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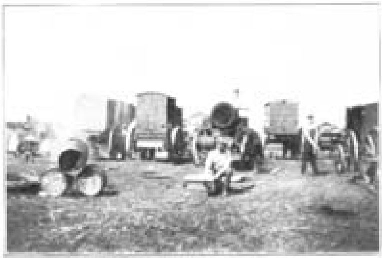

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## SEARCHLIGHTS IN FIELD OPERATIONS

# *SEARCH LIGHTS IN FIELD OPERATIONS.*

*By* CAPT. R. WALKER.

NO one will deny that Search Lights have their uses in night operations. How far they may be useful is open to discussion. It is obvious, too, that there are occasions when to use them is a mistake; and also that when once it has been decided to employ them, it is equally a mistake to expose them too soon.

It will be as well to lay down at once what lights can do, and how far they make night operations approximate to day operations in discovering the enemy and enabling aimed rifle fire to be brought upon him. This, we may assume, is their primary *rôle*.

The power of illumination on land (spoken of generally as "Ranges"), is so dependent on the nature of the terrain and atmospheric condition that the figures given below, which have been fixed for this country on an averagely clear night, may in many other instances—such as on a very clear night, or in Egypt or South Africa—be considerably increased.

## (1). IN DEFENCE.

(*a*). Dispersed beams can illuminate the foreground up to 600 yards, and within this distance bodies of advancing troops can be easily detected. Low-power glasses are necessary beyond this range.

(*b*). Concentrated beams in conjunction with expert observation can be employed to watch a defile, bridge, road, or edge of a wood at 3,000 yards distance.

## (2). IN ATTACK.

(*a*). Concentrated beams can illuminate an objective, or indicate direction, or give any determined signal when 2 miles distant from the advancing troops.

(*b*). Concentrated beams can assist artillery fire at ranges up to 3,000 yards.

(*c*). Concentrated beams will assist an advance by lighting up the ground, especially when the defenders have no lights.

## GENERALLY.

Lights impart confidence, can seriously impede the enemy's vision, and are useful for long-distance signalling by day or by night.

Their limitations and their disadvantages are as follows :—

(1). Mist, or rain accompanied by mist, makes them useless.

(2). It is impossible to have an absolutely silent engine, although it is possible to have a light-tight projector.

(3). An insufficient number of lights (in defence) may be a source of danger by imparting false confidence.

An insufficient number of lights means that some beams must be "wandering," and when these are used, attacking troops can get close up, although it may take time; and while the defenders are looking for the attack in the beam, they may be rushed from the dark intervals.

For effective defence a fixed illuminated area in front of the position must be obtained, necessitating a very large number of lights.

(4). In close broken country, like the south of England, it is almost impossible to ensure this illuminated area without siting the lights too far in advance and endangering them.

(5). There will always be difficulties in getting the lights away, for they are most useful when the attack has come in to close ranges.

Experience to date has proved that lights must be in, or very near to, the firing line; the ideal ground where it is possible to site them 500 yards behind the firing line shining over the defenders' heads, is rarely met with.

(6). In case it is necessary to change position during the night, the move can never be done in absolute silence, with wheeled vehicles and horses.

(7). If inadvertently exposed before the proper time, a point is immediately given for the attack to march on, and for the hostile gunners to range on.

(8). To ensure the best effect, a very careful and reliable system of communication is necessary between the O.C. Lights, the O.C. Defence Section, trained observers in front, and the O.C. R.A. This is not easy to arrange for at night.

(9). If used at all, the element of surprise—which up till now has been the "leading factor" in all night operations—is done away with.

With these points before us, it is possible to determine what lights are the best, and what must be the essential details of construction.

## For Defence.

The majority of the lights should be 35-cm. (14″) size, and three of these lights can be run off one engine. Their use approximates to that of Maxim guns and they can be easily man-handled if necessary.

In addition, positions could as a rule be formed in any defensive position for one or two 90-cm. lights (3′) with wide (45°—30°) dispersed beams shining to the front, and also for one or two 10° and 16° dispersed beams shining across the front of a position.

## For Attack.

Large 90-cm. lights are of most use, concentrated beams sited over a wide arc. Small lights (35-cm.) would be very useful in the last stages of the attack, keeping directly in rear of it and above it, and shining into the eyes of the defence.

## Essential Features of Construction.

The employment of field search lights approximates to that of Maxim guns and field artillery, and in their construction this fact must be kept in view.

## Large and Medium Lights, 90-cm. and 60-cm.

The projector itself is mounted on a trail carriage fitted with springs and having seats for two men and buckets for four rifles. It should be made absolutely light-tight, *i.e.*, when running it must be invisible from the front; it must be capable of accurate and easy "setting," the traversing gear must be on ball-bearings, and used in conjunction with a graduated arc and pointer.

Rough siting arrangements are necessary. All other details, such as lamp, recording instruments, and switch, must be simple and strong and part of the projector.

The trail carriage must be fitted in front with a bullet-proof shield, and must carry a box with a spare reflector. In the trail boxes small stores, such as carbons, pliers, etc., must be carried.

The limber carries the 300 to 400 yards of twin cable and all other necessary stores. It is hung on springs, and carries two men and four rifles; it is fitted for pole draught and quick release R.A. harness. The whole weight behind the team of four horses must be kept under 30 cwt. The brake on the trail carriage is operated from the rear of the trail carriage. The small size (35-cm.) should follow on these lines. The weight must not exceed 16 cwt. It should be possible to carry a pair on each carriage.

We are at the present time ready to standardize the heavier type of trail carriage and limber. The projector has been standardized.

It has been the custom up to date to transport three small lights in one G.S. wagon, moving into position by hand; but this method is impracticable, as capture is inevitable, and must give way to the trail carriage.

We may here assume, and experience proves it, that two sizes of lights are sufficient for all requirements—the 90-cm. or 3′, and the 35-cm. or 14″.

## THE ENGINE WAGON.

The engine wagon is an ordinary 4-wheeled wagon with underlock forecarriage, hung on stout springs, and having a strong rear brake.

The engine is a 4-cylinder 18-H.P. Siddeley, starting on petrol and running on paraffin. This, and a direct-coupled dynamo of 8 kw. are carried suspended between the main girders of the frame, the centre of gravity being kept as low as possible.

Over this is constructed an iron framework body consisting of four angle-iron corner pieces, 3′ high, carrying a sheet-iron roof. The ends are boarded, and the sides are covered by curtains or sliding doors. The underside of the engine and dynamo is also protected. The wooden end behind serves as a switchboard, and carries the stands and straps for the rifles. The weight behind the horses should not exceed 50 cwt.

## ORGANIZATION.

It is considered that 1 company with headquarters and 3 sections is sufficient for 1 division of the field army.

Each section, at war strength, consists of—

Two 90-cm. lights and four 35-cm. lights.
2 engine wagons.
1 store wagon.

The *personnel* required is—

| | | |
|---|---|---|
| Dismounted | ... | 2 sergeants, 16 rank and file. |
| Mounted | ... | 1 officer, 2 sergeants, 2 corporals, 16 drivers, 7 wagons, and 30 draught horses. |

The length of road required for the whole unit is 430 yards.

To equip 1 company would cost approximately £7,000. The upkeep during peace should not be very great, and it should be possible to organize the units on the lines of the bridging trains with a somewhat large cadre, in connection with a small school of instruction. The reason for this is that the lights will only be wanted on occasions. Their employment however differs considerably from the idea of a train, and this is the difficulty. When lights are wanted they must be handled as smartly, and be as reliable in action as field guns are at present. For this, high training is required, especially as everything must be done in the dark and in silence.

It is not generally known that there were nearly 100 search lights of sorts in use during the latter part of the South African War, and since then they have been used in the Russo-Japanese War, the Natal Rebellion, 1906, and by the Germans in South-West Africa.

Besides the uses already quoted, and borne out by three years' experience in peace time, other instances are bound to crop up in war time when lights would really be of great assistance.

The following are suggested :—

(1). To assist in the night reconnaissance of a well-defined position.

(2). In conjunction with cavalry to dispute the passage of a ford or bridge, and to stop the construction of a hostile bridge.

(3). Long-distance signalling, up to 40 miles or more. This is rarely possible in England.

(4). Deceiving an enemy by exposing lights some miles away to a flank.

(5). To detect and oppose a night retirement after a hard-fought action.

(6). For general illumination—of a battlefield after an action, of a camping area, and in several other cases.

(7). On the lines of communication.

(8). In detached posts, blockhouses, armoured trains.

(9). On all occasions for savage warfare the presence of one light will save much tedious night outpost work, and will be likely to prevent night attacks.

## Vulnerability.

Ranges of an opposing light can be quickly and accurately taken with Service range-finders, and no difficulty is found in laying guns directly on a search light. Laying rifles and machine guns when in the beam of light is harder, but can also be done. For accurate shooting the sights must be illuminated.

It is however a difficult matter to "knock out" a search light. Of course, a projector, if sited in the open without frontal or head cover, would sooner or later suffer from shrapnel fire. But the difficulty of observing artillery fire, the ease with which lights can be doused and moved, the smallness of the target, and the possibilities of providing adequate cover make it very difficult to hit the projector.

If the beam is reflected from a plain glass mirror, the light is quite invulnerable, but this is only applicable to semi-permanent works.

As regards the reflectors, a glass one supported over its back will hold three or four bullet holes, and the light at close ranges is little affected until a large part of the reflector is shot away. A metallic reflector, when struck, rapidly loses its shape, and a ragged beam is the result.

Until the untarnishable metallic reflector is produced, experience teaches that it is best to use glass and take the risk. Parabola-ellipse reflectors are used instead of front door lenses (the difficulties of producing an accurate metal P.E. reflector have not yet been overcome).

The value of lights was proved in the South African War, and as stated above there were nearly 100 in use during its later stages, chiefly in armoured trains, in blockhouses, and fortified posts on lines of communications.

It has been said that two lights of the Boers considerably helped them in their advance to attack Wagon Hill. There are cases, too, when lights were bombarded, but no instance of their being destroyed.

The Russians at Port Arthur had at one time seven lights in use, and although their usefulness was belittled by the Japanese, it is a known fact that no further night attack was made after August 23rd, when they lost over 5,000 men. Their own two lights, being sited some 6,000 yards in rear, were of little help, while the Russian dispersed beams gave such valuable assistance that the Japanese attack on the parts of the defensive position, where the lights were installed, failed completely.

Bearing on this, the following extract is of considerable interest, from *The Great Siege*, by W. B. Norregard, who was formerly an artillery officer, and was present with the Japanese forces, as correspondent, when they were besieging Port Arthur :—

A strong detachment marched against the entrenchments at the foot of Itzeshan and the Shuishi lunettes. The Russian search light from Itzeshan soon detected the moving troops, and we saw that, instead of seemingly flashing erratically all over the ground, it suddenly became fixed and immovable. The Japanese advance was slow and cautious. The light blinded and confused them, and where they were exposed to its rays the Russian bullets fell fast and furious. With no means of retaliation against their enemies, hidden behind a stream of light, they had to take cover during the advance in declivities in the soil or behind mounds or hillocks, where the rays of the implacable light could not reach them. The Japanese artillery tried to destroy the light. We could see small clouds of smoke and dust springing up in front of it, and for a moment draw a thin veil across it, and from our angle of observation we saw shells burst nearer and nearer. Suddenly the light went out; a shell which burst right in front of it had been lucky enough to hit it, we thought, and the night seemed doubly dark after. Taking advantage of this darkness, the Japanese advanced rapidly. There was no longer any need for caution; it was all-important to come to close quarters with the enemy before another light was turned on them. They had advanced to some 400 or 500 yards from the Russian positions, when suddenly the light flashed out again. And not that alone, but the light from Golden Hill and another light from somewhere behind the Erhlung forts, which we had not seen until then, concentrated on them, and in the combined glare of the three search lights the Japanese stood out against the darkness like lantern pictures on a screen. Instantly a tremendous fire opened on them from rifles and especially from machine guns, which at this range played sad havoc amongst them on the coverless plain.

