance within that total for all absolutely necessary and unavoidable services, there will normally remain a margin to be devoted to new services at the discretion of the Army Council, subject to Treasury concurrence in the case of any new departure or in the event of recurrent expenditure being involved. The claimants to a portion of this margin are innumerable; and the definition of their order of precedency is one of the most important duties of the military members of Council, as it rarely happens that the margin is sufficient to admit more than a percentage, a very small percentage in the case of Works Services. To take the Works Vote alone, one pressing need may be for the provision of new infantry barracks at Chatham, another for the general provision of dining rooms, another for the purchase of new training areas and the construction of new ranges, and so on; and it may be that these various claims have to be considered not only on their merits as between themselves, but in competition with extraneous claims, under other votes, such as, for example, the need for an increase in the establishment of horses, for the annual issue to the soldier of an extra shirt or an additional pair of boots, or for a special grant for manœuvres on a large scale. Moreover in the case of each item consideration must be given not only to the effect on the estimates then in course of preparation but also to the effect on the estimates of future years; for as in private life, so also in the affairs of the State the old maxim holds good: "A Man ought warily to beginne Charges, which once begun will Continue; But in Matters, that returne not, he may be more Magnificent."

When a settlement has been made of these conflicting claims, the estimates for the year, after submission to the Treasury, are presented to Parliament. As soon as they are passed, the funds voted are placed at the disposal of the Army, and the financial consideration of estimates gives way to the financial control of expenditure.

Let us examine for a moment the method of this control, which embraces the greater part of the field of Army administration, as there are but few spheres of military activity which do not involve expenditure. Owing to the uncommercial nature of our return, the accounts cannot be made to furnish a commercial test of economy; practically the only measure of economy is the amount of expenditure, which must therefore be watched and controlled with much greater care than is necessary in an ordinary business undertaking. I may here point out that for this purpose the existing system of accounts suffices. That system has, moreover, as we saw before, the great merit of simplicity. On the whole, therefore, I think that we would now be justified in coming to the conclusion that the Appropriation Accounts, though at first sight anomalous in character, are not in reality irrational, and that a more scientific system would not prove to be of sufficient practical utility to justify the very considerable extra trouble and expense that its adoption would necessarily involve.

To return from this digression—efficiency has no cash equivalent; and, in the absence of accountability in its commercial sense, true financial responsibility is, in nearly every case, impossible. This consideration is sufficient, I think, to convince us that we cannot escape recourse to regulations, not merely as a guide to administration but also as an instrument of control.

The money voted by Parliament takes the form of a grant to the Crown, limited in total amount and in regard to the total of each vote and subhead, and subject to the rigid rules of "appropriation." It is the duty of the Treasury to ensure the fulfilment of these conditions, and in a general way to check extravagance; and it carries out this duty by imposing on the War Office regulations from which no departure is permissible without their Lordships' sanction, and requires annually from the Accounting Officer for the Army a certificate that these regulations have been duly observed. The post of Accounting Officer is held by the Assistant Financial Secretary, the permanent head of the Finance Department, with definite functions laid down in an Order in Council; and is a post to which genuine responsibility attaches, inasmuch as the Accounting Officer has to appear every year before the Public Accounts Committee of the House of Commons to answer for the whole expenditure of the Army and to defend his own actions and those of his subordinates against any criticisms that may be made by the members of that committee with the aid of their own official, the Comptroller and Auditor-General.

The War Office in turn imposes its own regulations on the Army, to enable it, in the first place, to discharge its responsibilities to the Treasury and to Parliament, and, secondly, to discharge its own responsibilities in the way of securing economy and thereby increasing the efficiency of the Army as a whole.

Regulations are a nuisance. Nobody likes them. Moreover no amount of regulations can in themselves engender a true spirit of economy or ensure efficiency in administration. We should certainly eliminate all that are unnecessary; but we cannot dispense with regulations altogether or to any great extent. On the administrative side, a certain measure of uniformity is indispensable; on the financial side, in view of the considerations I have mentioned, it will, I think, be readily admitted that a free hand, except within well-defined limits, is impossible. In the absence of accountability—and in our uncommercial business it is so often absent—the free hand can only spell irresponsibility. Those outside the War Office may occasionally chafe under War Office regulations, as we do under Treasury regulations; but if their abolition would lead to irresponsibility, it is better for the average man that they should not be abolished. He must console himself with the argument that has been adduced in support of the principle of a Second Chamber, that it is mentally, morally, and politically bad for the holders of power to have none whom they must consult. Moreover the necessity for stating one's case conduces towards clear thinking, and often reveals an unsuspected weak spot in either premises or conclusions.

It is customary nowadays to preach the gospel of decentralization. Its merits are undoubtedly great, but should not be exaggerated; and I must enter a caveat against the indiscriminate condemnation of the principle of centralization, to which it is opposed. Centralization is an ambiguous term. It is sometimes used to convey the idea that local authorities are being hampered by the central authority; in that sense it is to be deprecated. I should prefer to define it as the arrangement by which the various local authorities are brought into proper contact with one another and with the central authority. Such centralization is indispensable, if chaos is to be avoided. We must recollect that the British Army organization is necessarily centralized. It is not a federation of local armies; and uniformity may often be a greater gain than independence.

Although our method of control is not on commercial lines, the machinery through which it is exercised bears a general resemblance to that obtaining in the world of commerce. In every business concern comparable in magnitude with the business of the Army there are five distinct elements, each one of which has its own functions, while the co-operation of all is essential to the successful working of the undertaking. There are the shareholders or owners; the directors; the managers; the accountant; and the auditor. The shareholders find the money, and with the auditor settle the form of the accounts which are checked by the latter on their behalf. The corresponding elements in the Army system are the House of Commons, and the Comptroller and Auditor-General. The Directors—in our case, the Army Council—decide all questions of policy, the execution of which is left to the managers, who in the Army organization are represented by the General Officers Commanding. Lastly there is the accountant or internal auditor corresponding to our Accounting Officer with his subordinate officials at the War Office and in the commands. It is important to notice that in large businesses the accountant is distinct from, and independent of, the managers. A manager, for instance, may have a free hand in buying and selling, and sign the invoices; but he does not keep the accounts. If this separation of functions is found to be necessary in the world of commerce, the necessity is still greater in the case of the Army, where economy cannot be gauged by a Profit and Loss Account but has to be measured in each case by the total of expenditure, and the real cost of any operation cannot without difficulty be extracted from the accounts. Our managers, like all managers, are—or at any rate should be—enthusiasts, and *pro tanto* unreliable. The accountant, on the contrary, should be a cold, dispassionate outsider, concerned only with facts.

Now when once the estimates have been passed, the Military Departments have power to authorize, without previous reference to the Finance Department, all expenditure covered by regulation and provided for in the subheads of the estimates. Within these limits the Military Directors at the War Office and the General Officers Commanding have a free hand. In large commands the General Officer Commanding-in-Chief is assisted by a General Officer in Charge of Administration, who is charged with direct responsibility to the War Office on financial subjects.

When expenditure is incurred, it must be duly certified by the responsible officer; payment is then made by the local paymaster, and if no objection arises on internal audit the charge is incorporated in the accounts which are finally summarized in the central ledgers of the War Office.

For some years past, under the reorganization scheme adopted on the recommendation of Lord Esher's Committee, the pay, accounting, and internal audit services of the Army were merged in one comprehensive Army Accounts Department; but a reversion has now been made to the previous system under which the local pay and accounting services are performed by an Army Pay Department, a military administrative department under the General Officer in Charge of Administration, while audit is entirely separated and assigned to a civilian Local Auditor, representing the Accounting Officer of the Army. The authority of the Local Auditor is derived from that of the head of his department, whose functions, as I have already mentioned, are defined by an Order in Council, which is of sufficient importance to justify quotation in full:—"The Assistant Financial Secretary to the War Office shall act as deputy and assistant to the finance member of Council and shall advise the administrative officers at the War Office and in commands on all questions of Army expenditure. As the accounting officer of Army votes, funds, and accounts, he shall be charged with the allowance and payment of all monies for Army Services; with accounting for and auditing all cash expenditure and preparing the annual accounts of such expenditure for Parliament; and with auditing all manufacturing, expense, supply, and store accounts."

With this quotation I have come to the end of the general survey of the system of Army Accounts and the sphere of Army Finance. I propose now to devote the remainder of the space at my disposal to particular aspects of the question, relating especially to Works Services, and to offer a few general remarks on Contracts and on Storekeeping. They may appear to some to be in the nature of platitudes; but their recognition of them as such will, at least, show that they have already grasped the principles embodied in them and will not fail to apply them when they are called upon to deal with concrete cases.

In the first place it may be of use to run through a typical estimate of Vote 10, the Works Vote, subhead by subhead, showing thereby the structure of the vote, and at the same time to point out the various spheres wherein special responsibilities will be found to lie. Let us take the vote for the current year, amounting to a net total of £2,598,000 spread over 12 subheads.

Subhead A provides for the specialized staff or establishment for Works and Engineer Services at a total cost of £183,000 exclusive of the pay and allowances of Royal Engineer officers and of all staff employed at the War Office or on services chargeable to the Military Works Loan. In the sum of £183,000 are included the consolidated emoluments of civilians and pensioners, but only the pay in the case of such serving soldiers as Military Foremen of Works, Engineer Clerks, etc. In the case of the latter, in accordance with the general system of Army Estimates, lodging allowance, provisions, clothing, non-effective charges, etc., are provided for under the appropriate votes and subheads. Furthermore, this staff subhead does not cover the cost of offices and fixtures, nor of their heating and lighting; while all materials that come under the comprehensive heading of stationery are issued free of charge by His Majesty's Stationery Office. These considerations suffice to show that the real cost of our Works Staff is high, no doubt unavoidably so; but the tendency to increase which it exhibits is a constant source of anxiety to the War Office. The amount of work in any district is always fluctuating, and temporary increases of staff are unavoidable; but we rely on officers, as co-trustees of the public funds, to make reductions whenever and as soon as opportunities occur, and only to apply for extra assistance when the absence of such assistance would be really prejudicial to the interests of true economy. We should imagine ourselves to be in business on our own account, and consider in each case what the effect of the extra cost would be on our profit and loss statements.

Subhead B provides £16,000 for the incidental expenses of lands producing revenue—in other words, for the expenses incurred by the War Department in its capacity as landlord. The rentals, about £44,000, a year, are credited to Subhead L, to which we shall come later on. As a rule we do not receive full commercial rents owing to the lettings being subject to military user or to other restrictions due to military requirements. I may here point out that there has recently been established at the War Office a separate branch under a Comptroller of Lands, whose functions are exclusively to deal with the administration, purchase, and sale of War Department property. The local administration devolves on the Royal

Engineers, and is for the most part concentrated in the offices of the Chief Engineers of the commands, assisted in special cases by land agents.

Subhead C provides for telegraph, telephone, and signal services:—£13,500 of which the main item is £12,000 for construction and maintenance services. This subhead provides only for military exchanges and circuits; the work being executed locally by the Engineer officer in charge of telephones out of funds allotted by the War Office. The rentals for connections to civil exchanges are not chargeable to Vote 10, but to the vote which provides generally for postal and telegraphic expenses.

Subhead D provides £20,000 for miscellaneous Engineer services, the principal items being £11,000 for experiments and £6,400 for the Works charges for temporary camps for the Special Reserves.

We now come to the main subheads of the vote, those for Works Services proper. These subheads, formerly nine in number, have this year, I am glad to say, been reduced to three, viz.: E, F, and G. They cover the three main categories, known as Parts I., II., and III., into which works are divided. Under Part I. come new works, alterations and repairs, estimated to cost £2,000 and upwards, while Part II. comprises new works and alterations estimated to cost less than £2,000, and Part III. provides for ordinary repair, renewal, and maintenance services, costing less than £2,000. I should add that in some cases a Part I. item may provide for a programme of similar services to be executed at various stations, costing individually less than £2,000, but amounting in the aggregate to a large sum. Such items are known as "General Items."

Each Part or Subhead comprises three divisions—(prior to the present year each of these divisions formed a separate subhead of the vote)—devoted respectively to Fortifications and Artillery Ranges, Army Ordnance Buildings, and Barracks. Under Parts II. and III. the aggregates only for each division are given; but under Part I. each item is shown separately and a specific sum voted therefor by Parliament for expenditure in the current year. Under the system of Parliamentary and Treasury control, which I have already described, no material excess may be incurred on any subhead or on the total estimate for any individual Part I. item; nor may any new Part I. item be opened without the prior sanction of the Treasury. As there are about 100 Part I. items and the progress on any particular service cannot be accurately forecasted, owing to the uncertainty attaching to foundations, to the weather, and to the efficiency of a contractor, there is inevitably considerable difficulty in making the expenditure within the hard-and-fast limits of a financial year approximate to the estimate. This was recognized by the Committee on War Office Organization, which sat in 1901, and recommended us "to rearrange the Works Vote, so as to secure greater elasticity, and to carry over unexpended balances, in order to prevent a tendency to wasteful expenditure at the close of the financial year."

Now the principle of carrying over unexpended balances is opposed to the Parliamentary system of controlling expenditure, and has proved impossible of application. We have, however, made it our constant endeavour to secure greater elasticity in the financial administration of Works Services. For some time past a General Officer Commanding has been empowered, in the case of a Part I. service, to incur an excess on the provision for the year provided that the total estimate is not exceeded and that the excess is counterbalanced by savings in the year on other Part I. services within the same command; and now, in this very year, the War Office has at last been empowered to extend the application of this principle generally to all Part I. services irrespective of the separate commands; and it is by this extension of the practice of transferring savings to meet excesses on the provision for the year, provided that the total estimates sanctioned by Parliament are not exceeded, and by the simultaneous reduction in the number of subheads and of the limitations which they involve, that we hope to have obtained sufficient elasticity in administration to make the aggregate annual expenditure on Part I. services correspond closely to the aggregate estimate—a task in which we have hitherto signally failed.

The annual expenditure under these Subheads E, F, and G amounts to a very large sum. In the year which we are considering the estimates have provided for an expenditure of over £550,000 on Part I., over £216,000 on Part II., and £535,000 on Part III. services —the total provision amounting to over £1,300,000. From these figures it is obvious that the financial progress of the Works under the charge of the Engineers will need to be closely watched, and that great care will have to be taken to render accurate the forecasts which they are called upon to furnish to the Army Council to enable the latter to control the course of Army expenditure as a whole.

For all these services allotments of funds are made by the War Office to the headquarters of the commands, for subsequent distribution by the Chief Engineers to their subordinate officers. They must on no account be exceeded without special authority; and if savings of any magnitude occur, they should be reported as early as possible. It is necessary therefore for officers to keep accurate records of all allotments made to them and of their expenditure thereunder. These allotments are not, of course, actual allotments of cash; that is found by the paymaster who pays the bills on their certificate. They are authorizations to the Engineer officers to incur expenditure on specified services up to the limits fixed, and are made to them as the officers responsible for controlling the expenditure. They hold good only for the financial year in which they are granted.

I will defer till later a few remarks which I wish to offer on the nature of the certificates which officers have to give and their responsibility in connection therewith; but before passing on to the consideration of the remaining subheads of Vote 10, I must draw attention to the immense financial, as apart from accounting, responsibility that attaches to the officers of the Royal Engineers in respect of Works Services—a responsibility which I do not think has always been adequately realized in the past. Correct accounting, accurate forecasting, and a rigid adherence to regulations may simplify administration, and bring about indirect savings; but in connection with Works, which are in their nature expensive, the real source of economy is to be found in the designs of buildings and the types of construction. The thoughts of those who were at the S.M.E. last winter will naturally revert to the interesting lectures on Works Economics by Brigadier-General Scott-Moncrieff, with whom I had the happy experience of working at the War Office before he took up his present appointment of Chief Engineer at Aldershot. They may recollect that he divided the Science of Engineering Economics into two broad classes, the Economics of Policy and the Economics of Practice, and he confined his lectures to the latter. Policy, closely interwoven with finance, is primarily a matter for the Army Council, as I endeavoured to show in my earlier remarks; it is in the sphere of practice that the State looks to reap the full benefit of the technical skill of the Royal Engineers and of the individual economies which that skill may bring about. I need hardly say that by economy we do not mean economy of a cheese-paring kind, the economy of the jerry-builder. What we all aim at is the maximum of efficiency combined with the minimum of extravagance.