The author also adds :—

It is a noteworthy fact that after August 23rd no night attack was ever made by the Japanese on any place where the rays of the light could reach them, whilst all the Russian sorties and counter-attacks have been made at night, when they could have the assistance of their lights.

Several night marches and night attacks were made by the Japanese in Manchuria, but only once was a large force employed. This was at San-kai-shih-shan, where it was successful against a stubborn defence by the Russians. The Russians had ordered 10 sets of portable horse-drawn lights for their field operations, but they did not arrive at the front in time. It would be interesting to know what influence the presence of lights would have had on this battle. Then again, when the Japanese made other attacks at night they usually found the Russians had retired. Would not these lights have imparted some confidence to, at any rate, a portion of the firing line, and helped them to "remain?"

What conclusions, then, are to be drawn? Are lights wanted with the field army or not?

Experience gained since April, 1905, in peace operations at Aldershot, Okehampton, Salisbury Plain, Chatham, and command manœuvres may help us to a decision.

They are of undoubted use in a defensive position, provided that:—

(1). There are a sufficient number of them.

(2). They are sited to illuminate a fixed area, and, as a rule, are not allowed to "wander."

(3). They can be made invisible from the front when fully turned on, but ready to be exposed at any moment when information has been received from advanced observers that the enemy is advancing to the attack.

They should be used in conjunction with efficient obstacles and to assist machine-gun fire. They should, wherever possible, be sited in rear of the firing line, to give assistance to aiming by their diffused light.

*In attack* their use is not so obvious, but given a well-defined target, they can materially assist artillery fire, and aid an advance by illuminating an objective.

*In counter-attack* it is claimed that, by their aid, it should be possible to throw back or disorganize a force which is assembling within short range of a defensive position, with a view to attacking at dawn.

Their moral support no one will deny.

Taken altogether, their assistance to night operations must not be lightly ignored, for should we find ourselves opposed to an enemy provided with search lights we should be at a disadvantage, and the extent of our night operations would be curtailed if we had not got them ourselves.

Other armies, we know, have field search lights, and, if only to put us on an equal footing, we should adopt them, and should we ever be opposed to an enemy not provided with lights, we shall then hold a distinct advantage.

# *NOTES ON REINFORCED CONCRETE* VERSUS *WOOD.*

*By* MAJOR A. H. D. RIACH, R.E.

THE use of reinforced concrete in lieu of steel, brick, and stone is rapidly becoming more general, but its advantage as a substitute for timber is, at first sight, less evident. As a general rule good timber can be subjected safely to greater stresses, both in compression and tension, than armoured concrete, and the consequent greater dimensions required for members of this material, its great weight and the care needed in its manufacture, would appear to outweigh any arguments in favour of its adoption for beams, rafters, small posts, etc., in ordinary building construction, particularly when the adaptability of wood, and ease with which it can be worked, is taken into account.

In the new barracks at Jubbulpore, Major Stokes-Roberts, R.E., has however taken the bold departure of making up (amongst other parts of the buildings) door frames, verandah rafters, battens, bressummers, pillars and pillar caps of concrete suitably reinforced, and finds that he has effected a large saving thereby.

The following notes, describing the methods and first results of a trial of the same material, now in progress in the barracks at Ahmednagar, may be of interest.

In the barracks first built the lintels were made of reinforced concrete, and the pillar bases and bedstones for trusses of plain moulded concrete blocks. Except for small areas of flat roofs, no other armoured concrete was introduced. The verandahs are roofed with tiles on wooden rafters, posts, etc. It is proposed to discuss in this article however the advantages of employing reinforced concrete in members usually made of wood.

*Nature of Members Manufactured.*—It was considered that no gain would result from the use of concrete rafters and battens on account of the largely increased dimensions necessary for these members. On the other hand, the posts, pillar caps, bressummers, and verandah wall plates needed little or no increase of dimensions, and these have therefore been made up, as described and illustrated below. The standard spacing of verandah pillars was fixed at 9′ c. to c. (in lieu of 7′ 6″, as hitherto adopted for timber), rafters being 3′ c. to c.

*Materials Available.*—An abundant supply of shingle of all sizes, from ¾″ downwards, is available, and this forms an ideal aggregate, after washing and screening out all pieces below ¼″. The sand available is poor, being round, friable, and hard to clean thoroughly, but in practice excellent results have nevertheless been obtained. The proportion of voids in the shingle ballast is low, and the quantity of mortar needed for a dense concrete is consequently less than the average. It has therefore been possible to reduce the proportion of sand to cement to below what is usually given, without increasing the cost of the concrete.

*Proportions for Concrete.*—A concrete of 3 parts shingle, ½ part sand, and 1 part cement (by volume) has been used for pieces likely to be subjected to direct blows, *e.g.*, for posts for wire railings, or for chairs of verandah posts in barracks, and has proved exceedingly tough. For lintels and members not liable to direct shocks the proportion of 5 shingle, 1½ sand, and 1 cement has proved satisfactory. With shingle up to 1″ gauge, 5 shingle, 2 sand, and 1 cement is used. For the work herein described the proportion adopted is 4 shingle, 1 sand, and 1 cement.

*Consolidation.*—The proportion of mortar being low, greater care in consolidating is taken than is customary in American and Continental practice. Every mould is well tamped as it is being filled, and when filled the surface is thoroughly rammed with the heaviest rammers of which the surface will admit. The result is a very compact concrete.

*Proportion of Water.*—Much depends on the right proportion of water being given. For clean surfaces and compactness the concrete is mixed so that while it looks only damp when being handled, yet, on ramming, water comes readily to the surface, and the whole becomes quaky. If the unrammed concrete is wet and pappy-looking, it is not possible to effectively consolidate it in small moulds owing to the excessive sloppiness. In heavy masses (*e.g.*, bridges) more water is beneficial, as less ramming can be given than with small batches; in short, the more the ramming, the less the water.

Actually in practice proportions work out to:—

(*a*). For lintels, in moulds which can be rammed with heavy rammers, 12 gallons of water to 10 c.f. of completed product. This works out to shingle 5 c.f., sand 2 c.f., cement 1 c.f., water ·95 c.f.

(*b*). For the posts, bressummers, etc., described in this article, 13 gallons of water to 10 c.f. of finished articles, *i.e.*, 4 c.f. shingle, 1 c.f. sand, 1 c.f. cement, ·83 c.f. water (the amount of shingle used is almost exactly the cubic measure of the finished article, except with very rich mixtures).

*Weight.*—The average weight of the finished articles is 153 lbs. per cubic foot. The weight of the ingredients is:—

| | |
|---|---|
| Shingle, unrammed, dry ... ... ... | 92 lbs. per c.f. |
| Sand, loose, dry ... ... ... ... | 95 lbs. „ |
| Cement, loose... ... ... ... ... | 92 lbs. „ |

*Specific Gravity and Porosity.*—The specific gravity of the concrete alone, varies from 2·44 to 2·62 (the higher figure being for a block of concrete of 1 cement, 1 sand, and 3 of hard black trap ballast). The porosity (*i.e.*, ratio of increase of weight after thorough wetting) from 1·6 to 3·6 per cent. This factor is relative, and not absolute, as the degree of dryness is a variable quantity, for in wet weather the increase of weight due to soakage of water will be less than in dry weather. It is given as affording some indication of the compactness or density and watertightness of the concrete. The porosity of samples of 1:2:4 cement concrete obtained elsewhere, and tested at the same time, varied from 5·2 to 8 per cent.

*Armouring.*—It is very convenient to make up the armouring as a skeleton, ready to drop into the moulds. The skeleton armour is shaken as the concrete is being filled into the moulds, to get the rods into correct position and well-embedded. No rods have been found exposed when moulds are removed.

*Moulds.*—It has been found profitable in every way to manufacture the pieces in moulds with a large number of partitions (*vide Plate* I., illustrating the moulds used for railing posts, and *Plate* II., those for bressummers). In every member, the armouring of which is unsymmetrical, the lower edges are chamfered, or the tops and bottoms of the pieces otherwise distinguished. The moulds are made of wood, carefully planed and sandpapered, and pickled in cocoanut oil for three days. The base plates consist of steel plates. Great care is taken with the fitting of the moulds, as it has been found that roughened and warped moulds give much trouble.

*Oiling.*—Before filling, the whole is wiped over with a fairly dry oil rag, and no concrete ever sticks. The armouring is then placed in position (care being taken that no surplus oil is about, to get on to the armouring), and the bolts to form holes for dowels, etc., are wiped over with the oil rag and fixed.

*Treatment after Consolidation.*—These bolts are turned as soon as the mass has been rammed, and are removed the following morning. The sides of the moulds can be removed after 24 hours, but otherwise the pieces are left untouched for 10 days under straw, which is kept well wetted. They are then removed and stacked, and kept wet for a further five days or more. It is most desirable to allow them to dry out in the shade. Sudden partial drying in the sun is liable to cause unequal shrinkage and hair cracks, which are unsightly and may cause weakness. This applies especially to slabs and thin pieces, and particularly in dry weather. Ten days on their beds is laid down ; if handling earlier is unavoidable, it must be done with the greatest care.

*Touching Up and Surfacing.*—Surfacing, if required, is done on the tenth day (exposed surfaces can be surfaced on the second day). The pieces come out with clean surfaces and sharp arrises, and, except for the sake of appearance, they need no touching up other than filling in a few holes left by excess water, or touching up chance injuries; in fact, the surfaces are so clean that they have to be roughed before sand rubbing will adhere.

*Sand Rubbing.*—The sand rubbing is done by applying and rubbing in with wooden floats the thinnest possible skin of specially chosen sand 2 parts and cement 1 part. Care is taken to avoid streakiness in this coating. Trowels are unsuitable as they give a polished surface. The difficulty of making the sand coat adhere is a defect to be guarded against.

*Ornamentation.*—The simplest possible design is followed, viz., plane surfaces with plain chamfers, the members being treated as cut-stone. It is considered that in barracks, otherwise plain and solid, the addition of anything in the nature of florid embellishments would be out of place. At the same time ornament can be applied with little extra trouble if desired.

*Conditions of Work and Labour Employed.*—The work is done as far as possible under cover. Two trained masons with a few coolies are constantly employed; they fill three or four moulds daily, empty a corresponding number which have lain 10 days, and surface and water as required, in rotation. The armouring is made up into skeletons beforehand by one or two khalassies. A carpenter is employed, if specially required, for alterations or repairs to moulds. In this way no labour is wasted, and supervision is reduced to a minimum, a most important matter when the quality and trustworthiness of the product depends on reliable work efficiently supervised.

*Cost.*—The following details show the cost of the work; they are actual figures, not specially selected :—

I. 112 RAILING POSTS* OF 1 CEMENT, $\frac{1}{2}$ SAND, 3 SHINGLE, EACH $6' \times 4'' \times 4'' = \frac{2}{3}$ C.F.—TOTAL, 75 C.F.

| | R. | a. | p. |
|---|---|---|---|
| 72 c.f. screened and washed shingle at R.3 8a. per 100 c.f. ... ... ... ... .... | 2 | 8 | 3 |
| 24 c.f. cement at R.2 per c.f. ... ... ... | 48 | 0 | 0 |
| 12 c.f. sand, washed, at R.3 per 100 c.f.... ... | 0 | 5 | 9 |
| 3 cwt. $\frac{1}{4}'$ round steel, mild, at R.8 per cwt. ... | 24 | 0 | 0 |
| 1 cwt. wire, 150 lbs. to the mile, at R.14 per cwt. | 14 | 0 | 0 |
| Labour ... ... ... ... ... ... | 28 | 0 | 0 |
| Straw, oil, etc. ... ... ... ... ... | 1 | 2 | 0 |
| Total ... ... | R.118 | 0 | 0 |

Cost per c.f., R.1 9a. 2p., exclusive of surfacing.