One—and only one—further remark on the Works subheads of the vote. The total estimate entered against any item represents only the estimated total of expenditure to be charged against the particular subhead, not the real total cost of the service. If land has to be bought, its cost is charged to the special subhead for the purchase of land, the incidental expenses being similarly charged, or to the Vote for Law Charges, which is not an Army Vote at all. Again, the cost of design, of drawings and bills of quantities, and of supervision is borne by other votes or subheads, for the most part in the shape of the pay and allowances of the persons employed thereon. Finally, any vocabulary stores that may be required are obtained free from the Ordnance Department without payment and any stocks of Engineer stores, not specially bought for the service, may similarly be freely drawn upon, while in many cases the cost of carriage and freight may fall on the Vote for Transport.

Although these charges do not appear against the Works item, it is obvious that they form part of the true cost and that this fact must never be lost sight of in discussing new services or in comparing costs generally.

To pass on now to the remaining subheads of Vote 10, we have next in order Subhead H, which provides nearly £11,000 for grants in aid of works carried out by other departments or bodies, in which the War Department may be interested. The special grants made to County and other Councils for the strengthening of roads and bridges, or as compensation for damage due to extraordinary military traffic, often present very great difficulties, into which, however, we need not enter here.

Subhead J provides £46,000 for purchases of land; and Subhead K £42,000 for the "rents payable" for lands and buildings, with the exception of buildings hired to supplement barracks.

Subhead L provides for Appropriations-in-Aid, that is to say for credits to the vote, estimated for the year in question to amount to £186,000; the principal anticipated receipts being £130,000 from the sale of lands, buildings, and materials, and £44,000 on account of "rents receivable" for lands and buildings belonging to the War Department. In every Army Vote there is a special subhead for Appropriations-in-Aid; the total of all these subheads amounting to nearly £3,500,000. Excess receipts are not available for increasing the gross expenditure.

There remains one further subhead, peculiar to Vote 10. This Subhead M provides for repayments under the Barracks and Military Works Acts. Under these acts money has been advanced on loan to the War Office for the purpose of carrying out large programmes, the loans being subsequently repaid by a series of annual payments, including principal and interest, spread over a definite number of years. The amount shown this year as payable to the National Debt Commissioners and to the Treasury is over £1,150,000. These Military Works Loans, sanctioned by special Acts of Parliament, form an exception to our national system of finance which, as I explained before, is based on the principle that the expenses of any one financial year must be met from the revenues of that year. In the case of extensive purchases of land or of large works services, the execution of which necessarily extends over several years, such loans present undoubted administrative advantages; but, as there is a tendency for services to be included in a Loan Programme without the same consideration that they receive when they have to run the gauntlet of the annual estimates, it has been found that loans do not always make for economy; and the policy of loans for Military and Naval Works Services has been abandoned by the present Government.

I propose now to revert for a moment to the consideration of the certificates required on the bills for Works Services before they can be passed for payment. I will only deal with one form of bill—the most important of all, on Army Form P. 1901. It is the Final Bill for a Works Service, and on it are entered all the measurements in detail. Now the primary authority for payment is the certificate of the Division Officer that the work has been satisfactorily executed, that the measurements are correct, and that the charges are in strict accord with the schedule of prices embodied in the contract. The bill is then passed to the Commanding Royal Engineer for technical examination and for him to certify that funds are available out of his allotment to meet the charge and to state the vote, subhead, and item, against which the charge should be made, before the bill is passed to the paymaster for payment. It is the duty of the latter to check the correctness of the bill as far as he can before paying; but, as the checking of measurements and schedule items requires technical qualifications, the full responsibility for the accuracy of Engineer bills in this respect has been assigned to the Royal Engineer officers in charge of the services. It is a responsibility which should not be lightly undertaken, as it is on the Division Officer's certificate that the whole system of accounting is based.

The fundamental necessity is that the measurements should be correctly taken; and it is now more than ever important that officers should be fully acquainted with the art of taking measurements. It has always been one of their duties; but until recently there was a staff of surveyors who relieved them to a considerable extent of this duty. Surveyors as such have, however, ceased to exist for Engineer Works; as Inspectors of Works they have to all intents and purposes become Division Officers. In the circular notifying the change it was clearly laid down that "Division Officers, both R.E. and Inspectors of Works, will be responsible for the complete execution of their services in every respect including designing (if not done by higher authority), estimating, and measuring up."

In the multitude of their duties officers may be forced on occasions to leave part to their subordinates. In such a predicament they will naturally reserve for their personal attention the matters which appear to them to be of the highest importance. They must not forget, at such a time, that from an accounting point of view, the taking or checking of measurements is of paramount importance. Their Foreman of Works may be, and generally is, a hardworking and trustworthy person, but it is not fair either to him or to themselves or to the State to leave to him the responsibility which rests with them. The rates and schedule items in a bill may all be correct; and the certificates signed without misgiving in the apparent absence of even the slightest ground for suspicion; but if the initial measurements are wrong, the whole superstructure is worthless.

The number of certificates on Engineer bills has recently been reduced, the reduction being accompanied by a stipulation that the remaining certificates shall not be signed by anyone under the rank of commissioned officer. My excuse for this lengthy digression is that in the bills that have recently come before me I have noticed a tendency on the part of the officer signing to avail himself somewhat readily of the proviso, intended for exceptional use only, that he may when necessary sign the certificate with the endorsement that the measurements have not been taken or checked by himself. If he cannot be present when they are taken, he should make every endeavour to check them.

A word or two in regard to the financial aspect of the various methods of execution of Works Services may be expected. Officers can either execute a service personally by the direct employment of military or civil labour, or can employ a contractor to do the work, either by measurement or under a contract for a lump sum.

The direct employment of civilian labour has latterly been more common than it was some years ago; the main difficulty that it involves, from my point of view, is that of securing an adequate check. A daily check is made by the Foreman of Works, and it is on that that the weekly wages bill, which Division Officers have to certify, is based. I fear, however, that in the past the latter have not had any adequate means of checking the foreman; and without such a check the system cannot be held to be entirely satisfactory, regarded merely as a system of accounting. The difficulty is not peculiar to the Army; but the commercial builder has his Profit and Loss Account to show him whether the work is progressing satisfactorily. It has always seemed to me desirable that, as is commonly done in the building world outside, and as, I understand, is the practice both at Chatham and at Aldershot, every workman should personally keep a weekly time sheet, showing for each day the hours worked and the particular work on which he is employed. These records must enable officers, by occasionally calling for and scrutinizing them, to exercise a better check than it is possible for them to do where no such records exist. Moreover, if every now and then they abstract the time taken by certain workmen over certain jobs, they will be in a position to compare their cost with contract prices; and such comparisons will assist them to determine whether or not their day labour is being economically administered. I was glad to see, in last month's Army Orders, that this system of time sheets, already in vogue at Chatham, has been officially recognized and made of general application in all commands where civilian day labour is employed.

The normal procedure, however, in the execution of an important Works Service is to employ a contractor. Measurement contracts have many attractions, as they do away with the necessity for the preparation of full drawings and bills of quantities. Embodied in such a contract is a schedule of prices for different materials and operations, and the contractor undertakes to execute any kind of work specified in the schedule at the prices named or at a fixed general percentage on or off these prices. This is an excellent system for jobbing work, that is to say for repairs, renewals, and small new services; and we have therefore at most stations a running measurement contract for all services the estimated cost of which individually falls within a certain limit. At present that limit is fixed at £400, but it is proposed to reduce it to £300, except at certain stations, where the volume of work is sufficiently large to justify a special higher limit of £500. These contracts for artificers' work run for periods of three years, and for this reason are generally known as Triennial Contracts.

For new services of any magnitude Measurement Contracts are apt to prove expensive, and financial considerations require that they should only be resorted to in cases of extreme urgency or in which there is no other alternative. Lump sum contracts should be the rule.

In regard to contracts in general, more especially for the purchase of stores, I should like to say a few words both on the system and on its application. In any large business concern there are two possible systems of buying; the purchaser may have recourse to competitive tendering to definite specifications, a system which gives him the benefit of low prices, but necessitates the maintenance of an adequate staff for inspection to ensure that the goods supplied are in each case in accordance with the specification; or he may employ special expert buyers and dispense to a great extent, if not altogether, with specifications and inspection.

In the case of the Army, where we are spending the public money without any Profit and Loss Account to show the result of our various transactions, special buyers would always be open to the suspicion of partiality, if not of corruption; and would prove extremely costly, in view of the great number and variety of articles required. We therefore adopt the alternative system of open or limited competition, and, as is done in most large businesses, employ a central buyer distinct from, but the agent of, the requisitioning departments. We have at the War Office a permanent official, the Director of Contracts, whose duty it is to make contracts for any articles or services demanded by the military departments, to specifications drawn by them, and subject to their inspection. Not only does this centralization lead to economy; but it also ensures continuity of policy and uniformity in the treatment of contractors and of labour questions. It is for this reason that Works Contracts, although of a different nature to contracts for stores, are included in the duties of the Director of Contracts.

The Contract Department is the nearest approach we have to a business department in the commercial sense; but if we wish contractors of the better class to deal with us, it is important that we should only imitate business methods in so far as they are above suspicion. It is therefore the duty of the Director of Contracts to be responsible for the general conditions of all Army Contracts and for the procedure to be adopted in calling for tenders and in the placing and subsequent administration of contracts, whether the contracts are made at the War Office or locally in commands. The regulations governing this procedure are detailed in character and of a stringent nature. A first impression of them may be that they are too rigid, and that they imply some distrust in officers; but it will soon be realized that this insistence on correct method of procedure is of the utmost importance, not only in the interests of the State, but in the interests of the officers themselves. For, like the man who deals in horses, the man who touches contracts is, in the opinion of a great part of mankind, immediately suspect. Disappointed contractors are at times reckless in their insinuations; and in order that there may be no difficulty in rebutting them, it is necessary that the chain of procedure should be formally correct in every link and such as can be publicly explained and justified without the possibility of the honesty of any single individual being called in question.

At home stations tenders for Triennial Contracts and for special Works Services estimated to cost £2,000 or more are invited locally, but accepted at the War Office. For smaller services at home and for all services abroad the acceptances are made locally, subject to an *ex post facto* review of the proceedings by the Director of Contracts. In any case it is important to remember that the contract is between the Secretary of State for War and the contractor; and the Commanding Royal Engineer, whose duty it is to see to its faithful execution on both sides, cannot alter its conditions in any way without reference to the War Office through the General Officer in Charge of Administration. It should always be borne in mind that the contractor, as well as the War Department, has his legal rights, and that considerate treatment may facilitate the satisfactory execution of the work and by encouraging firms to tender increase competition and thereby lead to economy. The conditions of contract are, perhaps unavoidably, somewhat stringent; hence the special need for equity and consistency in their enforcement.

I should like before concluding to submit a few remarks on Store Accounting in general and Engineer Storekeeping in particular. As in the case of cash expenditure, so also in the case of stores detailed and accurate accounts are indispensable. "Put all in writing that thou givest out or receivest in." That maxim is more than 2,000 years old; yet even in this present day it is extraordinary how many people there are, both in and out of trade, who are insensible to the importance of accurate book-keeping. In all store accounting the transactions must be supported by proper vouchers for both receipts and issues. If goods are purchased for delivery to store, a certificate of receipt must be given on the bill before it is passed for payment; if they are received from another store there must be a receipt voucher corresponding to the issue voucher supporting the account of the issuing store. It is the auditor's duty, by comparing store accounts with cash accounts and with other store accounts, to see that the goods bought or transferred are correctly brought on, or it may be written off, charge. There is not much difficulty in the case of Ordnance Stores, which are for the most part wholesale stores; in their case transactions are in bulk, and the issues are normally made to other wholesale stores or to retail stores under the Army Service Corps or the Royal Engineers, to whom the responsibility for retail issues is thus transferred. Retail issues are generally made for consumption; they must be supported by the signed requisition of the officer or other official duly authorized to make such requisitions. This is the case with both Barrack Expense Stores and Royal Engineer Stores. The issues from the former are, however, generally based on scales laid down in regulations; and the consumption can therefore readily be checked. But in the case of consumable Engineer Stores any definite scale of issue cannot be prescribed, and there is consequently no efficient check on consumption, beyond the general check of the Division Officer or the Officer in Charge of Stores. In matters of detail we have, as in so many other instances, to rely on the honesty of the Foreman of Works, on whose authority the issues are made.

It is admitted on all sides that Engineer Storekeeping has not in the past been satisfactory; but it is admitted at the same time that such failure as there has been has, for the most part, been due to inadequacy of staff and to a faulty system. Both these defects have now been remedied, by the appointment of Quartermasters as Officers in Charge of Stores with a special staff of ledger-keepers and store clerks, and by the introduction, now being made, of a new system, under which the discrepancies, so frequent and considerable in the past, should tend to disappear.

It is one of the first principles of a sound system of store accounting that the ledger-keepers should be entirely independent of the storeholders, and that the latter, who should keep their own records on tallies, should be forbidden all access to the ledgers. Disregard of this principle paves the way for dishonesty and the "cooking" of accounts; and it is in the disregard of this principle that one of the main faults of the old system of Engineer Storekeeping lay. I need hardly point out that, whatever the system may be, efficiency of storekeeping and accuracy of store accounting can best be secured by careful and continual stocktaking.

Finance and Accounts cover a wide field. The survey which I have attempted has embraced but a small portion of that field; and space has restricted me to considerations of a more or less general nature. Those who desire details, will find a plethora of them in the book entitled *Regulations for Engineer Services*. The size of the book, though it has been reduced, may still be forbidding, for we are all agreed that regulations are irksome and the multiplication thereof an evil; but it is justified by the responsible authorities at the War Office on the ground that the book is not strictly confined to regulations, but is more in the nature of a manual. A new and completely revised edition, so badly needed, has at last made its appearance; and I may, in conclusion, recommend it to special study as the book wherein is set forth the whole duty of man—at any rate within the sphere of Finance—if he happens to be a member of the Works Branch of the Corps of Royal Engineers.

CEMENT IN THE TROPICS.

By CAPT. K. E. EDGEWORTH, R.E.

INTRODUCTION.

THE use of Portland cement in the construction of buildings has largely increased in recent years both in England and in America, and fresh opportunities for its employment are constantly being brought to notice. Although the ordinary uses and treatment of Portland cement are matters of common knowledge, there are certain properties of the material less widely known, which attain importance in tropical countries, and it is with these special peculiarities that it is proposed to deal in the present notes.

In discussing the setting of Portland cement there are two distinct stages which may conveniently be referred to as "setting" and "hardening" respectively. "Setting" is the initial change from a soft or plastic mortar to a friable solid. It is usually effected with great suddenness and is accompanied by the evolution of heat. "Hardening," with its accompanying increase of strength, continues for months or even years, and is due to a different set of chemical changes, although the exact nature of the reactions taking place is imperfectly understood.

The first six subjects which it is proposed to discuss are matters which affect the amount of cement used. In England cement is so cheap that economy of cement is usually of less importance than facility of construction. Abroad however the cost of cement may be much higher than it is at home, and the question of economy of cement may become of paramount importance.

SELECTION OF A SUITABLE CEMENT.

The British Standard Specification ensures a material which will give fairly uniform results when used at home, but it by no means follows that the same cements will be equally reliable when used in the tropics. The effect of temperature in increasing the rapidity of set will be discussed below, but increase of temperature does not affect all cements equally. Certain cements are slow setting at 20° C. and quick setting at 30° C. This can only be ascertained by testing the cement at the higher temperature, and it is desirable therefore that the tests specified should be carried out as nearly as possible at the temperatures at which the cement will probably be used. It will always be found that manufacturers are willing to meet customers requirements by producing special cements for special purposes.