These are for use in lieu of jarrah wood posts of the same dimensions, costing R.2 per c.f., unwrought. There is a gain of say 8a. per finished post in favour of concrete. The resulting railing is neat and satisfactory.

* As *Plate* I.

## II. Ferro-Concrete Work in Pillars, Bressummers, Caps, Gate Posts, etc., of 1 Cement, 1 Sand, and 4 Shingle.

*Work Done from* 21. 1. 08 *to* 5. 2. 08.

| | | | |
|---|---|---|---|
| 36 verandah pillars, | 6′ 2″ × 5″ × 5″ ... | ... ... | = 38 c.f. |
| 20 bressummers, | 9′ 0″ × 5″ × 5″ ... | ... ... | = 31 „ |
| 36 caps | 3′ 0″ × 5″ × 5″ ... | ... ... | = 19 „ |
| 6 gate posts | 6′ 0″ × 5″ × 5″ ... | ... ... | = 6 „ |
| 3 struts to do. | 6′ 0″ × 4″ × 3″ ... | ... ... | = 2 „ |
| | | | 96 c.f. |

*Labour Employed.*

| | R. | a. | p. |
|---|---|---|---|
| 2 masons, 16 days at 14a. ... ... ... | =28 | 0 | 0 |
| 4 coolies, 16 days at 4a. ... ... ... | =16 | 0 | 0 |
| 2 women do., 16 days at 2a. 6p. ... ... | = 5 | 0 | 0 |
| 1 khalasee, 16 days at 8a. (wiring steel work) | = 8 | 0 | 0 |
| ¼ carpenter, 16 days at R.1 ... ... ... | = 4 | 0 | 0 |
| ½ bhisti, 16 days at 10a. ... ... ... | = 5 | 0 | 0 |
| | 66 | 0 | 0 |
| Deduct:— | | | |
| Labour value of 24 pillar bases and 24 bed-stones made by above labour=48 at 3a. | = 9 | 0 | 0 |
| Total labour ... ... | R.57 | 0 | 0 |

*Materials.*

| | R. | a. | p. |
|---|---|---|---|
| 96 c.f. shingle at R.3 8a. per 100 c.f. ... ... | = 3 | 5 | 9 |
| 24 c.f. sand at R.3 per 100 c.f. ... ... | = 0 | 11 | 6 |
| 24 c.f. cement at R.2 per c.f. ... ... ... | =48 | 0 | 0 |
| Round steel, mild, 6 cwt. 3 qrs. 23 lbs., at R.8 per cwt. ... ... ... ... ... | =55 | 10 | 3 |
| Steel wire, 2 qrs., at R.12 per cwt. ... ... | = 6 | 0 | 0 |
| Cocoanut oil, 3 lbs., at 4a. per lb. ... ... | = 0 | 12 | 0 |
| Grass, etc., say ... ... ... ... ... | = 0 | 8 | 6 |
| Total material ... ... ... | R.115 | 0 | 0 |
| Total labour and material ... | R.172 | 0 | 0 |

Rate per c.f. = $\frac{172}{96}$ = R.1 12a. 8p. per c.f.

P.S.—The above includes labour and material used in sand rubbing the surfaces.

*Issue Rate.*—The labour charges tend to get lower as the workmen become more expert. The issue rate of the members described, *including moulds*, has been fixed at R.2 per c.f.

Including the comparatively simple lintels, with their lesser proportion of cement and the pillar bases which have no armour, an all-round rate of R.2 per c.f., *fixed in position*, amply covers the cost of the work. In the comparative statement below this rate has been taken.

*Comparison with Cost of Teak.*—Comparative cost of teak and ferro-concrete for a verandah 100′ long.

(*a*). Mangalore tiles on battens $1'' \times 1\frac{1}{2}''$, rafters $3'' \times 5''$, bressummers $5'' \times 4''$, pillar caps $2' \times 5'' \times 4''$, posts $5'' \times 5''$ at $7\frac{1}{2}$ c. to c., pillar chairs of concrete blocks, wall plate $3'' \times 4''$, all woodwork teak.

(*b*). Mangalore tiles on battens $1'' \times 1\frac{1}{2}''$ and rafters $3'' \times 5''$ of teak, bressummers, ferro-concrete, $5'' \times 5''$, pillar caps, ferro-concrete, $3' \times 5'' \times 5''$, posts, ferro-concrete, $5'' \times 5''$ at $9'$ c. to c., pillar chairs of concrete blocks, wall plate, ferro-concrete, $3'' \times 4''$.

Detail of cost of above:—

| | | |
|---|---|---|
| (*a*). 14 concrete chairs $1' \times 1' \times \frac{2}{3}'$ ... | = 9·33 c.f. at R.2 c.f. | =R. 18·66 |
| 14 posts, teak, $6'\ 6'' \times 5'' \times 5''$ ... | =15·80 | |
| 14 pillar caps, teak, $2' \times 5'' \times 5''$ ... | = 3·89 | |
| 100′ bressummer, teak, $5'' \times 4''$ ... | =13·89 | |
| 100′ wall plate, teak, $3'' \times 4''$ ... ... | = 8·33 | |
| | 41·91 at R.3 12a. c.f. | =R.157·16 |
| 14 holding-down bolts, complete, at $6\frac{3}{4}$ lbs. ... | $=94\frac{1}{2}$ lbs. | |
| 14 straps for posts, complete, at $4\frac{1}{2}$ lbs. ... ... | =63 ,, | |
| 34 rafter cramps, complete, at 2 lbs. | =68 ,, | |
| 34 connection rafter to wall plate at $\frac{1}{3}$ lb. ... | $=33\frac{1}{3}$ ,, | |
| | $258\frac{5}{6}$ lbs. at R.21 cwt. | =R. 48·56 |
| | Total ... | R.224·38 |

| | | | |
|---|---|---|---|
| (*b*). 12 concrete chairs $1' \times 1' \times \frac{2}{3}'$ ... | = 8 c.f. | | |
| 12 posts, ferro-concrete, 6′ 2″ × 5″ × 5″ ... ... | = 12·85 | | |
| 12 pillar caps, ferro-concrete, 3′ × 5″ × 5″ ... ... | = 6·25 | | |
| 100′ bressummer, ferro-concrete, 5″ × 5″ ... ... | = 17·36 | | |
| 100′ wall plate, ferro-concrete, 3″ × 4″ ... ... | = 8·33 | | |
| | 52·79 at R.2 | | = R.105·58 |
| 12 anchor dowels for chairs, complete, at $4\frac{1}{3}$ lbs.... | = 52 lbs. | | |
| 12 dowels for posts $\frac{1}{2}'' \times 9''$ at $\frac{1}{2}$ lb. ... | = 6 „ | | |
| 3 × 12 dowels pillar caps $\frac{1}{2}'' \times 9''$ at $\frac{1}{2}$ lb. ... ... | = 18 „ | | |
| 22 dowel bolts for rafters with nuts $\frac{1}{2}'' \times 10''$ at $\frac{2}{3}$ lb.... | = 15 „ | | |
| 12 ditto with turned ends at $\frac{4}{5}$ lb. ... | = 10 „ | | |
| 34 connections wall plate and rafter at $\frac{2}{3}$ lb. ... ... | = 29 „ | | |
| | 130 lbs. at R.21 cwt. | | = R. 24·38 |
| | | Total ... | R.129·96 |
| | | Saving ... | R.94·42 |

*Practical and Financial Advantages.*—These figures show a saving, bulk for bulk, in favour of ferro-concrete of R.1 12a. per c.f., or, in the case of the verandah, a saving of 15a. per r.f. of verandah, due to this and the increased spacing of the posts permissible with concrete bressummers. Adding the cost of painting, initial and recurring, the saving comes to R.1 per r.f. of verandah.

It is therefore evident that when it is found possible to run the manufacture of reinforced concrete under proper supervision, and with a sufficient output to pay for the moulds and other initial expenses, a very substantial gain can be realized by employing this material extensively in place of teak or other expensive timber. Once erected, the members need no maintenance and are practically indestructible.

*Strength.*—Finally as regards strength.

The formula employed is as follows :—

Factor of safety, 3.

$d$=effective depth (*i.e.*, to centre of reinforcement) in inches.

$b$=breadth in inches.

Mild steel bars.

For supported beams uniformly loaded

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

where W=safe distributed load in pounds.

L=span in feet.

X=45, 57, 73, 100, and 130 where percentage of armour is $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{2}$, or 2 per cent. respectively.

(Major Stokes-Roberts' *Application of Reinforced Concrete*).

The following tests of members, made as specified hereafter, serve to show that the factor of safety allowed by this formula for members loaded as beams is sufficient even when the members have a visible defect. They also confirm results already observed, that the adhesion of the armouring to the concrete is not sufficient to prevent round rods from drawing, when subjected to a tensile strain far short of that which can be borne when the armouring is prevented by its shape from drawing.

Carefully-made members, with armouring suitably applied, can be safely stressed to a far higher limit than that given by the formula.

I. *Test of Railing Post.*—Ferro-concrete railing post, made as per *Fig.* 6, *Plate* I., age $3\frac{1}{2}$ months.

Post tested had been cracked through at the centre, crack visible on all four sides, and had other cracks, due to carelessness during manufacture.

In order to see what it would stand in its defective state, it was tested as follows :—Beam supported, clear span 4′ 6″, load suspended by slings from centre. Load oscillated considerably, and is assumed to be equivalent to a dead *distributed* load $2\frac{1}{2}$ times greater.

Load 634 lbs. applied, and again removed.

Beam recovered ·12″.

Load 761 lbs., deflection ·18″, some flaking at top edges of central crack, bottom edges opened slightly.

Load 886 lbs., deflection ·36″.

Load 1,013 lbs., beam broke slowly by crushing at upper edges of central crack and drawing of lower rods of armouring, *which were not fishtailed or bent* to prevent drawing.

Beam did not fall.

Effective section of beam $=4'' \times 3\frac{1}{4}''=13$ square inches.

Section of armour in tensile edge $=2 \times \cdot 049 = \cdot 1$ square inch say.

$\therefore$ proportion of armour $=\frac{\cdot 1}{13}=\cdot 77$ per cent.

From formula $bd^2=\frac{WL}{X}$, where $X=57$,

$$W=4 \times \frac{169}{16} \times \frac{57 \times 2}{9}=535 \text{ lbs.}$$

=safe distributed dead load.

By assumption, the breaking load of 1,013 lbs. $=2\frac{1}{2} \times 1{,}013=2{,}532$ lbs. distributed dead load.

The factor of safety is therefore nearly 5, with seriously defective beam; strength would have been greater had rods not drawn.

II. *Test of Bressummers.*—Tests of 5″ × 5″ ferro-concrete bressummer (Specification III.) moulded between 20. 2. 08 and 5. 3. 08. Tested 5. 5. 08.

Load applied symmetrically and distributed over bressummer and 4″ × 5″ teak joist, both supported over 6′ clear span.

Load 2,800 lbs. = 1,400 distributed over each beam, no observable result.

Load increased to 3,422 lbs. on each beam.

Bressummer deflected about $\frac{1}{16}''$.

Load left on for eight days, deflection increased to nearly ·2″.

Load lifted by jacks, beam regained ·177″.

Load reapplied, deflection of f.c. beam ·35″, of teak beam, ·48″.

Load 6,000 lbs. per beam, deflection of f.c. beam ·52″, of teak beam ·62″.

Load 7,900 lbs. per beam, deflection of f.c. beam ·53″, of teak beam ·70″.

Load lifted, residual deflection, f.c. beam ·06″, of teak beam ·02″.

F.c. bressummer had a central crack visible before testing. This did not develop, and beam was absolutely serviceable after test.

As load was applied in a manner which *may* have caused formation of a bridge effect, a further test was made, as below.

III. Similar ferro-concrete bressummer, and teak joist 4″ × 5″, clear span 6′, beams supported, load applied symmetrically to both beams and distributed. Tested 21. 5. 08.

The deflection of f.c. beam is shown in the following diagram (*Fig.* 1).

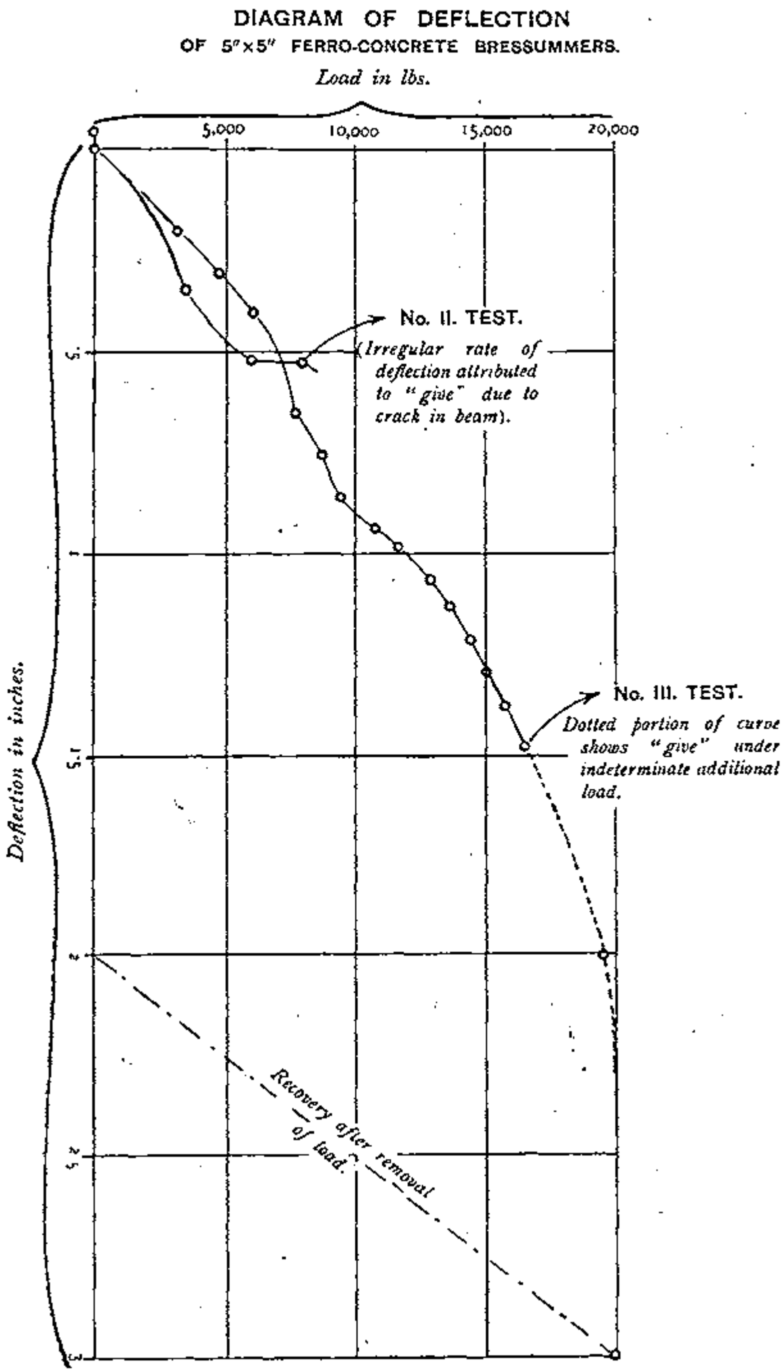
DIAGRAM OF DEFLECTION
OF 5″×5″ FERRO-CONCRETE BRESSUMMERS.
Load in lbs.
5,000
10,000
15,000
20,000
Deflection in inches.
.5
1
1.5
2
2.5
3
No. II. TEST.
(Irregular rate of deflection attributed to "give" due to crack in beam).
No. III. TEST.
Dotted portion of curve shows "give" under indeterminate additional load.
Recovery after removal of load.

FIG. 1.

| Load on each Beam in lbs. | | Deflection. | |
|---|---|---|---|
| | | F.C. Beam. | Teak Beam. |
| 1,550 | Left on all night, deflection gradually increased to .................. | ·15 | ·12 |
| 6,125 | Do. do. | ·40 | ·56 |
| — | Load jacked off, no residual deflection ........................ | — | — |
| 6,125 | Again re-loaded, deflection as before .................................. | ·40 | ·56 |
| 8,770 | Do. do. | ·75 | 1·08 |

Deflection of f.c. beam increased gradually as load was added to up to 2″, and, after load had remained on for 24 hours, to nearly 3″. That of teak beam increased at a lesser rate, but accurate progressive record was not kept.

After uniform load had been increased to 16,364 lbs. per beam, deflection of f.c. beam was 1·47″ and of teak beam approximately 2″. Further load then applied unsymmetrically, in such a way as to reduce load on teak beam, deflection of which was $1\frac{1}{3}$″ after 24 hours.

Total load applied to f.c. bressummer amounted to not less than 20,000 lbs.

As no further load could be applied without endangering the coolies employed and neither beam had broken, load was removed after four days.

The condition of the ferro-concrete beam, when still under the load, on 22. 5. 08 is shown in *Fig. 2*. Both this and the teak beam may be said to have been stressed almost to fracture.

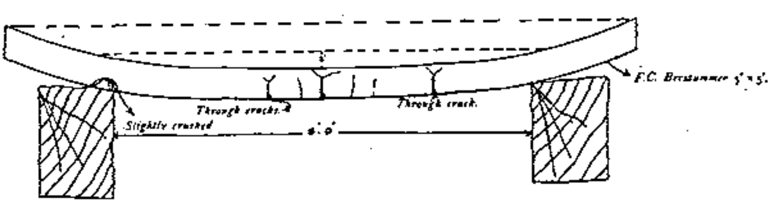


FIG. 2.—*Beam under Maximum Load (200,000 lbs.). Showing Deflection after 24 hours.—East Side.*

*Scale—2½ feet = 1 inch.*

On removal of load the concrete beam recovered 1" (*vide Fig.* 3), and the teak beam almost entirely. The latter is usable, but shows a horizontal crack 1½" above and parallel to the lower edge of the beam.

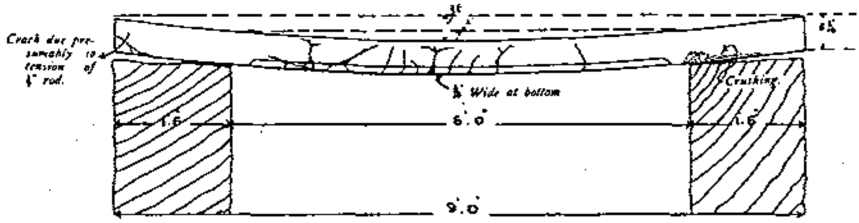


FIG. 3.—*Beam Five Weeks after Removal of Load.—West Side.*
*Scale—2½ feet = 1 inch.*

In the concrete beam crushing is apparent at one of the points of support, and also at one end, where the splayed ½" rods of the armour had apparently commenced to tear through the concrete.

IV. *Test of Wall Plate.*—Test of 3" × 4" verandah wall plate (Specification IV.), moulded on 13. 7. 08, tested 19. 11. 08.

Load applied symmetrically and distributed over ferro-concrete beam and teak beam of same dimensions (3" × 4"), both supported over 5' clear span :—

| Distributed Load on each Beam in lbs. | | Deflection in Inches. | |
|---|---|---|---|
| | | F.C. Beam. | Teak Beam. |
| 144 | ........................................ | ·05 | ·085 |
| 596 | ........................................ | ·085 | — |
| 1,008 | ........................................ | ·15 | ·245 |
| 1,296 | ........................................ | ·265 | ·35 |
| 2,016 | ........................................ | ·425 | ·51 |
| — | Load lifted, residual deflection ... | ·085 | not measured |
| 2,016 | Deflection as before.................. | ·425 | — |
| 3,024 | ........................................ | ·585 | ·69 |
| 3,456 | Teak beam suddenly failed........ | about ·65 | fracture |

Failure of teak beam, throwing all the load into the ferro-concrete beam, caused the concrete to crush and beam to fail at the centre.

Steel armour bent, but load did not fall to the ground. Horizontal shearing cracks formed at each end and near quarter spans during failure. Rods did not draw.

V. *Test of Batten.*—Test of $2'' \times 1\frac{1}{2}''$ ferro-concrete batten armoured with four rods $\frac{3}{16}''$ diameter. Age of test pieces about two months, tested 19. 11. 08.

Load applied symmetrically and distributed over batten $2'' \times 1\frac{1}{2}''$ on flat, and similar batten on edge, both supported over 5′ clear span :—

| Distributed Load on each Test Piece in lbs. | | Deflection in Inches. | |
|---|---|---|---|
| | | Batten Flat, $2'' \times 1\frac{1}{2}''$. | Batten on Edge, $1\frac{1}{2}'' \times 2''$. |
| 150 | ........................................... | ·61 | ·31 |
| — | Load lifted. Deflection at once decreased to ........................ | ·125 | — |
| 150 | Load re-applied, deflection as before | ·61 | — |
| 250 | ........................................... | failed slowly | — |

The failure was due to the gradual crushing of the concrete at the centre of the upper edge and the bending of the steel rods. No shearing cracks or drawing of rods apparent. Failure occurred at central hole in member. After the test the $1\frac{1}{2}'' \times 2''$ piece carried two men, say 220 lbs. live load, centrally, without damage. The whippiness of these small sections is most noticeable.

*Inferences.*—These tests are described in detail, as they illustrate the remarkable resiliency of the material, as well as the fact, so often remarked on, that with low percentages of armouring ultimate failure rarely occurs without unmistakable signs becoming apparent for some time beforehand.

Another point observed from these and other tests is that, for beams of approximately equal strength, concrete is considerably stiffer than teak.

Examining the results by the formulæ given in the report of the Joint Committee on Reinforced Concrete, published by the Royal Institute of British Architects, we can ascertain the maximum stresses on the materials under the loads applied, *e.g.*, test No. IV.

Effective section $= b \times d = 3'' \times 3{\cdot}25''$.

Sectional area of steel $= 4 \times {\cdot}049 = {\cdot}196$ square inch $= A_t$

(all four rods in tension at centre of beam, no armour in compression edge at this point in beam tested).

Then percentage of armour P

$$=\frac{\cdot 196}{3\times 3\cdot 25}=\cdot 0182$$

and. $$pm=\cdot 3015, \text{ where } m=\frac{Es}{Ec}=15$$

$$k=\frac{\text{depth of neutral axis from top edge}}{d}$$

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

$$=\cdot 53$$

or $$kd=1\cdot 722'' \text{ and } z=\cdot 574''$$

$$M=\frac{WL}{8}=\frac{3456\times 5\times 12}{8} \text{ at moment of failure.}$$

$$t=\text{tension on steel}=\frac{M}{A_t(d-z)}=49345 \text{ lbs. per sq. in.,}$$

which is within ultimate strength of steel

(factor of safety as regards steel $=3$).

$$c=\text{compression concrete}=\frac{zM}{A_c(d-z)}$$

(where $A_c$ = area in compression $=kd\times b$)

$c=3744$ lbs. per square inch,

giving a factor of safety for concrete of 6·2.

Similarly for Test V we find, at moment of failure,

$t=42300$ lbs. per square inch, and

$c=3980$ lbs. per square inch.

In the case of Test IV. the results would have been considerably higher had the failure of the teak beam not caused the premature collapse of the concrete member, while in Test V. the concrete had not dried out, and had not developed its ultimate strength.