Even more important than temperature, however, is the effect of storage. Cements containing free lime are improved by storage, since the hydration of the free lime increases the soundness. On the other hand cements containing a high proportion of alumina, particularly if underburnt, become quick setting by the absorption of water and carbon dioxide. A typical example is given by Messrs. Reibling and Salinger. The cement contained 8·5 per cent. alumina and certain samples were collected in cans while others were collected in paper bags. After eleven days the samples were tested. Those from the cans showing 2·63 per cent. loss on ignition (H_2O and CO_2) set in 1 hour and 30 minutes, while those from the bags showing 3·92 per cent. loss on ignition set in 23 minutes. Such a cement is obviously quite unsuitable for use in countries where it is liable to long storage and exposure.

No method of overcoming this difficulty has been definitely accepted by engineers, but two points appear to be of primary importance. Firstly the cement should be low in alumina, the best results being obtained if the alumina is less than one third the silica. Secondly underburnt cement is particularly to be avoided.

The importance of proper packing should also be emphasized. It is not sufficient to exclude water from the cement, but as far as possible air should be excluded also.

It may be well to include a warning against "slag-cement" and similar materials which are manufactured in considerable quantities on the Continent. They resemble Portland cement in many ways, but are much less reliable, and should be used with great caution.

Many interesting points arise in connection with the testing of cement, but they are not suitable for abstracting and a reference should be made to larger works on the subject.

FINENESS OF GRINDING.

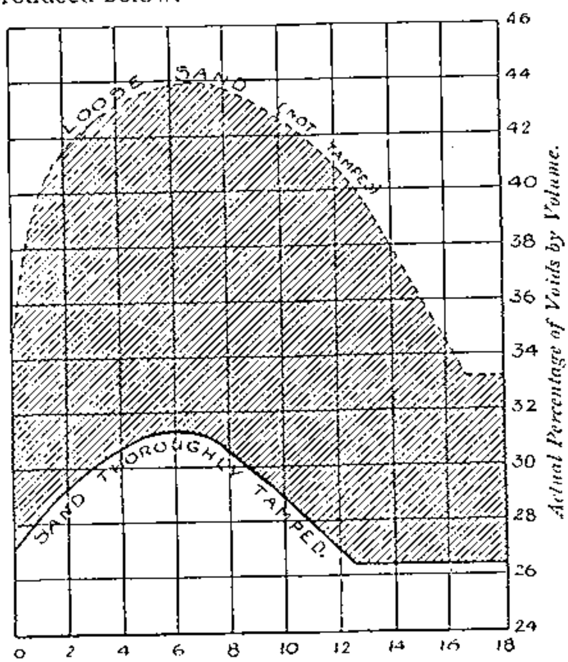
It has long been recognized that Portland cement depends for its activity upon the fineness of the grinding, and that it is only the very fine and impalpable powder which constitutes the active material. In ordinary commercial cement, it is probable that this active material is less than 40 per cent. of the whole, and there is therefore abundant opportunity for increasing the activity by finer grinding. For use in England it is found that, beyond a certain point, the increased strength is not a compensation for the increased cost of additional grinding, but it is obvious that different conditions may lead to different results, and that the value of the finer cement will increase in direct proportion to the cost of transport. When cement has to be brought a long distance, it is worth while to consider whether it would not be cheaper to employ a lesser quantity of finely ground cement at an increased price per ton, instead of the usual commercial article.

A good example of the advantages of fine grinding is furnished by the material known as "sand-cement." This is produced by mixing the ordinary Portland cement with two or three parts of sand and then regrinding it. The resulting material can be mixed with a fresh portion of sand, and will give results not much inferior to the original cement. Thus 1 part of cement may be mixed with 2 parts of sand to produce 3 parts of "sand-cement." The 3 parts of "sand-cement" may then be remixed with 6 parts of sand, and the resulting mortar will have approximately the same strength as a 1 : 3 mortar with the original cement. It might be expedient in certain cases to import cement and convert it locally into "sand-cement," thus effecting a considerable economy in the cost of transport.

Water used in Mixing.

The amount of water used in mixing a concrete affects the strength in various ways. In the first place an excess of water retards the setting and gives lower strengths especially for short periods. In the second place an excess of water is liable to wash away the grains of cement leaving portions of the concrete without any cement at all. In the third place the quantity of water used affects the density of the concrete when placed in position.

This last effect is well illustrated by some experiments of Mr. Fuller's on sand. He took a natural sand and measured the voids with different proportions of moisture. The results are shown in the diagram reproduced below.



Percentage of Absolute Voids in a Natural Bank Sand containing Varying Percentages of Moisture.

(From "*Concrete, Plain and Reinforced.*" *Taylor & Thompson*).

There is no doubt that the effect is due to the surface tension of the water. When the grains of sand are covered with a film of water, the surface tension will cause the grains to adhere together. This will increase the friction between the grains, and will prevent the sand from being consolidated to the same extent either by gravity or by ramming as the case may be. It is evident that the effect will reach a maximum when each grain is just covered by a thin film of water, and that it will decrease if the water is either in defect or in excess. It being impracticable to place concrete dry, the surface tension can only be avoided by using more water than is necessary to wet the surface of the grains, that is to say by using a plastic mortar. Small grains will obviously require more water than larger ones as they have a larger surface per unit volume.

Probably the ideal concrete in practice is obtained when the water will *just* flush to the surface when the mixture is fully rammed. Varying conditions will lead to corresponding variations in the amount of water which is required to produce the best result. Thus concrete blocks which are to be removed at once from the mould require to be rather dry, as an excess of water makes them lose shape and stick to the mould. Up to this point the more water they get the better. On the other hand reinforced concrete is used rather wet, as it must be free from hollows and the presence of the reinforcement prevents proper ramming.

ADDITION OF LIME.

The effect of lime on Portland cement mortar has been discussed recently in the *R.E. Journal*, and I shall merely quote the principal results.

(i.). A mortar of ·85 cement, ·15 lime, and 3 sand is as strong as 1 cement, 3 sand.

(ii.). A mortar of ·6 cement, ·4 lime, 5 sand compares favourably as regards strength with 1 cement, 5 sand.

(iii.). A mortar of ·85 cement, ·15 lime, and 5 sand is almost impervious to water while a mortar of 1 cement and 5 sand is not.

The advantages of adding lime are greater with weak mortars. The writer has found that tension briquettes composed of 1 cement, 1 lime, and 12 sand, have the same strength as 1 cement and 8 sand. The briquettes were set under water but were tested dry.

Lime should not, however, be used in reinforced concrete as it may contain substances injurious to the steel.

SANDS AND AGGREGATES.

That coarse sand is better than fine sand for making mortars is generally recognized, but the true reason is not so well known.

Suppose a number of spheres of radius r resting against a flat surface, the arrangement of the spheres being hexagonal. The distance from the centre of each sphere to the surface is r.

If a fresh layer of spheres be added the distance between the two layers will not be $2r$ but $2r\sqrt{2} \div \sqrt{3} = 1{\cdot}63r$, and so on for other layers.

That is to say that the layer in actual contact with the surface will have a greater proportion of voids than the bulk of the grains which will take up the arrangement known as "normal piling."

It is well known that sand grains, though not perfectly spherical nor uniform in size, can assume an arrangement giving a maximum density and corresponding to the "normal piling" of uniform spheres. When sand grains adjoin a surface they will also exhibit a similar increase in the normal proportion of voids, or to put the matter more simply, the layer nearest the surface will be less dense than the remainder.

When two sets of grains of different diameters are mixed together the finer grains will not be able to adjust themselves perfectly to the voids in the larger. Even when the difference in size is great, there will still be a "surface effect" due to the causes described above. A calculation on the assumption of uniform spheres shows that the effect is still appreciable when the finer grains are one-fiftieth the diameter of the larger. Since a considerable number of cement grains will exceed $\frac{1}{500}''$ in diameter we should expect to find that the strongest mortars could only be obtained with sand grains measuring $\frac{1}{10}''$ and over, a result which agrees well with experience.

Coarse sand alone, however, is only suitable for very strong mortars such as those containing 1 cement : 2 sand, and for weaker mortars the introduction of some fine sand is desirable.

A French authority, M. Feret, took three sands :—

A very coarse sand	·20″ to ·08″
A medium sand	·08″ to ·02″
A fine sand	less than ·02″

He mixed these sands in every possible proportion, and used the mixtures in mortars composed of 1 cement and 3 sand. He found

(i.). That a sand composed of 4 parts very coarse sand with 1 part fine sand gave the best possible mortar of 1 cement 3 sand.

(ii.). That the strength of such a mortar is more than twice as much a 1 : 3 mortar made with ordinary coarse (*i.e.* medium) sand, and more than three times as strong as mortar made with fine sand only.

It is necessary to observe, however, that the advantages of very coarse sand are less marked when used in concrete than when tested alone, as the coarse sand does not accommodate itself so readily to voids in the aggregate.

M. Feret also found that for other proportions than 1 : 3 the most advantageous mixture was obtained when the weight of coarse sand is equal to twice the combined weight of fine sand and cement. This result is of particular importance for the weaker mortars and concretes. A mortar containing the proper proportion of fine sand may be 50 per cent. stronger than a mortar in which fine sand is entirely absent, or in the alternative a mortar of equal strength can be obtained with about 30 per cent. less cement.

The proportioning of sand to aggregate is usually done by measuring the voids in the latter, and this method is sufficiently accurate when the aggregate consists of fairly large uniform pieces such as broken stone. Better results can be obtained however when the aggregate and sand together contain material which is uniformly graded from the largest to the smallest.

The question has been very fully examined by Mr. Fuller, an American investigator, who has devised a method of grading the aggregate by means of sieve analysis curves. He found that, with an ordinary gravel divided into two grades, the proportions required for a waterproof concrete were about $1 : 2\frac{1}{2} : 4\frac{1}{2}$. Using the same gravel but separating it into five grades instead of two, he found that a water-tight concrete was obtainable with a mixture of 1 : 3 : 7, thus effecting a saving in the quantity of cement used of more than 26 per cent.

Regarding as aggregate all particles greater than one-sixth the maximum, his ideal curve shows that the aggregate should be to the combined sand and cement in the proportion of three to two. The aggregate should in itself be uniformly graded, that is to say one-half should be more than the mean diameter and one-half should be less than the mean diameter. Mr. Fuller's curve for the sand gives mixtures not very different to M. Feret's as regards fine sand, but it recommends coarse and medium sands in about equal proportions instead of coarse sand only. The discrepancy is probably due to the fact that the former experiments refer to concretes whereas the latter were made on mortars only. It is noticeable that the proper proportioning of fine sand is of more importance than all the rest put together. The following is an example of a concrete proportioned according to the above rules :—

2 cement.
2 fine sand (under ·02″).
4 medium sand (·02″ to ·08″).
4 coarse sand (·08″ to ·25″).
9 small aggregate (·25″ to ·87″).
9 large aggregate (·87″ to 1·50″).

For stronger mixtures cement can be substituted for the fine sand and *vice versâ*.

It is not always necessary to separate all the above constituents. Sometimes a mixture of three grades will fulfil the above rules with sufficient accuracy for practical purposes.

USE OF MINIMUM QUANTITY OF CEMENT WHICH WORK ACTUALLY REQUIRES.

Strength is not the only property which has to be taken into account in deciding the proportion of cement to be used in any particular job. In Europe a porous concrete would be liable to disintegrate under the action of frost, or an impermeable concrete may be required for other reasons.

For the construction of dwelling houses in tropical countries there is no need to use an impermeable concrete, and the only considerations are those of strength and convenience of manufacture. Owing to the great cost of forms when concrete is used in mass, the most usual method of construction is by means of concrete blocks which are allowed to set before being built into the work.

The blocks are usually made with a comparatively dry concrete, and are immediately removed from the mould on carrier plates. After one or two days they are tipped off the plates and covered with damp sand until sufficiently hard for building with. The present writer has found that blocks can be successfully manufactured with a mixture of 1 : 8 : 16 (by weight), if the blocks are allowed to remain two days on the carrier plates. With care in handling the breakages should not exceed 5 per cent. In this case 90 per cent. of the sand passed a sieve with 30 meshes to the linear inch, and the sand must therefore be classed as fine. With a mixture of fine and coarse sands in the proper proportion there should be no difficulty in making blocks with a mixture of 1 : 12 : 24. The crushing strength of such a mixture should be about 700 lbs. per square inch at the end of three months. This is considerably more than is required for single storey buildings, and it may in fact be stated generally that, for single storey buildings, the block will be more severely tried during manufacture and erection than it can afterwards be in the building itself. By setting blocks under glass in the sun, the writer has actually used a mixture containing half the proportion of cement stated above, but the cost of cement was about £12 per ton and the circumstances must be regarded as exceptional.

Time of Setting and Hardening.

The rapidity of setting increases to a remarkable extent with increase of temperature as will appear from the following table (due to Bauschinger) :—

Temperature. °C.	Initial Set. Hours.	Final Set. Hours.
0	21	38
5	9	20
10	5	13
15	3¼	10
20	2	7½
25	1½	6¼
30	1	5
35	¾	4¼
40	½	3½
45	¼	3
50	0	2½

This property of cement has several important practical applications which are enumerated below.

(i.). The British Standard Specification states that the cement must be tested between certain temperatures. If this is not possible then an allowance would have to be made for the conditions under which the test is actually carried out. The increased rapidity with which cement sets in hot climates has occasionally been a source of misunderstanding between purchasers abroad and manufacturers at home.

(ii.). In hot climates the materials for the day's use should not be exposed to the sun, and water should be used as cold as possible.

(iii.). Only slow-setting cements should be specified for ordinary work.

(iv.). Cement mortar or concrete should only be mixed in such quantities as are required for immediate use, as they may deteriorate perceptibly in a couple of hours.

(v.). The accelerated set may be taken advantage of in various ways. For example concrete blocks may be set under glass frames in the sun. There is also a process for manufacturing blocks or tiles from wet concrete which is poured into a mould containing a steam jacket. The block dries sufficiently in a few minutes to enable it to be removed from the mould and no doubt the partial setting of the concrete plays an important part.

The increased rate of hardening (as distinct from setting) with increasing temperature depends greatly on the quality of the cement, as certain ingredients may adversely affect the strength at high temperatures. This falling off in strength is less noticeable with Portland cements than with the natural cements which are largely used in America, but it should always be allowed for in blocks prepared by any of these processes.

As an example of what can be done, the writer has found that tension briquettes composed of 1 cement $7\frac{1}{2}$ sand, placed under a double glass in the sun in Cairo during the summer time, attain a strength in three days which they would take about three weeks to acquire under ordinary circumstances.

CHANGE OF VOLUME IN SETTING AND HARDENING.

In the absence of impurities there is no appreciable change of volume during the setting of cement.

During hardening, cement expands in water and contracts in air.

Hardened in air, neat cement shrinks almost uniformly for the first three months, the linear shrinkage in that time being from ·12 to ·34 per cent. Mortar composed of 1 cement and 1 sand shrinks from ·08 to ·17 per cent. in the same time. Further information is needed, but the writer suggests that the ultimate value of the shrinkage is not less than the higher of the two figures given above, and that the contraction of weaker mortars is in proportion to the amount of cement, *i.e.*, the final contraction of a 1 : 6 mortar would be about ·03 per cent. or 1 in 3,300.

When cement concrete is used, or when masonry or brickwork is built in cement mortar, the contraction will depend on the nature of the aggregate. The more rigid the aggregate the less will the contraction of the cement affect the masonry as a whole. A good example of the truth of this principle recently came to the writer's notice. Some new barracks in Egypt were constructed with "sand-lime" bricks in 1:6 cement mortar, the roofs being of steel joists filled in with concrete. The modulus of elasticity of the "sand-lime" brick is less than half that of the cement mortar, and in consequence the cement mortar exerted a predominating influence on the final result. The buildings cracked right across, floors, walls, and roofs being equally affected. The average distance between the main cracks was about 60′. The enclosure walls showed the same trouble with even greater regularity, the cracks appearing throughout the entire wall at intervals of 20′ or 30′. Walls built on the same site and with the same bricks, but in lime mortar, were comparatively free from cracks. Sometimes the cracks made their appearance when the wall was only a few courses high.