Calculating from the data given in Test III. in the same manner with a load of 20,000 lbs. distributed, and neglecting the effect of the 1″ teak batten over the 5″ × 5″ beam, $t$ works out to 131,000 lbs. per square inch, and $c$ to 9,000 lbs. per square inch; but as these figures are clearly too high, the depth of the beam may be taken, for purposes of the calculation, as 5·25″. Even then we get $t=104{,}000$ lbs. per square inch and $c=6{,}479$ lbs. per square inch (assuming the ½″ rods alone to be in tension).

These figures are still very high, but the explanation may lie in the fact that the stretching of the ½″ lower armouring enabled the tensile strength of the upper ⅜″ rods to come into play. The results by any computation show the ultimate strength to be far in excess of the commonly accepted limit.

*Reduced Scantlings Permissible.*—From the foregoing it appears that the sizes of the members as made up are needlessly great, and that the saving shown as attainable can be further increased, particularly in buildings where the liability to improper usage is less than it is in barracks.

*Watertightness and Corrosion.*—One matter more calls for remark, namely, the possibility of corrosion of the armouring in exposed situations. The ½″ or so of concrete over the steel is sufficient to protect it under all ordinary circumstances, and it is considered that the life of the members in wet situations is at least as great as that of teak wood. For piles in wet ground, and other cases where excessive and constant moisture has to be expected, the armouring will need to be covered with a thicker layer of concrete, which must itself be rich enough to be waterproof.

Coke breeze concrete must not be used, as the sulphur corrodes the steel, and failures from this cause are on record.

*Conclusion.*—As already stated, work of this nature should not be undertaken unless it can be effectively looked after. Also it must be remembered that every piece has to fit correctly into the place it is required to occupy, so moulds, etc., must be standardized. The material can be cut with care, but all cutting and dressing should be avoided as far as possible, as it takes much time, and the concrete may be damaged. Further, it is necessary to handle the pieces with somewhat greater care than is usual in fixing carpenter's work, for it is not easy to neatly repair chipped corners, and cracks, even if they do not materially reduce the ultimate strength, are unsightly.

The excellent results here described are due to the care and interest taken by Lieut. Lee, M.W.S., by whom the workmen were instructed and supervised in every point.

The decision to extend the application of the material to buildings still to be put in hand finds ample justification in the confidence and experience already gained.

*Postscript.*—The percentage of armour it is desirable to employ is not discussed in these notes. In the specifications quoted the proportion applied at the tensile edge varies from 1½ per cent. to 2 per cent. of the *effective* section of the member. When there is no objection to members being of larger dimensions than are needed for these proportions, it may be advantageous to reduce the armouring. The tougher the concrete the greater the percentage of the armour which has to be applied at points subject to tension (and shearing), to balance the resistance to crushing the concrete is capable of exerting. No rule can be laid down, but in general the members should be so reinforced that when stressed to failure, that failure should be due to the gradual stretching of the steel, and not to the sudden collapse of concrete crushing (or of armour slipping).

In view of the results described in these notes, the following modifications are being introduced :—

(*a*). Verandah posts to be $4\frac{1}{2}'' \times 4\frac{1}{2}''$, armoured with four rods $\frac{1}{4}''$ diameter, tied into skeletons, as in specifications.
(*b*). Bressummers to be $4\frac{1}{2}'' \times 5''$ in lieu of $5'' \times 5''$.
(*c*). Pillar caps to be $4\frac{1}{2}'' \times 4\frac{1}{2}''$.

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## CALCULATIONS AND SPECIFICATIONS.

I. *Verandah Posts*.—$5'' \times 5'' \times 6'\ 2''$, assumed to suit $5''$ bressummer. A plain square column with stop chamfers ($1\frac{1}{2}''$ face of chamfer) (see *Figs*. 8 to 11, *Plate* III.).

Armour, four rods mild steel longitudinally, $\frac{3}{8}''$ diameter, formed into a skeleton with wire hoops at $6''$ intervals.

Sectional area of armouring, $4 \times \cdot 11 = \cdot 44$ square inch.

Proportion of armour to total section $= 1 \cdot 76$ per cent.

Method of armouring is as adopted by Capt. Traill, R.E., at Cauvery Power Station.

The longitudinal armour is to prevent bending. The wire ties are not large enough to enable the member to resist the tendency to burst if the stress exceeds that which good concrete will safely stand. This is taken as 350 lbs. per square inch for the type of construction employed (hooped concrete columns may be safely stressed to nearly three times this limit).

(Calculating as per *Military Works Handbook*, Formula V., where

$$l = 15h \text{ and } c = 350 \text{ lbs. per square inch.}$$

$$P = \frac{1}{2}\, cs = \frac{350 \times 25}{2} = 4{,}375 \text{ lbs.}$$

Now with posts $9'$ c. to c., roof slope $12'$, of which $\frac{2}{3}$ is borne on bressummer, $W = 9 \times \frac{12 \times 2}{3} \times 30$ lbs. $= 2{,}160$ lbs. So column is twice as strong as is necessary for safety for $10'$ wide verandahs).*

* Rafters are secured to wall plate, which is itself secured to wall, so roof does not tend to slide downwards.

At each end of the post a hole, ⅝″ diameter and 4½″ deep, is moulded, to receive dowels to connect post and pillar base and post and pillar cap.

II. *Pillar Caps.*—The pillar cap consists of a plain square member, with moulded ends (see *Figs.* 12 to 19, *Plate* III.). The armouring consists of ¼″ diameter rods tied into a skeleton with wire.

Three holes, ⅝″ diameter, are moulded, as shown, to receive the dowels connecting the pillar cap to the pillar and bressummers. For special cases similar pillar caps, 2′ long, are made up (*e.g.*, for use on posts next to corners of buildings).

For corner pillars, four-way pillar caps are moulded. The pillar caps are intended to act as cantilevers, so as to shorten the clear span of the bressummers.

In erection the members are bedded on a thin layer of cement mortar to ensure even bearings.

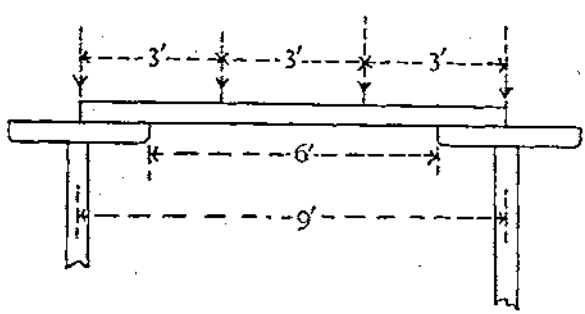
The dowels, shown in the drawings as ½″ diameter and jagged as lewis bolts, are more conveniently made of ⅜″ steel rods, slightly bent to act as a spring, so as not to fall out of holes. These bolts are bedded in cement, flushed into the holes.

III. *Bressummers.*—(See *Figs.* 21 to 24, *Plate* III.).

Take standard spacing of verandah pillars as 9′ c. to. c.

Pillar caps 3′ long.

Clear span of bressummers 6′.




Actual load is supplied at two points, each 1½′ from support. Scott-Moncrieff, *Principles of Structural Design*, Vol. I., pp. 72 and 73 (case 8) :—

$$M_f = W'a = W'\frac{l}{4},$$

and as $$W' = \tfrac{1}{2} \text{ total load } (W),$$

$\therefore M_f = \frac{Wl}{8}$ = moment of flexure for uniformly loaded supported beam.

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

and assuming percentage of armour as $1\frac{1}{2}$ per cent.,

$$X=100; \text{ taking } b=5'', d=4\tfrac{1}{4}'', L=6',$$

and substituting

$$W=5\times\frac{17}{4}\times\frac{17}{4}\times\frac{100}{6}=\frac{144500}{96}=1500 \text{ lbs. say.}$$

Actually in verandah with a 12′ slope ($\frac{2}{3}$ weight borne on bressummers)

$$W=6\times8\times30=1440 \text{ lbs.}$$

Make bressummer $5''\times5''$ (effective section $5''\times4\frac{1}{4}''=21$ square inches).

Armour in tension flange, two $\frac{1}{2}''$ rods $=\cdot39$ square inch.

" " top flange, two $\frac{3}{8}''$ rods $=\cdot22$ " "

As the beam is practically "fixed," the top armour is necessary.

For ease of manufacture the armour is made up into skeleton as for pillars.

Mould with two stop chamfers in lower flange (similar to posts).

Connections consist of $\frac{3}{8}''$ or $\frac{1}{2}''$ dowels, for which $\frac{5}{8}''$ holes are moulded as shown (see also *Fig.* 32 for arrangement of connections). All dowels bedded in cement in holes.

The armouring, if arranged as for verandah wall plates, could be reduced, but the skeleton as used is easy to fix, and the upper rods serve to prevent development of cracks prior to fixing, and is recommended for these heavy members.

IV. *Verandah Wall Plates.*—(See *Figs.* 25 to 30, *Plate* III.).

Corbels, 6′ c. to c.

Assume beam $3''\times4''$, with four rods $\frac{1}{4}''$ diameter.

Effective section, $3''\times3\frac{1}{4}''=9\cdot75$ square inches.

Section of armour, $\cdot196$ square inch $=2$ per cent., nearly, at centre.

$$\therefore \quad bd^2=\frac{WL}{120}, \; b=3'', \; d=3\tfrac{1}{4}'', \; L=5\tfrac{1}{2}'.$$

$$\therefore \quad W=3\times\frac{13}{4}\times\frac{13}{4}\times\frac{120}{11}\times2$$

$$=691 \text{ lbs. distributed}$$

Actual load applied,

$$=6\times\tfrac{1}{3}\times12\times30=720 \text{ lbs. distributed, or } 360 \text{ lbs. central.}$$

This is not considered excessive for the wall plates as above, which are supported, by the thrust of the rafters, against the wall.

Armour formed into skeleton and tied with wire; $\frac{5}{8}''$ diameter hole at centre for dowel bolt, and notches for ditto at ends.

(P.S.—A few wall plates, made as above, having cracked through the central hole, from mishandling in erection, two additional pieces of $\frac{1}{4}''$ rod, 3′ 6′ long, are now fixed to complete the upper longitudinal armour).

## *MODERN SEWAGE DISPOSAL.*

*By* CAPT. AND HON. MAJOR G. B. WILLIAMS, R.E. (T.).

THE recent publication of the fifth report of the Royal Commission on Sewage Disposal marks an important stage in the progress of modern ideas on the subject of the purification of sewage. The Commission was appointed in 1898, and since then its members have examined a number of witnesses, visited many sewage works, and, with the assistance of a special staff of experts, carried on a most valuable series of experiments and investigations, with a view to throwing light on many of the more obscure aspects of the question.

The results of their labours are embodied in a series of reports issued between 1901 and this year. The fifth report is the final and much the most important one of the series, and is practically a compendium of recent experience on the subject. Some of the conclusions which they have arrived at, after carefully sifting the mass of evidence which has come before them, are now published for the first time, and are of great value; and although they have not achieved the impossible—by succeeding in prescribing a perfect system of sewage disposal—they have suggested certain material modifications in the methods of bacterial treatment at present in vogue; and the effect of these and other of their recommendations will probably be seen in the improvements in future sewerage schemes, which a sounder and more scientific understanding of the problems involved will suggest.

Their general conclusion is so concisely stated at the commencement of the fifth report that it is worth while quoting it verbatim.

"We are satisfied that it is practicable to purify the sewage or towns to any degree required either by land treatment or by artificial filters, and that there is no essential difference between the two processes, for in each case the purification, so far as it is not mechanical, is chiefly effected by means of micro-organisms; the two questions therefore to be considered in the case of a town proposing to adopt a system of sewage purification are, first, what degree of purification is required in the circumstances of that town, and of the river and stream into which its liquid refuse is to be discharged; and second, how the degree of purification can, in the particular case, be most economically obtained.

The choice of a scheme must depend on a number of considerations which will be discussed later, but we may here state that we know of no case where the admixture of trade refuse with the sewage makes it impracticable to purify the sewage either upon land or by means of artificial processes, although in certain extreme cases especial processes of preliminary treatment may be necessary."

At first sight it might appear from these two statements, that the Commission consider that the sanitary expert should now be able to completely solve any problem placed before him involving the purification of the sewage of a community. The subsequent pages of the report correct this impression, and although it is undoubtedly true that, with unlimited funds and suitable surroundings, it would be possible to take a typical sewage, and by passing it through a series of processes finally convert it into pure water, such an operation does not usually come within the bounds of practical politics. It can by no means be said that an end to the difficulties of the sanitary engineer is as yet in sight.

While Royal Engineer officers have frequently to face sanitary problems, it is doubtful whether in many cases they can find time to study the mass of technical literature on the subject of sewage disposal, or to keep themselves informed of the rapid development of ideas which has taken place during recent years. The writer therefore ventures to put on record a short account of the principles of modern sewage purification, prefacing it with a brief historical sketch of the subject, and adding a detailed description of a small sewage disposal works, as an illustration of the practical application of these principles on a typical scale.

It is impossible in a paper of this description to go into the question of sewage disposal in any other country but our own, for in other climates and amongst less civilized communities the problems often present themselves in a quite unfamiliar form. Nor is it the writer's intention to discuss any of the other questions of public health with which sewage disposal is connected. Within the narrow limits indicated there is more than sufficient important matter to occupy a paper such as this.

*Earliest Examples of Sewage Works.*—Something in the nature of sewage disposal works was in use at an early period of history. In pre-Christian times several of the larger cities had some kind of sewers. Rome, Carthage, Alexandria, and Jerusalem are examples, and the latter town had a complete system of flushing water which irrigated the gardens in the city; there also appears to have been some kind of outfall works, consisting of a pool or tank, where the sewage collected, and whence it was taken by gardeners, who purchased it for manuring the soil of their gardens.

During the dark ages which followed the fall of the Roman Empire ideas on the question of sanitation were extremely primitive.

During the Renaissance period there were slight signs of improvement, but the progress made in these matters during the 16th, 17th, and 18th centuries was very slow, and it was not until the commencement of the 19th century that anything in the shape of a sanitary system can be really said to have existed at all.

At that time in large towns a certain number of underground culverts existed, conveying the streams which had at earlier periods flowed down open water courses alongside the streets. Although these culverts were not recognized as sewers according to modern ideas (prior to 1815 it was illegal to pass fæcal matter into the London sewers), they were the recipients of the effluent from cesspools and much other filth of all description. It is certain that they were very offensive from an early period of their existence, in fact it was the reason for their being covered up.

With the improvement in the system of water supply and the introduction of water-closets (which took place about 1810), the quantity of sewage proper rapidly increased, and its discharge into rivers and streams began to cause an intolerable nuisance to persons living on the banks. It became evident that it would be necessary to adopt some method of treating sewage so as to get rid of this nuisance.

The fertilizing powers of animal excreta had been long recognized and the deodorizing properties of soil are very evident, so it was natural that the first system of treating sewage should have been to apply it to land.

The earliest example of a sewage farm was on the Craigentenny Meadows near Edinburgh, a tract of land some 300 or 400 acres in extent, lying near the Firth of Forth. Some of the Edinburgh sewage was applied to this land as early as the middle of the 18th century, but the sole object of doing so was to obtain a profit, and the amount of purification obtained was extremely small or non-existent. According to modern standards, the Craigentenny sewage farm was never satisfactory.

In the early part of the 19th century attempts to purify sewage, by applying it to land on the system known as "broad irrigation," were made at Rugby, Croydon, and Macclesfield with a certain amount of success.

*Public Enquiries during the 19th Century.*—In the meantime the question of sewage disposal commenced to excite public interest; the object of the interest however was not so much the preservation of the public health as the realization of the profits which it was imagined could be obtained from the fertilizing properties of the sewage itself.

In 1821 the first public enquiry into the question of sewage disposal took place. Since then there has been a continual series of these enquiries—Royal Commissions, Parliamentary Committees, Departmental Committees, Committees of Experts, some of the latter appointed by Government, others by corporations of towns or by scientific societies. All these undertook exhaustive investigations, but with little satisfactory results until the Commission at present sitting was appointed. They merely served to illustrate the complete divergence of opinion which has at all times characterized the evidence of experts on nearly every point in connection with this subject.

*Introduction of Chemical Precipitation.*—In 1846 the first process of precipitating the solid matter in sewage by lime was introduced by a Mr. Higgs, and was followed by all kinds of patents for chemical precipitation. The objects of all these were the precipitation of the solid matter in sewage by means of chemicals, the production of what was expected to be a useful manure, and the deodorization and purification of sewage to such an extent that it could be safely turned into a stream along with the surface water.

It soon came to be realized however that the improvement in the effluent by means of any of these processes is much more apparent than real. Practically only the putrescible organic matter in suspension is removed, that in solution remaining untouched. The solids in solution subsequently decompose, and if the effluent is turned into a stream, cause a nuisance only less in degree than that caused by the sewage itself.

The expectations of profit from the sale of sludge as manure were also not fulfilled. Out of 17s. per 100 tons, which the Royal Commission of 1882 considered to be the theoretical value of sewage for farming purposes, they estimated that 15s. belongs to the matter in solution and only 2s. to that in suspension. The cost of precipitating the latter and the mass of extraneous matter with which it is mixed when the process is complete prevents the operation from being a profitable one. The Commission of 1882 went so far as to express some doubt whether there was any manurial value whatever in sludge, or whether it was not a worthless product to be got rid of in the easiest way possible.

The present Commission have, in conjunction with the Board of Agriculture and Fisheries, carried out a number of experiments with a view to throwing light upon this question. These experiments, which are still being continued, show that sludge has undoubtedly some manurial value, and that the question of its economic use as a manure depends to a large extent upon the cost of carriage.

As a complete purification process, chemical precipitation proved a failure; but the disfavour into which it fell after the introduction of the septic tank was not entirely deserved, and as a preliminary process it may in many cases offer advantages over other methods of getting rid of the suspended solids.

*Evolution of the Bacterial Filter.*—In 1870 Dr. Frankland, who was at that time a Member of the Royal Commission on Pollution of Rivers, commenced to devote his attention to a process of land treatment, to which the somewhat clumsy and meaningless term "intermittent downward filtration" was applied. A much larger quantity of sewage could be dealt with per acre by the new method than by the older system of "broad irrigation." An exaggerated idea was however held in the first instance of the quantity that could be purified. It was thought that the crude sewage of 2,000 to 3,000 persons could be dealt with on an acre of land, but subsequent experience has reduced this to 1,000 persons per acre.

The introduction of land filtration marks an interesting stage, for although the action of bacteria in purifying sewage was not understood at that time, this process was the precursor of the modern biological filter.

The experiments of Pasteur in 1857 had shown that lactic fermentation depends on the presence of minute organisms. Pasteur and Cohn also pointed out that putrefaction is a special case of fermentation, but for many years no effort was made to control those operations of nature by which organic matter is broken up into less complex substances, nor was it realized that the bacteria play an equally important part in the final stages of the transformation of animal and vegetable matter into harmless substances, such as when the carbonate of ammonia in sewage is oxidized into nitrites and nitrates, which in turn become food for plants.

In 1882 Warrington pointed out that solutions of ammonium salts would not undergo nitrification if they were sterilized, and foreshadowed the construction of artificial filter beds having greater oxidizing power than ordinary soil.

The next stage in the evolution of the sewage filter was the introduction of contact beds by Dibdin, after a series of experiments at the London Outfall Works at Barking. The mode of operating these beds by alternately filling them, then letting them stand full, subsequently emptying them and allowing time for them to "aerate," is now well known, so it is unnecessary to enter into a detailed description. Dibdin at first maintained that the whole process of purification could be performed by these beds, but it is now recognized that the idea that crude sewage can be applied to them, without any form of preliminary treatment, with any prospect of success, is a fallacy.

The most recent form of sewage filter is the percolating bed, over which the sewage is sprayed, either continuously or intermittently, by means of fixed or moving distributors of various kinds.

*Anaerobic Tanks and Sedimentation Tanks.*—The earliest method of liquefying the suspended solid matter in sewage under anaerobic conditions, with the object of getting rid of it by natural agencies, adopted on a practical scale, was that of Scott-Moncrieff, who in 1891 succeeded in reducing the suspended solids by passing sewage through an upward flow tank filled with coarse flints.

The introduction of the septic tank proper took place in 1896, when Cameron commenced to treat a portion of the Exeter sewage in a closed cemented watertight tank, subsequently passing the effluent through contact beds. The ideas at first held with regard to the quantity of sludge got rid of were undoubtedly too large. It is now found that somewhere between 10 per cent. and 30 per cent. of the total sludge is either decomposed into gases, or else liquefied and broken down into simpler substances. The claims originally made on behalf of the septic tank, that it digested practically all the organic solid matter and destroyed any pathogenic germs in the sewage, have certainly not been substantiated. As far as the latter claim is concerned, it appears to have practically no foundation at all, for sewage issuing from a septic tank is bacteriologically almost as impure as that entering it.

The failure of the septic tank to come up to the expectations of its introducers has led in some instances to a reversion to the system of precipitation as a preliminary to final filtration, the difference being that the settlement is now frequently allowed to take place without any assistance from chemicals, and is called "sedimentation." An example of a "sedimentation tank" is the "Dortmund," which is a circular tank with a conical bottom. In this the sewage is introduced at a considerable depth below the surface and flows upwards to an effluent pipe near the surface. The sludge makes its way to the bottom of the cone, and is removed at frequent intervals by means of a pipe, through which it is forced by the difference in head between the sewage in the tank and the outlet of the sludge pipe.

Recently a certain number of persons have gone so far as to deny that any digestion of sludge at all takes place in the septic tank, or in fact that the bacteria play any important part in the purification of sewage, and that the work is done by chemical, physical, or electrical agencies. Although it is quite possible that surface attraction, chemical action, and electricity all take some share in the complex series of changes which take place, the denial of the part taken by the bacteria is as extravagant as the pretensions made by the septic tank enthusiasts that all pathogenic germs were destroyed in their tank.

*General.*—A general review of the gradual development of the science of sewage purification shows us that with the introduction in turn of the various methods of treatment—land irrigation, land filtration, chemical precipitation, septic tanks, sedimentation tanks, contact beds, and percolating filters—there has been a constant tendency on the part of the introducers of a new system to exaggerate the benefits to be obtained by its adoption. On the other hand, there have been opponents in each case who have seen real and imaginary defects in the particular system to which they objected, which have frequently appeared to them to be far more serious than was actually the case. It may be said that each of the processes mentioned above is capable of performing useful work, but that under ordinary circumstances no single process is capable by itself of economically purifying sewage to the degree necessary to satisfy modern standards. The combination of two or more processes, if the works are properly designed, can produce an effluent sufficiently pure to turn into an ordinary stream or water course, providing the works are intelligently and scientifically managed; and it cannot be too frequently emphasized that no purification works, however well designed, will continue to work satisfactorily unless they are under proper supervision.

*Objects of Purifying Sewage.*—Before entering into any practical details of the actual works required under various conditions it is necessary to describe briefly what sewage consists of and the objects to be achieved in purifying it.

The chemical composition of sewage varies greatly in different places, and also at the same place at different times. The solids are chiefly excretory substances, household waste, grit and detritus from roads. Nitrogenous and carbonaceous matter, ammonia, chlorine, and many other substances are present in varying proportions. In towns, where trade wastes are admitted in large quantities, an endless number of other chemical compounds may be added, occasionally considerably increasing the difficulties of purification.

If an unpurified sewage is discharged into a stream or river its injurious effects may be generally classified under four heads:—(1), The deposition of solid putrefying matter on the bottom and sides of the river; (2), the absorption of the dissolved oxygen in the water, which may render it impossible for fish to exist in the polluted stream; (3), the promotion of the growth of sewage fungus or other objectionable vegetation; (4), the discharge of pathogenic germs into the river.