Although the trouble was due in the main to the use of cement mortar, it may be well to add that the "sand-lime" brick itself may have contributed to the trouble, as experiments have since shown that it expands about 1 part in 5,000 when immersed in water, and contracts again on drying.

In addition to large cracks affecting the whole building, vertical cracks are nearly always traceable in concrete buildings underneath the windows. According to the circumstances of the case they may vary in width from a mere hair crack to $\frac{1}{8}''$ or even larger.

There are three methods of avoiding cracks in cement buildings, or at all events of reducing them to a negligible amount.

The first method is to introduce horizontal reinforcement. Unless a very large amount is used the reinforcement will not prevent the cracks entirely, but it will diminish their importance by causing them to appear at more frequent intervals. Theory indicates that the larger the amount of reinforcement and the smaller the rods composing it, the closer together will be the cracks and the less in consequence will be their individual importance.

Reinforcement amounting to $\frac{1}{3}$ per cent. will be found to meet ordinary requirements.

The second method of preventing cracks is to introduce contraction joints at suitable intervals. The distance between the joints will vary from 5′ or 6′, in the case of pavements, to about 70′ in the case of sewers and culverts. In American practice they are usually placed 50′ or 60′ apart in ordinary buildings. These contraction joints, however, are not usually sufficient to prevent the smaller cracks which appear where the masonry is weakened by window openings. To avoid these it is desirable to introduce a little reinforcement both into the sills and lintels.

The third method of preventing cracks is only applicable to buildings constructed of concrete blocks. It consists in allowing the blocks to harden before building into the work for a sufficient period to enable the contraction to reach its full amount. Owing to the thinness of the joints and the rigidity of the blocks themselves, the contraction of the mortar is insufficient to affect the masonry as a whole.

The writer is not acquainted with any publication which gives the period after which contraction ceases, and the following results based on personal observation of actual buildings are put forward with all due reserve. He finds that buildings are free from contraction cracks if the blocks are set for twelve months, and that, if the blocks are set for three months, the cracks will not be of sufficient magnitude to attract attention unless specially looked for.

In any case it is well to avoid weakening the masonry more than can be helped in the arrangement of the openings. For example, reinforced lintels should be used instead of arches, and ventilation openings should be placed, not immediately above doors and windows, but in the intervals between them.

REINFORCED CONCRETE.

In all important construction the resistance of reinforced concrete is increased by the introduction of stirrups or similar devices to take the shearing stresses, but it is not usual to employ them except on work of some magnitude. The writer has observed cases in which horizontal cracks have made their appearance in reinforced concrete lintels. As failure did not occur it is obvious that the cracks were not due to overloading, and in fact the loads were far within the capacity of the beams.

The trouble is doubtless due to the contraction of the upper layers of the concrete in hardening. The contraction of the lower layers being prevented by the reinforcement, there is a tendency for the upper and lower halves of the concrete to separate.

In very dry climates therefore it would appear to be undesirable to omit the reinforcement against shearing, even in cases where the strength of the beam appears sufficient without it.

DAMP-PROOF COURSE.

Bitumen sheeting shows excessive softening in hot climates, and the action is more marked with concrete walls on account of their thinness. Trouble arises in two ways.

Firstly, the compression of the sheeting is seldom uniform, and cracks may develop in the masonry owing to unequal settlement.

Secondly, the bitumen sheeting acts as a lubricant and forms a plane of weakness on which the wall can slide. The writer has seen the centre of a long wall bulging outwards the ends being held in place by cross-walls. The actual movement was about an inch, and the wall was subsequently pushed back about half this amount and retained in place by buttresses. The unequal expansion of the wall due to the sun shining on the outside is the only force which can be suggested capable of producing the movement.

The remedy is to avoid bitumen sheeting if possible. There are many cases in which a damp-proof course can be dispensed with. For example, when building with concrete blocks on a dry, sandy, or gravelly soil, a course of solid blocks to separate the hollows in the walls from those in the foundations will usually be sufficient. Asphalte appears to give less trouble than bitumen sheeting if a damp course of some sort is required.

Concrete Roofs.

For roofs, concrete is generally employed in combination with iron either in the form of girders or reinforcement. Roofs composed of these materials possess not only great weight but also great rigidity, and their expansion and contraction are a frequent cause of trouble.

The expansion taking place in a direction parallel to the supporting walls presents no great difficulty. If the roof is constructed of steel girders filled in with concrete, the girders themselves form joints at which the necessary movement can take place. In reinforced roofs expansion joints can be left at convenient intervals.

The expansion taking place at right angles to the supporting walls however cannot be dealt with entirely by this method, as the span itself must remain intact. A description of two actual cases will give the best idea of the class of trouble which is to be anticipated.

Case I.—The buildings are ordinary barrack blocks and accessories with spans varying from 15 to 18′. The method of construction is shown below.

In the summer following the completion of the barracks it was found that large horizontal cracks had appeared at A and that the parapet walls were being bodily pushed outwards. Sometimes slight cracks were also noticeable at B.

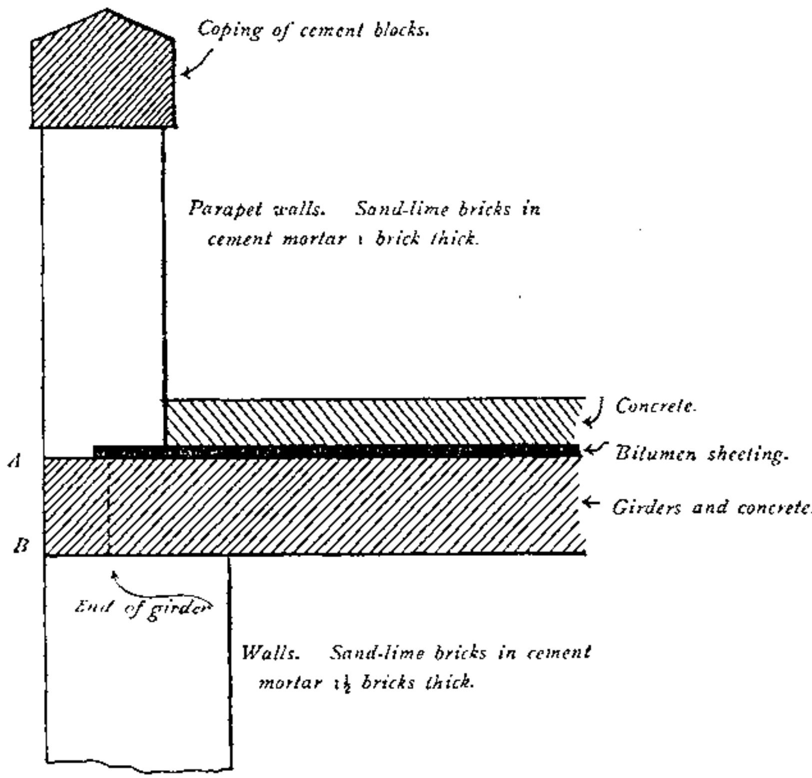
The following precautions suggest themselves as a means of avoiding similar trouble :—

(i.). Lime concrete should be used in preference to cement as a protection for the bitumen sheeting on flat roofs.

(ii.). If cement concrete must be used, a space should be left between the concrete and the parapet wall, and should be filled with asphalte or some other elastic material.

(iii.). The bitumen sheeting should not be carried straight through the parapet wall. It should first be carried a short distance vertically upwards and then tucked in.

(iv.). If the outer surface of the wall is plastered, the concrete of the roof should be carried outwards to form a cornice. Any small cracks that may appear will not then disfigure the building.



Case II.—A large engine room, span about 40′. Roof of reinforced concrete of the usual type with slab and T beams in one piece. No bitumen sheeting or other covering above the concrete.

The roof caused such extensive and repeated cracks in the walls that the owners were compelled to erect a galvanized iron pitch roof over the reinforced concrete in order to keep off the sun. The trouble then ceased.

This case is principally of interest as showing that expansion troubles are accentuated in large roofs. The actual remedy applied is somewhat crude, and a few inches of lime concrete would probably have been equally effective and would certainly have been more elegant. The trouble could of course have been avoided by the introduction of suitable expansion joints in the walls and roof when the building was first constructed.

Effect of Drying.

Some interesting experiments were made by Mr. Lucas at the suggestion of Major Tucker. A number of ordinary tension briquettes were made of neat cement. Some were tested wet, while others were allowed to dry for varying periods in air. The results were as follows :—

	Tensile Strength lbs. per sq. in.	Decrease Per Cent.
7, 8, 8½ and 9 days in water, mean	463	—
7 days in water + ½ day in air	315	32
7 " " 1 "	281	39
7 " " 1½ "	248	46
28, 29½, 30 and 30½ days in water, mean ...	596	—
28 days in water + ½ day in air	373	37
28 " " 1 "	320	46
28 " " 1½ "	236	61

Briquettes 7 days in water ½, 1, and 1½ days in air, replaced in water for ½ day and then tested gave a mean of 499 lbs. per square inch. Briquettes 28 days in water, ½, 1, and 1½ days in air, replaced in water for 1 day and then tested gave 541 lbs. per square inch.

Similar experiments on mortar of 1 cement, 3 sand did not show any decrease of strength on drying.

As experiments are still in progress it would be premature to offer possible explanations of this somewhat remarkable result.

Effect of Exposure to the Sun.

The usual method of hardening concrete blocks is to place them in piles and spray them from time to time with water. The writer undertook some experiments to ascertain whether exposure to the sun when the block was green was likely to prove detrimental.

The experiments were made in Cairo during the months of June and July. Tensile briquettes 1½″ × 1½″ of the usual shape were employed. Half the briquettes of any batch were left in a damp room for 24 hours and were then placed in water. The other half were placed outside. Being made in the evening they would usually be exposed to the sun within about 15 hours of their manufacture. After three days' exposure these blocks were also placed in water. The whole batch was tested after a period of three or four weeks. "Dry" mortars were removed from the mould at once and "plastic" mortars after 12 hours. The different batches are not comparable as they were made at different times with different cements.

The results were as follows:—

Proportion by Weight. Cement.	Sand.	Water.	Treatment.	Time of Setting.	Tensile Strength on 2¼ Square Inches.					Mean.	Effect of Exposure to Sun.
1	7	·45	Under cover	21 days	240	240	250	230	220	236	+ 11%
			Expd. to sun		230	270	240	260	310	262	
1	5	·4	Under cover	21 days	270	280	250	—	—	266	+ 14%
			Expd. to sun		320	290	300	—	—	303	
1	3	·3	Under cover	21 days	345	320	350	—	—	338	− 1%
			Expd. to sun		280	395	330	—	—	335	
1	3	·4 *	Under cover	28 days	570	560	600	—	—	577	− 16%
			Expd. to sun		420	560	480	—	—	487	
1	3	·45 *	Under cover	28 days	500	535	535	—	—	523	− 5%
			Expd. to sun		530	475	475	—	—	493	
1	2	·3	Under cover	28 days	640	640	—	—	—	640	− 16%
			Expd. to sun		480	600	—	—	—	540	

The mixtures marked * were plastic. The other mixtures were dry enough to admit of being immediately removed from the mould.

The general result is that the strong dense mixtures are adversely affected by the sun, while the weak porous mixtures receive no harm. Too much reliance must not of course be placed on results obtained from such a small number of specimens, and in any case different results might be obtained with other materials. In particular the amount of water used exerts an important influence.

CONCLUSION.

A list of references is given below. Extracts have been freely made from all the works named and the writer takes this opportunity of acknowledging his indebtedness. Thanks are also due to Colonel Davidson, R.E., and Major Tucker, of the Barrack Construction Department for permission to use apparatus and for advice and encouragement, and to Sergt.-Major Button, R.E., for help and advice with the actual tests.

One word may be added in conclusion. These notes are intended to arouse interest in the various points mentioned rather than to act as a guide on such an extensive subject. Those in charge of important works will naturally consult the original treatises for fuller information. It must always be remembered however that the materials used are of infinite variety, and that no amount of knowledge derived from books will take the place of that gained by experiment in the laboratory or observation of actual buildings.

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Major-General William Edmund Warrand, R.E. (Bengal), J.P., D.L.

From a photograph by BULLINGHAM, *Harrington Road, S.W.*

MAJOR-GENERAL WILLIAM EDMUND WARRAND

MEMOIR.

MAJOR-GENERAL WILLIAM EDMUND WARRAND, R.E. (BENGAL), J.P., D.L.

THE late Major-General William Edmund Warrand, R.E. (Bengal), J.P., D.L., Notts and Inverness; Alderman of the Notts County Council; F.G.S., F.B.A.A., was born on the 2nd January, 1831, at Westhorpe Hall, Southwell, Notts, the home for generations of his ancestors, and dating back to the reign of Henry VII. The Warrand family have produced many distinguished soldiers, and General Warrand was the son of the late Major Robert Warrand of the Inniskilling Dragoons who was wounded in the Mahratta War. His father, grandfather, and great-uncle before him saw active service, and his maternal great-uncle, General Jekell, married Lady Griselda Stanhope, who was a niece of Pitt.

Given a cadetship by Sir James Hogg, Bart., M.P., at the request of the Earl of Lincoln, Warrand entered the Honourable East India Company's Military College at Addiscombe in February, 1848, where his contemporaries were the late Lieut. Leverton Donaldson, killed in action near Rangoon in 1852; the late General William West Goodfellow, C.B., Colonel Commandant, R.E. (Bombay); the late General Sir George Chesney, K.C.B., C.S.I., C.I.E., Colonel Commandant, R.E. (Bengal); and the late Major-General William Spottiswoode Trevor, V.C., R.E. (Bengal). After passing through Addiscombe he was appointed 2nd Lieutenant in the Bengal Engineers on the 9th June, 1849, and having completed the usual course at Chatham he went out to India, and arrived in Calcutta in May, 1851. He was then ordered to do duty with the headquarters of the Bengal Sappers and Miners at Loodianah. In May, 1855, he was appointed to officiate in charge of the 3rd Division, Department of Public Works, and after passing the language examination he was placed in charge of the Western Sirhind Division in April, 1857.

On the outbreak of the Indian Mutiny, Lieut. Warrand was ordered to Ferozepore and aided in repelling an attack by the mutineers on the Ferozepore Arsenal which was the largest in Upper India. Had it fallen into the hands of the rebels, Delhi could not have been captured without considerable delay, as the besieging force depended mainly upon Ferozepore for the supply of the munition of war. The native garrison consisting of one cavalry and two infantry regiments, a battery of field artillery and a company of foot artillery, broke out on the 13th May. The mutineers forced their way inside the fort but were fortunately checked by the wall which surrounded the arsenal, and this obstacle, insignificant as it was, enabled the guard to hold its own. Originally this guard consisted entirely of native soldiers, but after the outbreak at Meerut, Europeans had been told off for this important post; so strong, however, here, as elsewhere, was the belief in the loyalty of the sepoys that the native guard was not withdrawn. This same guard when the attack took place, did its best to assist the assailants and even prepared scaling ladders to enable the latter to gain access to the magazine enclosure. The Europeans however were equal to the emergency; they overpowered and disarmed their treacherous companions, and then succeeded in beating off and dispersing the attacking party. Being foiled in this attempt, the mutineers returned to the cantonment, set fire to the church and other buildings, and then started for Delhi.*

From Ferozepore Warrand was ordered to Delhi and was appointed Field Engineer to the Delhi Field Force from the 29th July, 1857.

It may not be out of place here to give some idea of the difficult task in which he was now called to take a part.

During the early part of the siege the Delhi Field Force was engaged in repelling the enemy's sorties. There were usually three or four sorties in each week, and some of these were on a very large scale. Large bodies of the rebels could be seen issuing from the Lahore Gate, cavalry, artillery and infantry. The general plan of the sorties was to turn our right flank by a large force and to penetrate into our camp, while smaller numbers advanced under cover of the rocks and bushes for a direct attack on the ridge. In crossing the road leading from the Lahore Gate to the Subsi Mundee the cavalry and artillery came under the view of our right battery which poured a heavy fire into the enemy's troops. Those that escaped this ordeal swerved to the left, and returned in a disorganized state, by the Kabul Gate, or some of the other gates. The enemy also made frequent night attacks on our position, and a continual roll of musketry would be kept up for hours. There was a small post among the rocks on the right of the ridge called the Sammy House which was obstinately held by our men throughout the siege, and the writer of this Memoir remembers seeing the corpses of the mutineers after one of their attacks, piled up among the rocks and sweltering in the sun, there being no men available to bury them.