In the case of a comparatively large volume of sewage discharged into a small stream, the latter may become an open sewer and a general nuisance to the neighbourhood. This is an extreme case and includes all the evil effects enumerated.

Taking the fourth injurious effect first, the presence of disease germs can only be a danger in potable water, or in water from which articles of food, such as watercress or shellfish, are taken and consumed uncooked. The difficulty and cost of treating all the sewage of a town in such a way as to sterilize it is very considerable, and, as far as the writer is aware, has never yet been attempted on a practical scale. Although the effluent from a first-class sewage farm shows a very large reduction in the number of micro-organisms as compared with the crude sewage, and a good artificial filter also diminishes their number greatly (but not to the same extent), nevertheless pathogenic germs are liable to find their way through the soil of the farm or the material of the filter, and if the effluent were to be turned into a stream from which water is used for drinking without filtration, would form a serious danger.

The Royal Commission have carefully considered the practicability of treating sewage so as to render it bacteriologically pure, and for several weighty reasons, set forth in their fifth report, do not feel justified in recommending that it should be the duty of a local authority to do so. The idea of obtaining a bacteriologically pure effluent may therefore be at once dismissed as being a refinement rarely required.

With regard to the question of growths in streams, all sewage effluents contain a certain amount of plant food in solution, and therefore tend to promote vegetable growths; but in the case of well-purified and nitrated effluents these are green, and although under certain conditions they may give rise to nuisance, they are much less objectionable than the grey sewage fungus which makes its appearance in streams receiving imperfectly purified effluents.

The problem of purifying sewage is thus narrowed to the necessity of removing the suspended solids, and of producing an effluent whose capacity for absorbing oxygen has been so far diminished that it is not liable to cause any serious reduction in the quantity of oxygen dissolved in the water into which it is discharged.

These results are obtained by the precipitation or liquefaction of the suspended solids, and the oxidation of the carbonaceous and nitrogenous organic matter into harmless chemical compounds.

The first of these processes is partly or wholly a mechanical one. The second is the result of bacterial fermentation under aerobic conditions.

*Removal of Grosser Suspended Solids.*—In practice the removal of the suspended solids is usually accomplished in two or more operations, the first being the elimination of the heavier mineral matter, such as grit and road detritus, by settlement in detritus tanks, and the removal of grosser floating substances, such as sticks, cloths, paper, corks, scrubbing brushes, etc., by passing the sewage through coarse screens.

The detritus tanks are usually constructed to take about half-an-hour's dry-weather flow, and should be in duplicate. The greater part of the organic suspended solids are carried through these tanks, leaving the mineral matter behind.

The Automatic Sewage Distributors Company have introduced a tank which is a combination of a detritus tank and an upward flow sedimentation tank. The sewage enters the tank, which is circular, at the top, through a tangential inlet pipe, and first flows downwards, then passes under a circular baffle plate, and finally upwards through the inner space inside this ring. The sludge is removed by a travelling sludge pipe, which moves round the bottom on a spindle worked by gearing from the top.

*Precipitation and Septic Tanks.*—The removal or liquefaction of the organic solids in suspension is the next step, and this operation may either be performed by septic tanks, by chemical precipitation, or by settlement without the aid of chemicals (sedimentation).

Considerable confusion has been caused by the misuse of the latter term, which has sometimes been applied to tanks intended to work on the septic system and sometimes to detritus tanks. It is rather difficult to draw a hard-and-fast line between sedimentation tanks and septic tanks, for the action of the latter depends to a large extent on the settlement of the solids, and in the former there is a certain amount of septic action. The effect of this however is not important if the sludge is removed at comparatively short intervals, and consequently more sludge is produced than with the septic tanks.

If the quiescent system of sedimentation is adopted, that is turning sewage into the tank, letting it stand for two or three hours, and then draining off the clarified liquid, the quantity of sludge is still greater, whilst with chemical precipitation it is obviously further increased. The facilities for disposing of sludge are therefore important factors in the choice of a system of preliminary treatment.

*Comparison of Different Preliminary Processes.*—The portion of the Royal Commission's report which deals with the preliminary processes is particularly illuminating, and will probably have the effect of restoring chemical precipitation to favour in many cases. The Commission have come to the conclusion that out of 35 parts per 100,000, which may be taken as the average amount of suspended matter in ordinary domestic sewage, the amount left in the tank liquor after chemical precipitation is from 1 to 6 parts, according to the process adopted, after quiescent sedimentation, from 5 to 8 parts, and after continuous flow sedimentation or septic tanks, from 10 to 15 parts per 100,000. It is thus clear, notwithstanding the statements to the contrary which have been so confidently made, that chemical precipitation is a more efficient process for removing suspended solids than either sedimentation or septic tanks. It is however much more expensive, and the difference is particularly great in a small disposal works, where the cost of additional labour is greater in proportion to the other annual charges than in larger works.

For the same reason the system of quiescent sedimentation, which requires constant labour for emptying the sludge, is not suitable for small works, although in large ones it costs very little more, and, according to the Royal Commission, gives considerably better results than continuous flow sedimentation.

For small towns and villages the choice of an economical system of removing the suspended solids is limited to the septic tank and the different types of continuous flow sedimentation tanks, and will be largely determined by the question as to whether it is easy or difficult to dispose of the sludge.

*General Conclusion as to the Septic Tank.*—One of the most important claims advanced on behalf of the septic tank has been that the effluent is more easily oxidized than sewage which has passed through chemical precipitation tanks or sedimentation tanks. Experiments carried on by the Royal Commission have proved that it has no advantage in this respect over the other methods.

The following sentence shows the general conclusion arrived at by the Commission with regard to the septic tanks:—

"It must therefore be said that some of the more important claims which were originally advanced in favour of septic tank treatment have not stood the test of experience. At the same time we think that in certain circumstances the adoption of this mode of treatment as a preliminary process is efficient and economical."

*Other Forms of Preliminary Treatment.*—The form of sedimentation tank, known as the Dortmund tank, has been already referred to. Various forms of upward-flow tanks have been used, and have been comparatively successful, although they are not free from defects. In Birmingham the liquor from the septic tanks is passed through Dortmund tanks before final purification, and the suspended solids are reduced by this means from 20 parts to 6 parts per 100,000.

A tank for removing the suspended solids has been in operation at Hampton for some time, and has been given the name of "hydrolytic tank." A description appears in the *Minutes of Proceedings of the Institution of Civil Engineers*, Vol. CLXIV.

The authors of the descriptive paper held somewhat fantastic notions with regard to the purification of sewage, alleging that the process is in the main the result of physical operations, and that bacteria only play a subsidiary part. These remarkable statements were made on the basis of very slender evidence, and apparently the only scientists who have agreed with them are the German chemists, W. Biltz and O. Kröhnke. The paper was however of value, for it drew attention to the fact that many of the solids in sewage are in a colloidal state, or in semi-solution, and that under certain conditions these colloids subsequently tend to become particulate. The hydrolytic tank is a somewhat complicated arrangement, and it is permissible to doubt whether, under the circumstances, it is likely to come into general use.

*Final Treatment.*—The final purification of sewage can be accomplished by passing the tank effluent through or over land, or by treatment in contact beds, or in some form of percolating filter. Of these three alternative methods there is little doubt that, under really favourable conditions, land treatment holds the first place for efficiency.

The effluents from the best land are both chemically and bacteriologically superior to those from artificial filters. Further, the preliminary treatment need not be so thorough as for filters, although some form of preliminary treatment is always desirable. When really good land can be obtained within a suitable distance and at a reasonable price, land treatment may be cheaper than artificial filters, but such cases are the exception in England, and when these conditions do not occur artificial filtration is more economical.

The relative merits of contact beds and percolating filters have been fully discussed during the past six years. The decision arrived at during that time by the majority of sanitary engineers who have had experience of both methods has been fully borne out by the Royal Commission.

In the fifth report they state that "a cubic yard of material arranged in the form of a percolating filter will generally treat satisfactorily nearly twice as much tank liquor as a cubic yard of material in a contact bed."

This being the case, it is not necessary in this paper to enter into further details with regard to contact beds, for although in some minor respects they have advantages over percolating filters, these are certainly not usually sufficient to outweigh the greater economy and efficiency of the latter.

*Percolating Filters.*—The sewage may be distributed over a percolating bed either (*a*) by a moving distributor, driven automatically by the head of sewage or by applied power; or (*b*) through fixed pipes by means of spraying nozzles or a number of small orifices; or (*c*) through dripping trays or tipping troughs, both of which are special forms of fixed distributors; or (*d*) the distribution may be effected by a layer of fine material on the top of the bed.

None of these methods are perfect, and each has its own special form of disadvantage. For a small sewage works the writer considers a moving distributor driven automatically to be the best type. The most common sprinkler is a revolving one on a circular filter bed. The details of a sprinkler of this kind will be described in the next part of the paper, and in the meantime it is only necessary to say that it is liable to considerable interference from a strong wind unless shielded from it, and that the numerous holes in the revolving arm require daily attention, otherwise they get stopped up. Nevertheless, there are many examples of these sprinklers working satisfactorily at the present time.

A form of sprinkler which has been more recently introduced travels up and down on rails over a rectangular bed. This distributor works on the principle of an undershot bucket water wheel. In one part of the apparatus the buckets are set in one direction and in the other part in the opposite direction; when the distributor reaches the end of the bed a valve is automatically reversed and causes the sewage to flow on to the opposite side of the distributor, which then travels back again. The disadvantage which would appear to attend the use of this form of distributor is that the distribution is not so even as with the revolving arms, being more of the nature of a concentrated flow during a very short period on each part of the bed at comparatively long intervals of time.

After filtration the final operation is the settlement of the suspended matter, which works its way through the filters and is washed out with the effluent. This matter, which is unobjectionable, and in appearance similar to the humus of soils, is deposited in a small humus pit, or chamber, and the final effluent should then be pure enough to pass into an ordinary stream or river.

*Amount of Purification Effected.*—It is next necessary to consider the degree of purification required and how the amount of purification effected is to be measured. Chemical analysis of a typical domestic sewage of medium strength would probably give some such result as the following:—

| | | |
|---|---|---|
| Ammoniacal nitrogen ... ... | 5 | parts per 100,000 |
| Albuminoid nitrogen ... ... | 1 | " " " |
| Oxygen absorbed in 4 hours ... | 10 | " " " |
| Suspended solids... ... ... | 35 | " " " |

The Royal Commission denotes the strength of a sewage by the number of parts by weight of dissolved oxygen which 100,000 parts of the liquid would take up during the complete oxidation of all the oxidizable matter contained in such liquid. The number is obtained by a calculation according to a formula suggested by Dr. McGowan.

This formula is (for sewage and septic tank liquors):—

$$(\text{Ammon. } \dot{N} + \text{Organic N}) \times 4{\cdot}5 + (\text{Oxygen abs. in 4 hours} \times 6{\cdot}5).$$

The strength of the typical sewage above referred to would be about 110.

In order to compare the amount of purification effected at different places Dr. McGowan had also devised a unit of purification.

To express the number of units of purification effected by a filter, the number of parts by weight of oxygen taken up by 100,000 parts of the effluent during complete oxidation is deducted from the number of parts by weight of oxygen taken up by 100,000 parts of the tank liquor, and the number so obtained is multiplied by the number of gallons of liquor per cubic yard passing through in 24 hours. The number of parts of oxygen which an effluent will take up is calculated from the formula:—

$$(\text{Ammon. N} + \text{Organic N}) \times 4{\cdot}5 + \text{Volatile matter of susp. solids} \times 2 - \text{Nitric Nitrogen} \times 3.$$

The sewage previously referred to would give, after complete treatment, some such chemical analysis as the following :—

| | |
|---|---|
| Ammoniacal nitrogen ... ... | ·50 parts per 100,000 |
| Albuminoid nitrogen ... ... | ·10 " " " |
| Oxygen absorbed in 4 hours ... | ·90 " " " |
| Nitric nitrogen... ... ... | 1·5 " " " |
| Suspended solids ... ... | 2·0 " " " |

The strength of this sewage would be about 2.