The ground around Delhi which was traversed by many canals and roads was, at the time of the siege, a tangled mass of old ruins, dense woodland, rice fields and swamps of notorious insalubrity. It offered innumerable facilities for occupation by armed men of any degree of

* The above account of the mutiny at Ferozepore is related in *Forty-One Years in India*, by Field Marshal Lord Roberts.

discipline, and indeed so incompatible were its features with the action of a mass of disciplined troops, that the many combats of which it was the scene were rather trials of skill between small bodies than operation by masses.

So many fluctuations in the strength of the Delhi Field Force occurred at an early period of the siege that the precise numbers cannot be given, but from 500 to 600 sabres, from 2,500 to 3,000 bayonets, and 22 field guns may be taken as fairly representing the strength during the earlier operations. It is extremely difficult to form an accurate estimate of the strength of the enemy, but as some of the most important accessions which he received did not occur until the siege had been some time in progress, it may be inferred that on the 8th June the garrison of the place did not exceed about 8,000 or 9,000 disciplined soldiers, supported by about the same number of half-disciplined and wholly undisciplined but armed men.

For operations in the open field the sole strength of the garrison was in the trained soldiers, but for the operations in the rugged ground around Delhi, resolute men familiar with their weapons and profiting by the universal cover everywhere supplied in some house or other, were antagonists whom it was necessary to respect.

The garrison by the beginning of July must have consisted of not less than 15,000 to 18,000 trained soldiers, and irregulars in even larger numbers.

The besieging force numbered of all arms under 5,500 fighting men, Europeans and natives. An enterprising enemy might therefore with perfect ease, have maintained one or more strong movable columns, operating constantly on the communications, stopping convoys, harassing small detachments, disturbing the whole tract of country whence supplies were obtained, and finally in all human probability compelling the General in command to raise the siege from the impossibility of procuring subsistence for his army in a position so utterly insecure.

Instead however of obstinate and continuous operations of this class, the enemy was satisfied to make feeble efforts, never sustained for any considerable time, and easily warded off by corresponding movements of columns detached from the force. It was necessary however at the time under notice to take precautions against both forms of attack. The vast numerical superiority of the enemy converted the position of Sir Henry Barnard's force from the very first into that of a besieged, instead of a besieging army.

The attacks by the garrison on all points of the ground held outside the walls were incessant. The casualties of the force day by day were incessant. Many of its bravest and best officers had been killed or wounded; the daily average of casualties among the soldiers averaged from about 30 to 40 and on occasions of vigorous combats the loss rose from 100 to 150. It was scarcely possible to resist the conviction that the army was steadily and surely being used up by the ordinary process of the siege, and it seemed as though a simple calculation would show how long such a rate of waste of life could be sustained in presence of an enemy, by a force numerically so feeble; long it plainly could not be. To shorten the siege, or limit the waste of life, were the urgent necessities of the position.

The total casualties in the two actions of the 10th and 15th July having risen to nearly 500 men, it was necessary to abandon all idea of any active operations against the place from the latter date. Up to that time it had been the personal conviction of the Chief Engineer, duly submitted to the consideration of the General Commanding, that the possibilities of success by assault were such as would justify the attempt being made, should the political necessity for it be so great as to warrant very grave risks being accepted. It was no matter of regret to the Chief Engineer that his judgment on this point was never put to the test, it having been held that the risks were greater than the circumstances of the moment would warrant the General in meeting, but from this time his views were entirely in accordance with that conclusion and thenceforward but one idea regulated the operations of the Engineer Brigade, to prepare, namely, by economy of men and material on the spot, and by the collection of the same from every available point for the breaching of the city walls, and the attack of the place by siege operations, followed by open assault.

It may be remembered that the siege took place during the rainy season, so that the troops were continually drenched. The Engineer officers had to take parties of unarmed coolies out at dusk, and to work between the ridge and the city, their work usually consisting of felling trees and brushwood, and clearing the ground in front of the picquets. Attacked by the enemy in the darkness and rain it was really wonderful how patiently these poor coolies bore their sufferings, and their conduct was a matter of universal admiration. All the troops suffered alike. The officers received a daily tot or ration of rum like the men. The sales of effects of officers who had been killed took place almost daily, and articles of uniform or clothing were in great request. A bottle of beer sold for 4 or 5 rupees, and a bottle of brandy for 20 rupees.

The unarmed pioneers, about 600 in number, were brought down by Lieut. (now Lieut.-General) H. A. Brownlow and they were formed from volunteers taken from the workmen employed on the Ganges Canal. Strange to say, these men, who were at once transferred from the peaceful tasks of day labourers to the most dangerous duties of working parties in siege operations, never exhibited a symptom of fear, but worked under the hottest fire like veterans, and were invaluable. The casualties among them were inevitably very numerous, but no instance occurred of their having hesitated to obey any order, whatever its consequences might have been. Lieut. Brownlow brought with him, under their escort, a large supply of stores of various kinds for the Engineer Park, drawn from the workshops of the Canal Department.

Capt. (now General) Sir Alexander Taylor, G.C.B., had succeeded on several occasions in penetrating alone through the enemy's outposts, for the purpose of studying the ground, and on the general information so obtained and on his own knowledge of the locality the Chief Engineer, Colonel Baird Smith, prepared the project for the attack. On the evening of the 6th September the project was formally considered by General Wilson. General Nicholson volunteered to accompany Taylor to see the ground and the posts selected for the batteries. It was now dusk and they did not know the strength or disposition of the rebels. They went to some of the places of importance and found them unoccupied. Nicholson was satisfied, and reported what he had seen to General Wilson who then gave his sanction to the Chief Engineer's proposals. The project of attack submitted by the Chief Engineer to the Major-General Commanding and honoured with his sanction, provided for a concentrated rapid and vigorous attack on the front of the place included between the Water or Moree and Cashmere Bastions, provision being made at the same time, for silencing all important flanking fire whether of artillery or musketry that could be brought to bear on the lines of advance to be taken by the assaulting column.

Due care was also taken to protect the exposed right flank of the trenches from sorties. The left was secured by being rested on the river, and by the occupation of the Koodsiah Bagh, a very strong post in front.

The best information procurable indicated that on the front of attack the fire of some 25 to 30 pieces would have to be subdued. To effect this 54 siege guns were available.

The plan of attack consisted in principle in establishing on the front of the fortification selected, an artillery fire so much more powerful than that of the enemy on the same front, that the result must be to silence his guns and crush his works.

The Chief Engineer had good information that on the front between the river and the Cashmere Bastion not more than 30 heavy guns could be brought to bear upon our approaches, so arrangements were made for placing 56 pieces of siege ordnance, of various calibres against this front, and in about four days the whole opened fire with terrific effect. Two excellent breaches were made in the walls within 48 hours; the cover for the enemy's infantry was at the same time utterly swept away; an incessant storm of shot and shell poured into the place, and on the 14th September all was ready for the final assault, which was accordingly given with brilliant success.

Lieut. Warrand had been wounded on the 30th August by a fragment of a shell, and his arm had to be amputated. The writer of this Memoir saw him several times after he had been wounded, and he bore his sufferings and the amputation with the greatest fortitude and patience. The plague of flies was very great, the surgical appliances were scanty, and very few either of the officers or men who had to undergo amputation of the limbs survived the operation. General Warrand's splendid constitution and courage enabled him to pull through. His great regret was that he was prevented from taking part in the final siege operations, and in the assault of the place.

When sufficiently recovered from his wound Warrand was sent as a convalescent to Simla, among his fellow travellers during a portion of the journey being the son of the famous Dr. Arnold. He returned to England in 1858, and was received at his family seat at Westhorpe with great rejoicings. He was promoted to be 2nd Captain on the 27th August, 1858, and on the same day was gazetted to a Brevet Majority. At the close of the year 1860 Warrand returned to India as the head of the Civil Engineering College at Calcutta, and he was appointed Deputy Consulting Engineer in the Railway Department at Lahore in March, 1863, and in November, 1863, he was appointed to officiate as Assistant Secretary to the Government of the Punjab in the Railway Department.

After again seeing service with a small expedition against the frontier tribes he returned to England in 1867.

He was promoted to the rank of Regimental Major on the 5th July, 1872, and his other promotions were Brevet Lieut.-Colonel 14th June, 1869, Regimental Lieut.-Colonel 1st April, 1874, Brevet Colonel 1st October, 1877.

He was appointed Commanding Royal Engineer at Chatham and Belfast, and after further periods of service at Newcastle, Aldershot, and Inverness, he retired from the Army in August, 1883, with the honorary rank of Major-General.

General Warrand was always ready to place his military experience at the service of younger men in his profession. He took very great interest in the Nottinghamshire regiments of Volunteers, and, later, in the carrying out of Mr. Haldane's Territorial scheme. He was at once asked to join the Nottinghamshire Territorial Association on its formation, and deference was always paid to his opinions and advice.

In civil life General Warrand proved himself to be possessed of great administrative capacity, and he was actively associated with almost every public body of importance in the county. He had been a member of the Notts County Council since its formation in 1889, and was elected Alderman in 1909. At Southwell he took an active interest in all local matters. He was one of the oldest Guardians on the Southwell Board, and after the remodelling brought about by the Local Government Act of 1894, he was and had been continuously since, triennially co-opted on the Board. For years he was also a member of the Rural District Council and took a prominent share in the discussions on the Southwell drainage scheme.

General Warrand was a Justice of the Peace, and Deputy Lieutenant of Notts and Inverness, and was senior magistrate of the Southwell Petty Sessional Bench.

He was also a Governor of the Southwell Minster Grammar School where he had received the earlier part of his education.

In politics he was an ardent Conservative and convinced Tariff Reformer.

General Warrand was greatly interested in all matters connected with the science of natural history. He was a regular contributor of articles connected with this science to the *Royal Engineers Journal.* At his house at Westhorpe he had a large astronomical telescope.

In the domain of sport General Warrand was always prominent. He was the oldest member of the Rufford Hunt, and also a regular follower of the Earl of Harrington's and the Blankney. He began hunting nearly 70 years ago, and for keenness, cleverness, and courage had few equals in the field. In December, 1909, he met with a bad accident. He had been out with the Blankney, and at dusk was riding a spare pony homeward when it stumbled pitching the General heavily on his shoulder whereon was pinned the vacant sleeve of his coat. He picked himself up and remounted his pony intending to ride on to the Midland Station, where he intended to entrain for Southwell, but his friends persuaded him to accept a cab home and it was then found that his injuries included a broken collar-bone, which to a man of his years was very serious. Such however was his wonderful fortitude and pluck, that he soon pulled through and was about again.

General Warrand was a man of fine physique and his distinguished bearing marked him out for notice at any public gathering. It was it is believed his intention to hunt again this season and he had ordered his horses up for preparation.

In October last after attending a meeting in Nottingham, General Warrand contracted a chill, and he had since been confined to his room. At his advanced age of 79, notwithstanding his splendid constitution, the development of his indisposition was regarded almost from the first with alarm, and after some days' illness he passed away on the 22nd October, 1910. When King Edward inspected the Crimean and Indian Mutiny veterans paraded on the occasion of the visit of the Royal Agricultural Show at Derby in June, 1906, General Warrand took command of the Notts contingent and accompanied His Majesty when he walked down the ranks. On June 3rd, 1907, the 50th anniversary of the Siege of Delhi, together with 52 other officers, survivors of the siege, he was presented to King Edward by Lord Roberts at His Majesty's Levée.

General Warrand was thrice married, firstly to a daughter of the late Rev. H. Houson, of Brant Broughton, Lincolnshire; secondly to Mrs. Grant, of Bucht; and thirdly to Helena Anne, daughter of Perceval Maxwell, of Finnebrogue, Downpatrick. He is survived by his widow, one son, the Rev. Henry Kenneth Warrand, Rector of Bilsthorpe, Notts, and one daughter, married to B. Prescott-Westcar, Esq., of Strode Park, Herne.

Officiating at Southwell Cathedral on the Sunday after General Warrand's death the Rev. H. Gray at the conclusion of his sermon said "Major-General Warrand belonged to the sister parish of Holy Trinity, but he was ever a familiar figure in our midst, and was so closely associated with all true Southwell interests, that it was only right and fitting that mention should be made of him from this place. An old soldier, who had rendered good service to his country, he possessed the true characteristics of a soldier; fearless and downright, accustomed to rule, impatient of opposition, high-principled and manly, there was a breeziness and heartiness about him that we shall all miss. Admirable on the Bench, a man of strong political bias, he took a prominent part in local and national politics, and if a little bit out of sympathy with the democratic tendencies of our times, was yet in many ways a type of all that was best in the old-fashioned squire of a period that is rapidly passing away."

Before the ordinary business of the Notts County Council was commenced at the Shire Hall on October 25th reference was made to the death of General Warrand, who was for many years a member of the Council. Lord Belper said he thought he should be voicing not only his own opinion but the feeling of all members of the Council in referring to the great loss they had sustained during the past two days by the death of General Warrand. The General's career was well known. He was an active soldier and took a prominent and distinguished part in the Indian Mutiny, but what they regarded, as much as any distinguished services he might have rendered to his country, was what he did during his life in the county after he had retired from active service. As a magistrate he was attentive to his duties, and he took a great interest in the work of the County Council. In conclusion Lord Belper moved: "That this Council wishes to put on record their sense of the loss the county has sustained by the death of General Warrand, and expresses its sympathy with Mrs. Warrand and her family in their bereavement." Viscount Galway seconded, and the resolution was unanimously carried.

The funeral took place at Holy Trinity Church, Southwell, on October 26th. A detachment from the South Notts Hussars, Territorial Yeomanry, composed of the Southwell Troop with the Permanent Staff from the Nottingham headquarters were present. There was also present a detachment from the 8th Notts and Derby Sherwood Foresters.

EDWARD T. THACKERAY.

TRANSCRIPT.

OBSERVATION LAND MINES.

Extracts from an article, by L. DEBOGORII-MAKRIEVICH, in the January, February and March, 1910, numbers of the *Injenerni Jurnal*.

THE author of this article was in charge of the mine defences on the land front at Port Arthur, and in this article he gives some notes on the work done during the siege and deductions from the experience there gained.

The Charges.—It was found by experiment that double cases, made of millboard with a 1″ layer of waterproof composition between them, were ineffectual for keeping out the damp of even moderate rainy weather. Single cases of wood were as bad, but double cases of wood with a 1″ thickness of waterproof composition were effectual in damp ground.

In Port Arthur, where the mines were intended to remain in the ground for several months, three kinds of receptacle were found to be suitable:—

(1). Consisting of two wooden cases, as described above, made of 1″, or ¾″, planking, carefully fitted, with composition poured between them;

(2). Also two cases, one of which was of tin, with either an inner case of millboard or an outer one of wood, with composition between them; and

(3). Thick iron mine cases with their mouths hermetically sealed.

Fig. 1 (see *Plate*) shows a receptacle for a 20 lbs. charge of powder. It consists of two cases, the outer a kerosene oil tin, and the inner a cylinder of millboard, with a mixture of asphalt and pitch poured between them. The top of the inner case consists of two millboard covers, the inner round and the outer square, with sawdust between them. Above this is a layer of composition, and a tin lid is soldered on the top. The composition was made of asphalt and pitch or tar, mixed in the proportion of 2 to 3 parts of asphalt to 1 of pitch, with a little sand added to thicken it. When intended for tarring the outside of mine cases less sand was used. When used for filling the space between the double cases, the mixture was poured in hot, the inner case having been previously filled with stones.

Fig. 2 shows the author's arrangement for hermetically sealing the passage of the leads through the lid of the tin case. Charges made up in this way were connected in groups, at intervals of about 21′ apart, to form the first experimental obstacles laid in the bed of the river Lun-ho. Although they were left under water for some months they remained in good order, and some, laid in February, were exploded by lightning in

May. They were never used against the enemy as he did not come into their neighbourhood.

Fig. 3 shows a case made of wood planking, to hold $2\frac{1}{2}$ puds (90·27 lbs.) of powder. This was the type most generally used, and it was applied both to fougasses and to ordinary mines. The sections explain the construction of the cases. They were fitted with three lids, the inner one being pierced with a single hole for the leads, but no wide opening was left in it for pouring in the powder, as it was found that this was best done before the lid was put on. A layer of sawdust separated the inner from the middle lid, in which there were two holes for the leads. The space between the middle and outer lids, and also that between the inner and outer cases, were filled with composition, and the outer cases of all mines were always given an outside coating of composition.

The leads were cut in short lengths of about 7′, and were fastened to the inside of the receptacle by means of copper screws, and to the outside on metal clamps, this last being done to prevent the waterproofing from being broken when they were stretched.

These receptacles were made in three sizes, the interior dimensions of the inner cases being as follow:—

For a $1\frac{1}{2}$ pud (54·16 lbs.) charge of powder			...	12″ × 12″ × 12″.
„ $2\frac{1}{2}$ „ (90·27 lbs.)	„	„	...	14″ × 14″ × 14″.
„ 5 „ (180·55 lbs.)	„	„	...	18″ × 18″ × 18″.

When filled they weighed 213·66 lbs., 266·88 lbs. and 435·54 lbs. respectively.

Charges prepared in this way were left in the ground for several months, but during the heavy rains there were a few cases of the powder becoming damaged by the damp. The chief faults of these cases were their size and weight, and the long time which they took to prepare.

Of the metal mine cases used, some were ordinary coast defence mines, and others were old Chinese iron cases captured in 1900. They did not possess the faults of the wooden cases. The tin-lined chests supplied with Chinese coarse-grained powder were also adapted for use as mine receptacles. Only those in the best state of preservation were selected, and these were carefully treated with composition, but they were not always waterproof, either from faulty construction or from the difficulty in closing their openings.

Size of Charge.—The effects to be expected of a mine explosion depend chiefly on the noise, the concussion of the gases and the air, and the vibration of the ground, and consequently the size of the charge need only be limited by the question of economy. Pyroxiline is preferable to powder. It is naturally unwise to use small charges with observation mines. There is a great deal of labour expended in preparing the firing station and carrying the leads under ground, and altogether it is very costly. In the case of mines laid near to one another, in a group, and the whole fired together, it is hardly worth while using charges of less than 90 lbs. of powder, and isolated charges should not be less than 300 lbs. The siting and combination of mines must depend on their object and upon the ground. Thus, is it better to use one charge of 900 lbs., or three of 300 lbs., or six of 150 lbs., or ten of 90 lbs.? The larger the charge, the more powerful is its action, but when we increase the number of charges we enlarge the sphere of their action, and we also render them less liable to the effect of the enemy's shells and counter-mines. The author is of opinion that groups are better than single charges, so long as each charge of a group has a considerable death-dealing sphere of action of its own.

The choice of the explosive used in a mine will be influenced by what kinds are available, their explosive force, and also by the question of smoke. Smoke may sometimes be of use and sometimes harmful. Thus, in driving off an attack the less smoke the better, while in covering a retirement or in case of a counter-attack, smoke may allow the defenders to retire or advance unnoticed. The tactical use of smoke on a battle-field is worthy of consideration. Belligerents should always have at hand the means of producing smoke over a large area and for a considerable period of time, and at a greater or lesser distance from themselves.

The Limitations of Land Mines.—Experience confirmed the common opinion that land mines can be used with success in supplementing the artillery and rifle fire of the defence.

Their advantages are as follows:—

1. Supposing that a hostile column passes over the mined area, then careful timing of the explosion is more easy to the miner than is accuracy of aim to the rifleman or gunner.

2. The explosion of a mine, besides causing actual loss to the hostile column and bringing it to a standstill, always produces panic. This moment of panic must be seized upon for bringing a heavy fire on the disorganized troops, and for the counter-attack.

3. Mines may be laid in dead areas which are safe from the rifle and artillery fire of the defence.

4. Mines laid for the defence of some work or battery may be fired from a neighbouring trench even after the work has fallen, and may thereby cause an alarm which will greatly assist the counter-attack.

Their disadvantages are:—

1. Fixity of site, which can only be remedied by their liberal distribution.

2. The mine acts only once. Time and suitable conditions are necessary for the preparation of a fresh one. This may to some extent be remedied by laying spare mines, in the same or in a second line, or even underneath the original ones. Care must be taken that the spare mines are not fired by the concussion caused by the explosion of the others. The disconnecting boxes, described later, for protection against lightning, may be usefully adapted for rapidly connecting up the spare mines, or better still some automatic system may be devised for connecting them up after the explosion of the others.

3. If the position of a mine is discovered by the enemy, its value is more than half gone. The same remark applies to a mine relaid in a site known to the enemy. Before attacking he will take care to demolish it or to cut off its connection.

Tactical Siting of Land Mines.—Under this heading the following points require to be considered:—

1. Distance from the firing line of the defence.
2. Direction of action of the explosions.
3. Mutual siting of isolated mines, and of groups.
4. Siting of charges in relation to the plans of defensive works and trenches, obstacles, and points most liable to attack.
5. Inequalities of the ground, open and dead areas.
6. General bearing of the minefield, whether along the lines of probable attack, or across them.

The distance of the mines from the defensive trenches may be limited by questions of materials, men, time, circumstances, objectives, or by the nearness of the enemy. It is unwise to make hard-and-fast rules which may trammel the initiative of those who are laying the mines, and who must study the ground, the local conditions and the requirements of the defending riflemen. The following limits and influencing factors may be mentioned:—

(*a*). The distance should not be less than 30 paces. If less, the explosion might damage the defenders or the mines might be exploded by shells aimed at the trenches, whereas the enemy should at least be obliged to expend special shells for the demolition of the mines. When a mine is exploded the defenders must pay no attention to the shower of earth and stones, but must keep up a heavy fire without waiting even for the smoke to clear off.

(*b*). The distance should not be so great that it is difficult for the defenders to see accurately when the enemy passes over the charge.

(*c*). The physical and moral effects are greatest when the mines are near the trenches—physical because the effect will be better the better the observer can see his work, and moral because the strain on the nerves of the attackers increases as they approach nearer to the works of the defenders.

(*d*). The value of all obstacles depends on their protection from damage, and the nearer the mines are to the defenders the more easy will it be for the latter to defend them.

(*e*). The value of a land mine is greatly increased by the rifle and artillery fire which can be brought on those of the enemy who are panic-stricken by its explosion. Therefore in open ground they should be sited within the sphere of accurate rifle fire of the defence, *i.e.* within 400 paces. But they may have to be put further off.

When placed in dead ground they tend to assist the rifle defence by driving the enemy into the open, where they can be shot down, and in this case the nearer they are to the trenches the more successful is their action, for they will then frighten his supporting columns from taking cover in such dead ground. In Port Arthur it was only possible to lay a limited number of mines and these were placed in the nearest dead areas, with the effect that after a few successful explosions they compelled the enemy to make use of open ground for their advances.

It may therefore be taken as a rule that it is *desirable* to site mines within the sphere of effective rifle fire, but it is *necessary* to have them within the sphere of protection and observation.

As regards the direction of action of a mine, this may be either (i.) vertically upwards, (ii.) inclined towards the enemy and perpendicular to the line of defence, (iii.) inclined towards the enemy and at an acute angle to the line of defence, or (iv.) from above downwards, in which case only stones thrown by the explosion, and not the explosion itself, will act upon the enemy.

Case (i.) is suitable to isolated mines in open ground where the enemy may be caught in masses. Care must be taken that the explosion will not injure the defenders.

Cases (ii.) and (iii.) are suitable to fougasses and ordinary mines on sloping ground. These are more effective than vertical mines, especially in the case of fougasses which cover a large area with their stones and shields. (ii.) is suitable when owing to local conditions the attacking columns may be expected to be deep and on a narrow front, and when there are many mines placed at narrow intervals, while (iii.) is suitable for opposing widely extended lines with mines placed at wider intervals. Or the direction of explosion may depend upon local conditions, as when the mines are spread like a fan round a salient of the defence, or when they are intended to enfilade a tract of dead ground lying along the front of a position.

Case (iv.) is suitable when it is desired to use a fougasse like a gun to sweep some ravine or particular area, or where leads are not long enough to reach the whole distance. Several cases occurred at Port Arthur of applying this method, principally when the enemy did not pass exactly over certain mines, and there appeared to be a probability of the latter being wasted. The effect of the stones alone is not nearly so great as that of the explosion, which of course is the really effective item of a land mine. Best of all is the combined effect of explosion and stones, which effects all parts of the attacking column.

In considering the least and greatest intervals at which mines, or groups of mines, may be placed one from another, the former are influenced by the size of the charges, the nature of the soil and the shape of the ground. The explosion of one charge must not be allowed to injure its neighbours, and for this reason the minimum interval between two mines may be taken to be that at which their areas of effective action *above* ground, due to concussion, etc., and, in the case of fougasses, to the stones also, meet.

Charges fired simultaneously, forming a group, may be placed at shorter intervals than isolated charges and groups, unless the charges of two or more groups are intermingled, in the intervals between one another, on one piece of ground (see *Fig.* 4).

The maximum intervals must depend on circumstances, and vary in different parts of the position. They may be influenced by the probable width of the attacking columns, due to the restrictions of the ground, or by the means and time at the disposal of the defenders. It is generally advisable to site charges as near to one another as allowable, and to economize by placing them only in the more important sections of the position. The ground and the general scheme of other defences will never allow symmetry in the arranging of land mines.

The siting of charges, or lines of charges, in the depth of a position, as regards minima distances, is subject to the considerations already given. The placing of many lines of mines may lead to a dangerous amount of smoke, or may cause too much confidence in their effectiveness, which may lead to disappointment if they become damaged by hostile fire and fail to act.

Generally speaking, in addition to considerations of means, time, labour, circumstances, and to the plans of the other defences, the number of lines of mines depends upon the following conditions:—

1. The necessity of having all within the range of effective rifle fire.
2. The shape of the ground.
3. The siting of other obstacles.
4. The need of free ground for counter-attack.
5. The desire of not allowing the enemy to come too near.
6. The desire of not having large clouds of smoke too near the defenders.
7. The risk of over-confidence and possible failure.
8. The tactical importance of the section of defence.
9. The possibility of several attacks being made on the one section.
10. To some extent, on the strength or weakness of the other works at any point.
11. If the defenders are much shaken, the enemy must not be allowed to come within 200 paces, and the mines must be placed proportionally further to the front.

Mines placed one below another, with a view to destroying men who run for shelter in the craters of those first exploded, involve a great amount of work and make large craters. They were not tried at Port Arthur and the writer has no experience of them.

Turning now to the siting of mines with regard to other works, they may be placed in front of the strong points, or in the intervals between them. In the case of some advanced works which are liable to capture, the parapets themselves may be mined, or egress from them may be obstructed by mines in rear and to the sides. Villages liable to capture may be similarly treated. At Port Arthur the mines were at first laid in the intervals between works, but when the direction of an attack was revealed some of the engineers insisted on mining the nearer approaches to the forts themselves. The difficulty of protecting the leads from bombardment when there is no time to dig deep trenches for them, must be taken into consideration. A device of Engineer Yakovlev is mentioned, by which the mines are laid in pipes.

As it will seldom be possible to lay mines continuously along the front of a position, they should generally be massed (i.) in sections liable to attack but otherwise weakly defended; (ii.) in sections where active defence is contemplated as the panic caused by their explosion forms a useful prelude to a counter-attack; and (iii.) where there is dead ground near the position which cannot be otherwise covered.

As regards the siting of mines with relation to other (passive) obstacles, this must depend on the siting of the latter, on the object of the mines and on the shape of the ground.

As the passive obstacles must be within effective range of the rifles, they will generally be placed between 10 and 200 paces in front of them, while mines can be placed from 30 to 600 paces. For this reason the mines cannot always be sited within the passive obstacle, though the advantage gained by causing a panic among the enemy, after he has passed the latter, is obvious. Mines and leads are also easily damaged, and require frequent examination and repair, and this is an additional reason for placing them within the passive obstacle. If the leads can be buried deeply and the outposts of the defence are far enough to the front to allow of the mines being examined if necessary, then the desire to secure a better target may justify the siting of mines further to the front.

Some people advocate the siting of mines at the passive obstacle itself where they may catch the attacking troops checked and crowded.

In the case of dead ground the choice of sites for the mines will in no way depend on the siting of other obstacles.

At Arthur the mines were generally laid in dead ground or in areas badly covered by rifle fire. This was due to the fact that the positions abounded in such places, and the scarcity of materials did not allow in addition the mining of open ground at the probable points of attack. The result noticed by the miners was that the Japanese came to avoid dead ground and preferred to advance over the open, where they were exposed to shell and rifle fire. Those mines, therefore, which were never fired, had a certain indirect value. The difficulty of finding observation posts for mines sited in dead ground had often to be got over by watching the approaches to the dead areas only. In the case of mines so laid, it was not often possible to take full advantage of them by bringing a heavy fire upon the disordered enemy.

A large quantity of smoke thrown up by the explosion of a mine may be useful to the defenders by concealing them and blinding the attackers. But with mines laid in the open smoke will generally interfere with the rifle fire on the disordered enemy, and in such cases it is better to use a smokeless explosive.

Details of Construction.—With *ordinary mines* the charge should be as near the surface as possible, in order to obtain the full effect of the charge and to reduce the size of the crater. If one considers, separately, the necessities of concealment, protection from weather, from rifle bullets, shells, saps and countermines, various results are arrived at, but a mean of between 2′ and 4′ of earth above the top of the mine may be taken as what would be generally suitable. The excavation may be perpendicular or inclined to the surface of the ground, and should fit the size of the charge receptacle as accurately as possible. The mine should be carefully tamped and skilfully masked.

The *fougasses* used at Port Arthur were of a special type, (see *Fig.* 5), which may be described as follows :—

The chamber for the stones was square in section, and so cut into the hillside that its end wall, which stood at right angles to the floor, was about 4′ square, and its top about 1′ below the surface. The floor was splayed outwards, and was about 7′ wide at the outside. The charge chamber was excavated in the middle, or slightly below the middle, of the end wall. On the floor of the stone chamber were laid two planks, abutting on the end wall and splayed slightly outwards. On these the shield, which measured 3½′ square, and will be described separately, was placed standing against the end wall. The planks and floor were covered with a 3″ layer of sand, which was intended to allow the shield and stones to slide freely in the sticky clay of the excavation, and a 6″ layer of sand was also filled in on the sides and against the shield, during the laying of the stones. No stones of smaller size than a man's head were used, and the bigger ones were placed in the centre of the mass, near the shield. The stones were covered up with earth, and the whole carefully disguised. A party of four men could bring up the charge, excavate the chambers, and lay one of these fougasses by night in four to six hours.

The size of the shields (see *Fig.* 6) was decided by the weight which four men could conveniently carry. They were made of three or four layers of 2½″ or 3″ planking, the planks of each layer being firmly fastened together by nails driven diagonally through the joints, before the layers were nailed one to the other. Shields made in this way having been found to break up by the explosion, they were afterwards strengthened by being bound together with four bands of hoop iron, two in each direction. These shields if carefully made did not break up with a 90 lbs. charge of powder.

The *trenches for the leads* can be arranged in any of four ways:—

1. With one "magistral" line, and branches from it to the charges.
2. With a separate trench running to each charge.
3. With a separate trench for each lead, *i.e.* two to four to each charge.
4. With trenches arranged to suit the ground.

The first type has the fault that all the mines can be put out of action by one shell. The second is safer, but gives more work, and if care is not taken in the aligning, when several leads get near the firing station, they will become as vulnerable as in the former case. The third is safer still but gives still more work. There is not the same necessity for separating the trenches near the mines, as the enemy can hardly be expected to expend shells in trying to discover the latter. This system is only suited to mines laid very close to the firing station. The fourth method, that of laying the leads on reverse slopes, in ravines, or on ground which is unlikely to be swept by hostile artillery fire, entails largely increased earthwork and leads, but is especially suited to rapid laying, where the leads have to be left unburied. *Figs.* 10, 11 and 12 explain the three first systems of arranging the leads to separate charges or groups. With armoured cables the armouring was very often used instead of a return wire, but earth was never used for this purpose.

The *masking* of the trenches was arranged either by carefully disguising the filled-up trench itself, or by turning up the whole surface of the ground, or by laying the lines in places defiladed from the enemy's view. Rain spoils the masking, as it makes the newly filled-in earth sink, leaving noticeable hollows, which must be quickly filled up.

Care must be taken, when filling in trenches, to lay shallow layers and to ram them well, but it is not permissible to leave a mound along the line of the trench.

In spite of the risk of their being cut, it is not wise to lay the leads too deeply, as this adds to the labour of repairs. At Port Arthur during the provisional period they were laid 2½′ to 4′ deep according to the soil, and during the siege from 6″ to a foot. When they became more untrustworthy they had to be laid in the open.

There were also occasions during the siege when mine galleries were used for the leads of ordinary fougasses, but the method of using boreholes for the leads was not used, owing to the want of tools suitable for boring the stony ground.

The *firing stations* were stoutly-built field casemates, measuring about 10′ × 7′, or 9′ × 9′, and sunk about 7′ in the ground. They were roofed with three layers of beams, and above these iron sheets or straw mats, and 5′ to 7′ of earth. The doors were made of 3″ planks, and were reached either by ladders or from communication trenches. Each casemate contained a guard bed, cupboard for food, etc., clothes pegs, arm-stand, stove, etc. If the casemate was too small for living in, another was made alongside for this purpose.

In choosing the site of a firing station the following conditions had to be satisfied:—That it was protected by rifle trenches either in front or in a line with it; that it was near a good observing post, from which all the mines connected with it, or the approaches to them, could be seen; and that it was protected from artillery fire. It was therefore preferably placed on high ground on a reverse slope, and not too near any work or battery which was liable to bombardment. If possible, the observers should be so close that their voices can be heard in the firing station. Telephones are unsatisfactory as their wires are easily cut, and it is not easy to use them during the noises of a battle; they are however suitable for work at night. If any mines could not be seen from the observation posts it became the custom to inform the neighbouring riflemen of their siting, and to trust to them to give information of the enemy's approach to them. A small rifle position should always be prepared near the observation post, from which the miners can themselves protect their station, and join in the fight if necessary. A supply of electrical and other tools was kept in each station, and also journals for registering tests and recording events. To each sector of the defence there was assigned an electrician on duty daily, for carrying out tests in the stations of that sector.

The *testing and firing tables*, fitted in the stations in the precautionary period, were arranged as shown in *Fig.* 7. They measured about 2′ × 3′, and 2½′ high. At the right end the firing keys were connected to the positive leads from the various mines, while the return leads were connected together and brought as a single line to the switchboard at the left end. A three-way switch connected up the firing or the testing circuit at will.

The keys were numbered to correspond with the numbers of the mines, the latter being shown on a plan which hung on the wall of the casemate. The table had an oilcloth cover to keep off the dust.

As the siege progressed and the arrangements became less elaborate, keyboards, hanging from the walls, were used. *Fig.* 8 shows one with firing keys, and *Fig.* 9 one with a wandering lead. The latter arrangement has the advantage of eliminating the possibility of mistakes, and can also be applied to a firing table.

The *firing apparatus* was either an exploder, a battery of Le Clanché cells, or an accumulator. The exploders are best, as they require little looking after, and the batteries are the most troublesome. Accumulators require means of charging them and men who understand them.

Mines may also be laid in the open and fired by our own artillery fire, or they may be fired by time fuze.

Of the various *leads* used during the siege the Government armoured ones were the best. They were less affected than others by the explosion of hostile shells and were not easily cut by hand.

Towards the end of May and the beginning of June several charges were exploded by *lightning*, and General Stessel ordered that means must be taken to protect the mines from such accidents. No special apparatus, such as that used with telegraphs, was available, and it was necessary to improvise. A former authority had suggested that such explosions are caused by currents set up in the leads at the points where they are brought out of the ground, but on the night of the 1st—2nd June, 18 charges, connecting up into two groups, but with the ends of their wires insulated and buried, and disconnected from the leads by a gap of 8′, which had been laid in rear of one of the Russian works were exploded in this way. The only remedy seemed to be to disconnect the leads close to each charge, and, with the object of doing this rapidly, the writer designed a disconnecting box (see *Fig.* 13) which would be buried a few inches deep near each charge, and contained two wandering leads, which could at will be connected with clips leading to the charges, or rapidly transferred to insulated recesses. In this way if the men could approach the charges they could connect or disconnect the latter in a very short space of time. But this could not of course be done from within the firing station, and some design which would render it possible to do this is greatly necessary.

In selecting sites for mine obstacles the writer was generally guided by the necessity of protecting the intervals between forts, and the ground in front of weak sections. It was desirable that the mines should (i.) aid in repulsing assaults and compel the enemy to a regular siege, (ii.) cover dead ground near the rifle positions, (iii.) bring actual loss on the enemy, (iv.) discourage the attack and encourage the defence, (v.) temporarily, at any rate, arrest the progress of surprise attacks, (vi.) compel the enemy to avoid cover which they might believe to be mined, and (vii.) compensate for the temporary removal of the defenders of a particular section in case of urgent necessity. But they cannot be expected unaided to repulse an assault, they are only subsidiary aids to the vigour and courage of the defenders, who must not be too greatly discouraged if they fail to act.

The *personnel* attached to each firing station—desired, if rarely attained, even at the beginning of the siege—consisted of an electrician as chief of the station, an assistant, and three reliefs of scouts, single or in pairs, for one or two points. Later on, when the scouting was almost entirely handed over to the riflemen, they were content to have one man on duty, day and night, at each station, watching the front-lying ground.

The following difficulties were encountered in the work:—

1. There was a great deficiency in the supply of well-insulated leads, of which there were only some 15 to 20 versts, when the total length required exceeded 100 versts, and even telephone cables had to be used. 2. The inferiority of the leads greatly hampered the scheme of mine defence. 3. The scarcity of money and labour compelled economy in trench work. 4. The Chinamen employed disclosed to the Japanese the positions of mines and cables. 5. The depths of $2\frac{1}{2}'$ to $3'$ in stony ground, and $4'$ in clay, though sufficient to protect mines and leads from the projectiles of field artillery, were useless against those of siege artillery, whose craters were often $7'$ deep. 6. The concealment of the cable trenches was often very imperfect. 7. There was no service mining equipment and everything had to be improvised. 8. The mining detachments were made up of riflemen, sappers, gunners, railway men and others. 9. The improvised cases sometimes allowed the powder to get damp. 10. The mining defences of a fortress like Port Arthur is a large business, and experience showed that theoretical knowledge on the subject requires considerable development.

There were also the following personal difficulties:—

1. There were insufficient officers, and their duties had to be largely done by N.C.O.'s. 2. Constant interruptions to the circuits led to much exhausting and dangerous night work. 3. Casualties among the *personnel* were either filled by men quite ignorant of the work and of the minefields, or were not filled at all. 4. As the leads got worse the difficulties increased. 5. While the work kept on increasing the men were getting weaker. 6. After the writer himself was wounded in the head, in mid-October, he was not so capable of pressing on the work *everywhere*. 7. In October three assistant officers were wounded, and there remained only an ensign to assist him in the administration of the laboratory and 15 stations, between Battery Letter A and the Lun-ho, working day and night, and constantly fighting. 8. The mines could not be properly observed, so that if the enemy came upon them in their saps, they sometimes cut the leads, and connected the ends together, with a view to leaving the Russians to suppose that the mines were still in working order.

Reports on the fighting during the defence hardly did justice to the effect of the observation mines, as the mining detachments themselves were generally reticent, and others were naturally inclined to attribute successes to their own efforts. But it says a good deal for the success of the mines that those commanding in the firing line were always asking for more mines, and up to the last day of the siege had not lost faith in them. All ranks in the neighbourhood of the firing stations were asked to notice and report on the effect of the mines as far as possible, but observing was very dangerous work and the smoke thrown up by a mine moves quickly away and is soon lost sight of amid the smoke of bursting shells. The only reports obtainable were from the firing line which contained few officers and were not often very reliable. In some cases the writer has found in foreign journals reports which coincided with and confirmed his own impressions.

Experience showed that it is a very good achievement if one can succeed in firing 30 per cent. of the mines over which the enemy passes. As he may only be estimated to pass over some 10 to 20 per cent. of all the mines laid on a position, it results that only 3 to 6 per cent. of all the mines will ever act upon the enemy. If the leads suffer much, the proportion may fall as low as 1 per cent.

F. E. G. SKEY.

NOTICES OF MAGAZINES.

NEUE MILITÄRISCHE BLÄTTER.

23rd September, 1910.

THE NEW EQUIPMENT OF THE BRIDGING TRAIN OF THE GERMAN ARMY.—The Bridging Trains of the German Army are allotted as follows:—

(*a*). As divisional troops.

(*b*). As corps or army troops.

Hitherto the equipment of both divisional and army troop trains has been the same, the only difference between the units lying in the lesser number of wagons of the former.

The main disadvantages of the old form of pontoon were:—

(1). It was found to be no longer large enough to form bridges capable of carrying such recent innovations as traction engines, other forms of mechanical transport, and heavy field artillery.

(2). When used as a single pontoon it was too unstable.

(3). Its weight deprived it of mobility, as men could not be carried on the wagons when they were obliged to move on at a trot to hurriedly get to the site of a new bridge.

The desideratum was thus, on the one hand, a pontoon capable of carrying greater weights, and *ipso facto* a heavier one; on the other, a lighter and more mobile boat. In consequence of the conflicting nature of these desiderata it was decided to abandon the idea of having but one type of pontoon, and to adopt two quite different patterns of equipment; the lighter for the divisional, the heavier for the army troop bridging trains.

To take the latter first, its length is 8 metres, breadth 1½ metres and freeboard ·85 metres; its bottom is sloped up towards the front, which is raised ·25 metres above the rest of the bulwarks; the stern is rounded off; its weight, 5,000 kilos., is only 100 kilos. greater than that of the old pontoon, but its supporting power is about 2,000 kilos. greater than that of the old pattern. Other differences are:—

(1). The baulks are no longer secured to the pontoons by lashing, but in the same way as in the British service.

(2). Ribands and rack lashings are replaced by a wire rope and the strength of the whole bridge is thereby increased.

(3). As regards trestles, the transom is now no longer suspended by chains from the top of the leg, but is secured to the leg itself.

As regards the divisional equipment:—A reduction in weight has been effected by the adoption of half pontoons, which can either be used as such or joined together in pairs to form single pontoons; this latter process is necessary when building bridges with the "normal" width of bay of 4½ metres. Thus, each pontoon wagon now carries a half pontoon and half the superstructure for one bay, is drawn by 4 horses instead of 6 as heretofore, and can carry in addition 4 pioneers.

In consequence of the lesser number of horses per wagon, the total number of horses and length of the column along the road has not been materially increased, although there are now 21 vehicles instead of 15. The advantage is moreover gained, that, should the bridging train be required anywhere in a hurry, it can proceed there at a trot carrying with it 60 pioneers to commence the construction of the bridge.

With the normal bay of 4½ metres, the bridge will carry all the vehicles which generally accompany troops. The superstructure must be strengthened however, without altering the length of bays, to take the 15-c.m. howitzer, of the 15-c.m. heavy field gun and of the lighter army mechanical transport.

For columns consisting only of infantry, cavalry and light vehicles, a length of bay of 5m. 80 can be adopted.

For infantry and cavalry in single file, a light footbridge of half pontoons can be employed, (3 baulks only are used in this case per bay).

The bridging capacity of the divisional train thus is:—

(1). Light, half pontoon footbridges, for infantry or cavalry in single file 60m.

(2). Bridge for infantry, cavalry and light vehicles (5m. 80 bays) 41 metres.

(3). "Normal" type 34½ metres.

(4). Reinforced bridge for heavier vehicles 21 metres.

In the case of the army troops train (1) is non-existent as there are no half pontoons; the length of (2) is 155m.; of (3) is 124½m., and of (4) is 75m.

With all its bridging trains, an army corps can cross 196½ metres with a normal bridge; or 235 metres with a footbridge. When they are used as boats, pontoons carry 18 men; for the transport of vehicles or mounted men, however, rafts of two pontoons must be formed with a capacity for 60 infantry; 7 horses and 7 riders; 1 machine gun, 8 men and the team; 1 field gun, 4 horses and 8 men; 1 heavy field gun and its detachment; or 6 heavy horses and 6 men.

The above figures are for the divisional bridging trains—from which 3 rafts can be formed. 12 rafts can be made from the army troops bridging train, and these together will ferry over 2 companies of infantry with their pack animals, ammunition cart and an ambulance; ½ squadron, or 1 battery with 1 ammunition wagon. The whole of the bridging *matériel* of an army corps can ferry over at the same time 3 companies infantry, ¾ squadron, or 1⅓ batteries with their ammunition wagons.

The introduction of this new equipment ensures to the German Army a more rapid and surer way of crossing rivers than heretofore, and is a notable improvement in its efficiency.

A. H. Scott.

Rivista di Artiglieria e Genio.

October, 1910.

Ventilation and Heating of Military Hospitals.—Lieut.-Colonel Fenolio of the Engineers contributes a valuable and exhaustive article on the above important subject.

The technical commission instituted by the War Minister at Turin at the commencement of 1906, for arranging a programme for the conference of specialists on the question of the heating and ventilation of buildings, especially in the military hospital at Turin, came to the conclusion that besides the conditions relating to the temperature of the air, the position of the stoves, and the pipes for the extraction of vitiated air etc., the introduction of pure air from the outside of hospitals should not be made at a less height than 4 metres above the level of the ground. Such precautions are indispensable to ensure that the air introduced should be free from impurities and from the gases that are found in the lower strata of the atmosphere of a great city. The wards for common and infected diseases and those for surgical operations having their floors raised about 1·80 metres above the ground, it follows that in all these buildings the air should be introduced at a height not less than 2 metres above the floors.

The air introduced at a low temperature has to be heated to a temperature suited to the different localities. The verandahs and corridors should have a temperature of 15° and 18° centigrade; the wards for surgical operations of 30° centigrade.

An aperture for the introduction of the air at a height of 2 metres above the ground floor opens to a vertical pipe within the walls, which descends to the level of the ground floor and is then conducted horizontally to the centre of the hospital where the air is heated in a stove and passes into the surrounding atmosphere.

Data for the Problem.—The following data are taken from an examination of the process of heating and ventilating the military hospital at Turin:—(*a*). A vertical pipe 2 m. in length leads into a horizontal conducting pipe length 4·50 m., which opens into the centre of the hall into a stove and radiators. The total length of the conducting tube may be said to be 7 m. (*b*). The external air passes through the conducting tube to the stove where it is heated, and expands in a room 9·10 m. in length and 5·50 in height, or a section of 50 m.². (*c*). Two extracting pipes which should not be at a height above 10 m. should be sufficient to give the required ventilation. We are here speaking of wards for 12 beds, and if two ventilating stoves are supplied each will serve for 6 beds. One extraction pipe is supplied for each stove. (*d*). The ventilation recognized as necessary and sufficient for the salubrity of a hospital for common diseases, was established at 80 m.^{3} per bed and per hour. So that we have to introduce into the hospital for each stove $6 \times 80 = 480$ m.^{3} of air or a volume per 1″ of $V = \frac{480}{3600} = 0{\cdot}134$ m.^{3}. (*e*). The stoves are of metal with radiators and are covered at the top with marble slabs which serve as a table. The measurements are about 1 m. in height, 1·20 m. in length and ·50 m. in width. Two openings of the same length as the stove or 1·20 m. give exit to the heated air. (*f*). The temperature of the hospital is fixed at a minimum of 15° centigrade, and a maximum of 18° centigrade when the external temperature at Turin is at its lowest, or about $-10°$ centigrade. (*g*). The dimensions of the pipes or channels for the introduction and extraction of the air are not precisely stated. In one of the specifications presented to the Commission the section of the channel is given as 0·20 m. × 0.20 m. or a superficies of ·04 m.^{2}. Such a section would be quite insufficient. The least section of the channel for the introduction of the air should be 0·3 m. × 0·3 m. = 0·09 m.^{2}, and the same for the extracting tube.

Elaborate calculations with detailed drawings and sections are given for the calculations of the temperature; of the sections of the pipes for the introduction and extraction of the air; and for the velocity of the extracting current, but want of space would prevent these being given in detail in this Journal.

The results obtained from the calculations are important since they show that the ventilation, notwithstanding the tortuous course of the air admitted into the hospital, may function regularly, provided that the channels or pipes for the admission of the air have a section not less than $S = 0{\cdot}09$ m.^{2}.

MISCELLANEOUS.—*France.—New Military Aeroplanes.*—We learn from the *France Militaire* of the 6th September that the French War Minister has sanctioned the acquisition of 10 Bleriot monoplanes and 20 Farman biplanes, which should be able to carry two passengers besides the pilot. France by the end of the year should have at its disposition 60 aeroplanes. It is also stated that the military aerostatic service, under General Roques has decided upon the principal characteristics of the new model of aeroplane which will be brought into service in the French Army next year. These characteristics are as follows:—the military aeroplane type 1911 should carry at least 300 k.g. and should be able to fly at least 300 k.m.; with a velocity of 60 k.m. per hour. A prize of 100,000 francs will be given for the production of an aeroplane which will satisfy the required conditions. With regard to the cost, General Roques asserts that it will be greater according to the greater velocity of the aeroplane, and considers that as one of the principal conditions of the stability and of the perfection of the apparatus.

REVIEW OF BOOKS AND PERIODICALS.—*Impressions of the Great Italian Manœuvres of* 1910.—Publications of the Military Library, Rome, 1910.—

The author of this work, Major Enrique Patiño, Military Attaché to the Legation of Uruguay, is well known in Italy as an able writer on military subjects. The book under review, as the title indicates, gives an account of the great Italian Manœuvres of 1909, at which the author was present as a foreign military attaché, and gives a clear and vivid account of the manœuvres. The author traces rapidly and artistically a picture of the manœuvres, and the book is adorned with historical records on many points and considerations of a military nature. He traverses the classic theatre of the operations, gives lists of the generals and the troops, and explains the general nature of the operations terminating in a decisive battle.

The book has been very well received in Italy where the writer is esteemed as a man inspired with a warm and generous friendship for Italy.

EDWARD T. THACKERAY.

CORRESPONDENCE.

RESISTANCE AND "DRIFT" OF A BULLET.

SIR,

The *R.E. Journal* of January, 1911, contains an article by Lieut.-Colonel R. de Villamil, late R.E. The subject is one of public interest and many efforts have been made to elucidate the "drift" and other phenomena of a projectile in flight.

On page 15 is an explanation of "drift," which is described by the author on page 16 as "simple and interesting and has not, that I am aware of, been previously presented."

The proof is "simple," because all effects of air friction have been ignored and the gyroscopic effects have been considered as though the projectile were travelling *in vacuo*. The proof given in the article has been well known for years; it is found in Crabtree's book on gyroscopes and spinning tops; also the Textbook of Gunnery, 1883 and 1897, contains similar proofs.

The proof given by Lieut.-Colonel de Villamil offers no explanation for projectiles which have drift to the left, such cases occur occasionally: no explanation of a satisfactory character has yet been given for such cases.

On page 15 the following paragraph occurs:—"For reasons which I cannot enter into very fully at present, the bullet is chiefly held up in the air by its rear end . . . . , by the vacuum formed there acting as a kind of sucker." It is a pity that no explanation whatever is given of the theory which is put forward in this paragraph.

I am, yours truly,

C. E. PHIPPS, *Major, R.A.*

Ordnance College,
Red Barracks, Woolwich,
6th January, 1911.

The Editor, *R.E. Journal*.

OBSERVATION LAND MINES.

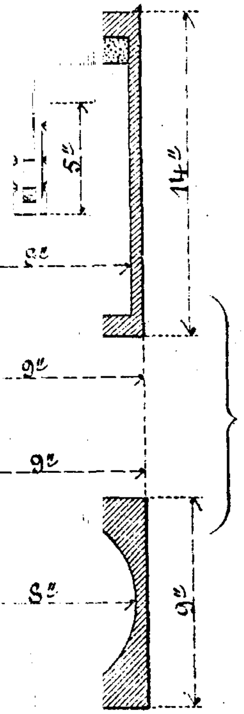

FIG. 1.

FIG. 2.

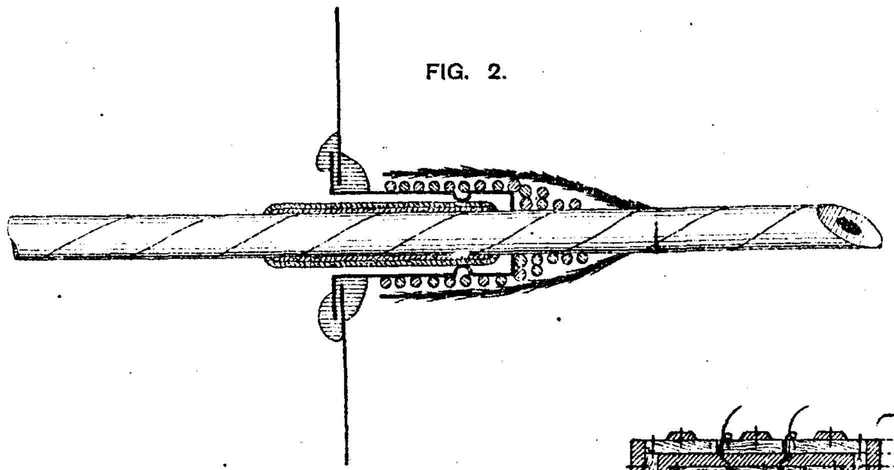

FIG. 3.

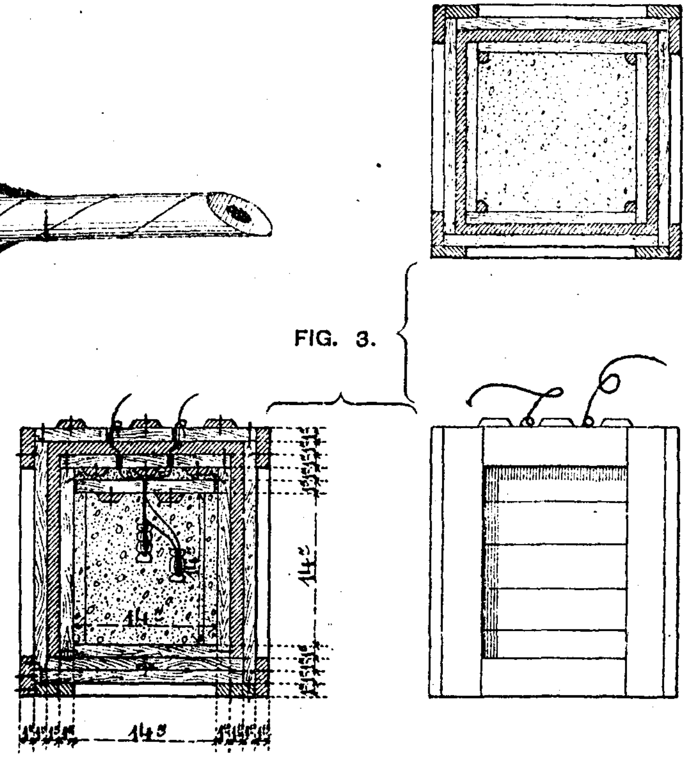

FIG. 4.

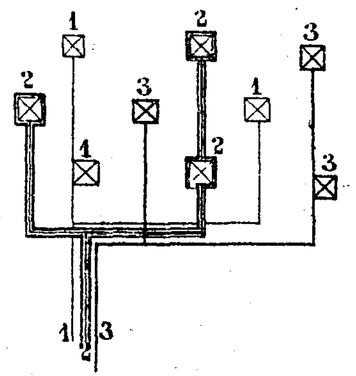

FIG. 5.

Fougasse.

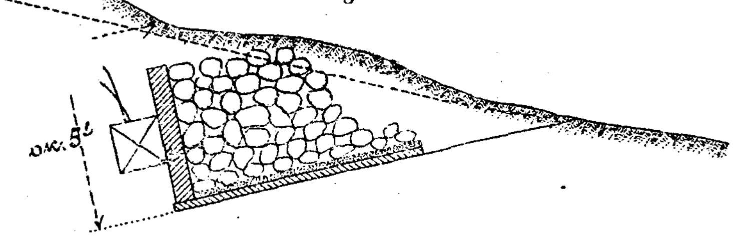

FIG. 6.

Shields.

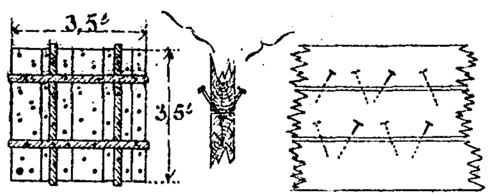

FIG. 7.

Plan of Testing and Firing Table.

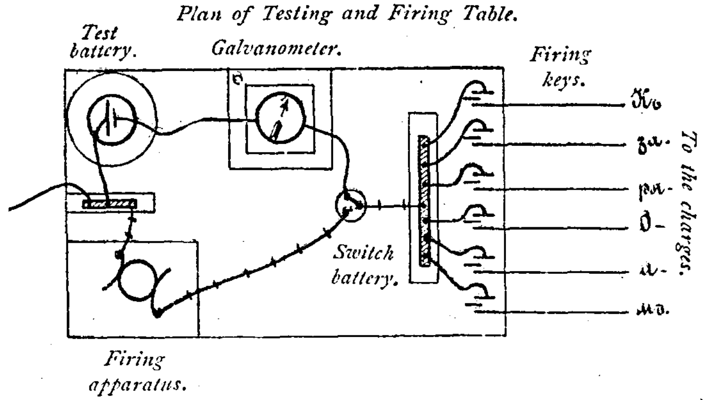

FIG. 8.

Field Keyboards.

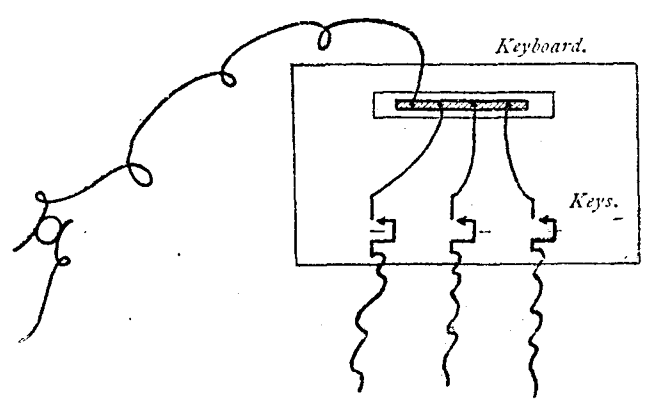

FIG. 9.

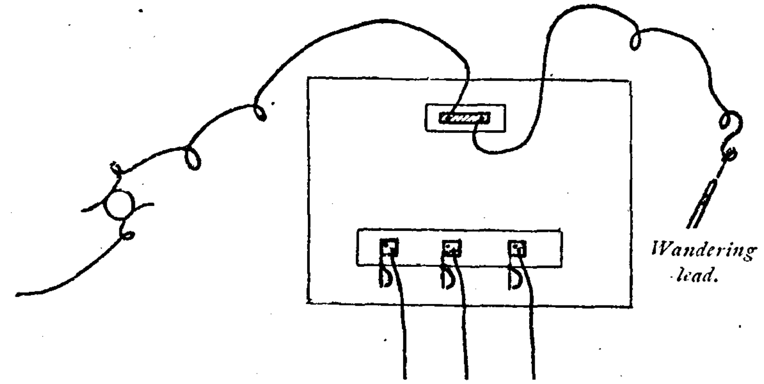

FIG. 10.

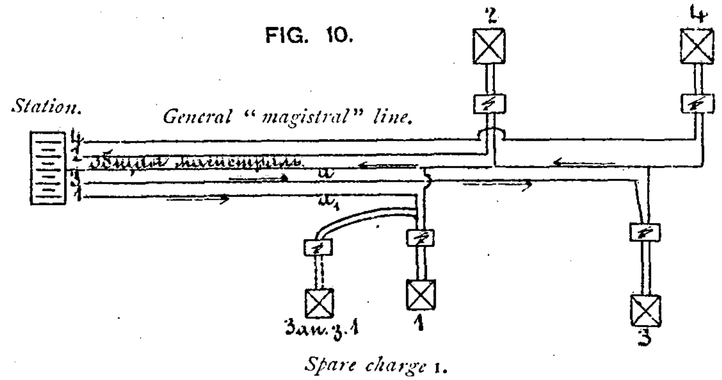

FIG. 12.

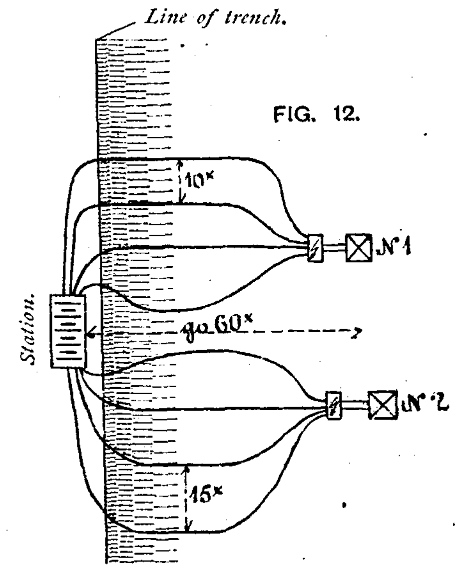

FIG. 13.

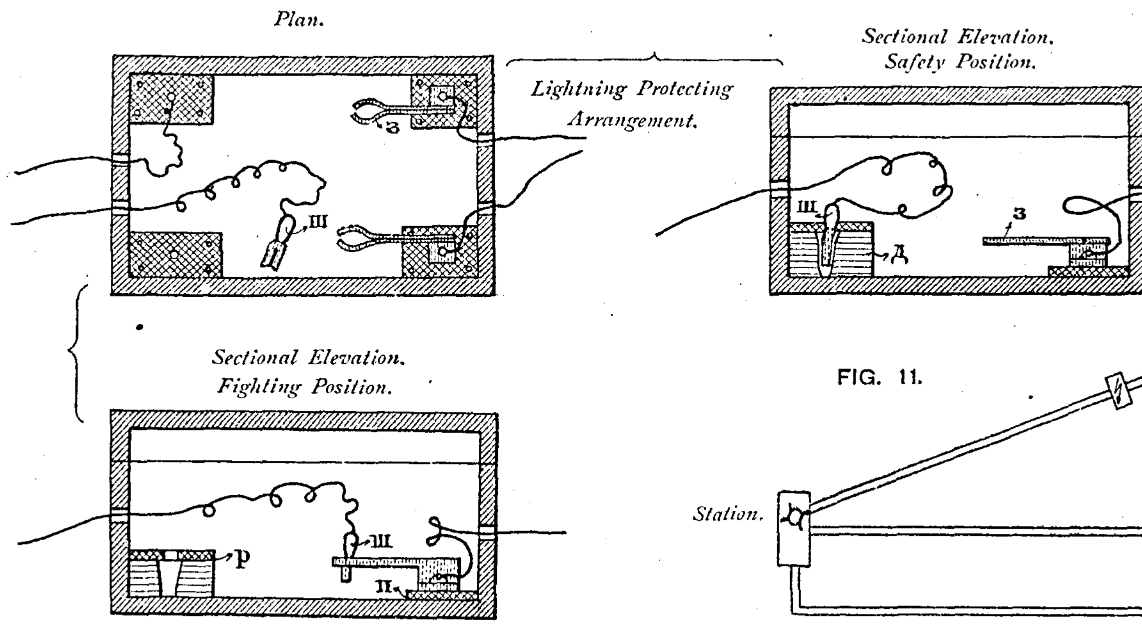

FIG. 11.