The strength of the tank effluent would probably be about 85, and, if the filtration was being carried on at the rate of 100 gallons per cubic yard per day, the number of units of purification would be $83 \times 100 = 8,300$ units.

The Royal Commission give the following Table as an approximate idea of what number of units of purification per cubic yard may be expected from different forms of treatment :—

| | Units of Purification per cubic yard. |
|---|---|
| Crude or partially settled sewage treated on contact beds. | 3,000 to 4,000 |
| Crude or partially settled sewage treated on percolating beds. | 2,500 to 3,500 |
| Well-settled sewage treated on percolating filters. | 7,000 to 8,000 and probably up to 11,000 |
| Septic tank liquor treated on single contact beds. | 3,000 to 4,500 |
| Septic tank liquor treated on double contact beds. | 3,000 to 4,500 |
| Septic tank liquor treated on percolating filters | 7,000 to 11,000 |
| Precipitation liquor treated on single contact beds. | Up to 11,000 |
| Precipitation liquor treated on double contact beds. | Probably up to 6,000 or 7,000 |
| Precipitation liquor treated on percolating filters— | |
| (*a*). Filters of coarse material ... | Up to about 8,000 |
| (*b*). Filters of fine material ... ... | Up to about 18,000 |

*Rates of Filtration.*—The Royal Commission have gone very fully into the question of how much sewage can be purified successfully per cubic yard of filter. Hitherto the rule adopted by the Local Government Board in sanctioning loans for sewage works has been to insist, in the case of percolating filters, that the rate of flow is not to exceed 56 gallons per square yard of surface of filter per foot in depth, or 168 gallons per cubic yard, when the filter is treating the maximum quantity (usually three times the dry-weather flow).

This standard has been generally quite strict enough, but a more elastic one is necessary, for a hard-and-fast rule takes no account of the strength of the original sewage, the nature of the preliminary treatment, nor the fineness or coarseness of the filter to which the tank effluent is to be applied.

The conclusion of the Royal Commission with regard to the rates of filtration through percolating filters may be summarized as follows :—

| | Gallons per cubic yd. per day Average Dry-Weather Flow. |
|---|---|
| *Coarse Material (3" diameter and upwards).* | |
| Tank liquor containing 1 to 4 parts per 100,000 | 150 to 200 |
| do. do. 4 to 7 do. do. | 100 to 150 |
| do. do. 10 to 20 do. do. | 100 |
| Partly settled and screened sewage containing 30 parts per 100,000 ... ... ... | 50 |
| *Medium Material (½" to 1").* | |
| Tank liquor containing 1 to 4 parts per 100,000 | 150 to 200, providing the filters are carefully rested when necessary. |
| do. do. 4 to 7 do. do. | 75 to 100 |
| do. do. 10 to 15 do. do. | 50 |
| Partly settled and screened sewage containing 30 parts per 100,000... ... ... ... | 25 |
| *Fine Material (¼" diameter).* | |
| Tank liquor containing 1 to 4 parts per 100,000 | 150 to 200 |
| do. do. 4 to 7 do. do. | 75 to 100 |

It would be inadvisable to try to filter tank liquors containing more than 6 or 7 parts per 100,000 on material as fine as this.

The above figures relate to ordinary domestic sewage of average strength.

*Stormwater Treatment.*—The question of the quantity of stormwater which it is necessary to deal with depends largely on the system adopted. It is obvious that where all the surface water is taken into the sewers the rainfall has a proportionately greater effect in increasing the flow of sewage than with a partially separate system, whilst with a completely separate system the increase in wet weather is very small.

The Royal Commission do not look with any favour upon the separate system, and give several reasons for their objections to it.

At the same time it is doubtful if they have clearly realized the engineering difficulties which the adoption of the combined system occasionally involves. In any case there are certainly some places where the separate, or partially separate, system is the obviously suitable one.

Whether the sewers are on the combined or on the partially separate system they will discharge many times the dry-weather flow in wet weather at the sewage works. It is therefore necessary to make provision there for dealing with the stormwater. The method which has hitherto been generally adopted has been to arrange that during rain storms an increase of the flow of sewage up to three times the dry-weather flow should go through complete treatment, and that an additional quantity of three times the dry-weather flow should be filtered through stormwater beds at the rate of about 500 gallons per square yard of filter per day. The depth of material in these beds is usually about 3′.

In this way a total of six times the dry-weather flow is treated. The remainder of the stormwater passes untreated into the streams, either through storm overflows spaced at intervals along the sewers, or at an overflow at the end of the main outfall sewer at the disposal works.

It has been recognized that this method of dealing with stormwater is in most cases not a very satisfactory one. The stormwater filter, if, as is generally the case, it is only in use at intervals, is never in a good biological condition, and has therefore hardly any oxidizing power. It merely acts as a straining bed and removes some of the grosser solids. The first flush of stormwater during heavy rain after dry weather is exceptionally impure, worse, in fact, than the dry-weather sewage, and in many of the existing sewerage schemes large quantities of suspended solids, some of them of a grossly polluting nature, are liable to be discharged into the streams during rain storms.

The Royal Commission recommend that the following provisions for treating stormwater should be made, in place of those usually adopted :—

(1). That special stand-by tanks (two or more) should be provided at the works and kept empty for the purpose of receiving the excess of stormwater, which cannot properly be passed through the ordinary tanks. As regards the amount which may be passed through the ordinary tanks, our experience shows that in storm times the rate of flow through these tanks may usually be increased up to about three times the normal dry-weather rate without serious disadvantage.

(2). That any overflow at the works should only be made from these special tanks, and that this overflow should be arranged so that it will not come into operation until the tanks are full.

(3). That no special storm filters should be provided, but that the ordinary filters should be enlarged to the extent necessary to provide for the filtration of the whole of the sewage, which, according to the circumstances of the particular place, require treatment by filters.

(4). As regards the overflow from the outfall sewer to the stand-by tanks, the size of the stand-by tanks, the amount of storm sewage which should be filtered, and the arrangement generally for dealing with storm sewage at the outfall works, the Rivers Boards, or the County Council in areas in which no Rivers Boards have been established, should have similar powers to that which we have proposed in regard to overflows on branch sewers, and the local authority should have a similar right of appeal to the central authority.

In a previous paragraph of the report it is stated: -"We think it may be taken that it is practicable to filter three times the mean dry-weather flow, and while there are few or no data to show that this is the right amount for which filtration is required, we doubt whether as a general rule the filtration of any larger amount will be found to be necessary to prevent nuisance."

In another paragraph we find:—"We have not sufficient experience to enable us to suggest by what means the capacity of the stand-by tanks should be determined, but we should think that tanks capable of holding a quarter (six hours' flow) of the mean daily dry-weather flow would usually be sufficient."

These recommendations will probably lead to much discussion, but in the writer's opinion the treatment suggested, viz., three times the dry-weather flow to be passed through the ordinary tanks and filters, and the remainder of the stormwater to undergo a partial settlement in a tank holding six hours' flow, will not be found sufficient.

The rate of flow of the dry-weather sewage fluctuates from hour to hour throughout the day, and may during several consecutive hours be more than one and a-half times the average rate. At such a time a comparatively small amount of rainfall would (especially in the case of a combined system) add sufficient surface water to bring the quantity of sewage up to more than three times the dry-weather flow, and the resultant mixture of sewage and stormwater would in most cases not be sufficiently inoffensive to turn into a stream after only undergoing a partial settlement in a subsidence tank.

It will probably be found in practice necessary to filter more than the suggested quantity of three times the dry-weather flow.

It is of course impossible to arrange to treat all the stormwater which might possibly arrive at the outfall works during very heavy rain storms, for in some places this might amount to 20 or 30 times the dry-weather flow; but it will probably be found necessary, in addition to giving three times the dry-weather flow the complete treatment, to pass a further quantity of three times the dry-weather flow through the filters after a settlement in the stormwater tanks. Anything in excess of six times the dry-weather flow would overflow from the stormwater tank into the stream. The filters would have to be enlarged so as to deal with six times the dry-weather flow. The extent to which this would necessitate their area being increased will be discussed later.

*Quantity and Strength of Sewage and Form of Treatment.*—An example of a sewage disposal works for a small town has been worked out in detail in order to illustrate some of the principles involved in the design of modern sewage purification works. Although the example is not altogether taken from actual practice, it is typical of many cases which arise, and includes some improvements suggested by the Royal Commission's Report.

The town for which the works are to be provided is supposed to have a population of 3,000 persons, with a daily dry-weather flow of 25 gallons per head. The sewage is ordinary domestic sewage of medium strength, the figure being about 100, according to the Royal Commission's formula previously referred to.

The form of treatment adopted is septic tanks followed by percolating beds; the latter are of the circular type with automatic revolving distributors, the beds being 6′ deep. Plans and sections of the works are shown on *Plates* I. and II. The ground levels shown on the sections give a good fall.

The average dry-weather flow is 75,000 gallons a day. In wet weather the filters take three times this amount, or 225,000 gallons a day, after passing through the septic tanks, and an additional 225,000 gallons a day after settlement in the stormwater tanks. Everything in excess of this quantity overflows from the stormwater tank into the river.

*Sewer Outfall and Overflow Weir.*—The sewage discharged by the main outfall sewer flows along a short length of open channel before reaching the detritus tanks (*Plate* I.). On one side of this channel there is a weir so arranged that when the quantity of sewage exceeds three times the average dry-weather flow, the excess overflows into an adjoining channel communicating with the stormwater tank. It is hardly necessary to mention that it is important to make this weir, as in fact all overflow weirs, as long as is possible, in order that when discharging at the maximum rate the depth over the cill should be small, and the quantity of sewage passing along the main channel not much increased beyond the necessary three times the dry-weather flow. Even with a long weir this difficulty still occurs in a lesser degree, and in order to keep the maximum flow to the septic tanks during storms as near the limit as possible, a hand sluice is fixed in the channel and acts as an orifice gauge. This can be opened and adjusted so as to take a greater flow if necessary, but cannot be closed below a certain point.

*Detritus Tanks.*—The detritus tanks are in duplicate, each being semi-circular with a conical bottom. A separate plug valve is provided for each tank in order to let out the sludge. Owing to the shape of the bottoms the deposited solids can be partially removed without emptying the tanks by raking them up the sloping sides. The capacity of each of the detritus tanks is 1,500 gallons, or about half-an-hour's flow. They are intended to be used separately, but in wet weather can be used in parallel.

The screens, which are formed of flat bars, set ¾" apart, are placed at the outlet end of the detritus tanks and are fixed at a slope of 45°.

*Septic Tanks.*—The two septic tanks hold between them 75,000 gallons, or 24 hours' dry-weather flow. They are of concrete, faced with cement rendering, the channels and copings being of brickwork.

Each tank is divided into three compartments by two diaphragm walls; the walls nearest the inlet end are solid, and the others, which are intended for strengthening purposes, are pierced, so as to allow free communication through them. The first walls divide the tanks into two unequal portions from about 12" below the top-water level, the compartments nearest the inlet end having a capacity equal to one-third the total capacity of the tanks. The object of the division is to enable the first, smaller compartments, in which the greater part of the sludge will be deposited, to be emptied without emptying the rest of the tanks. This arrangement forms practically a combination of a sedimentation and a septic tank, the first compartment being emptied at comparatively frequent intervals, and the second being allowed to run as long as possible. The sewage enters and leaves the tanks below top-water level through rows of pipes communicating with the external channels, the object being that there should be no disturbance of the surface.

*Stormwater Tank.*—The stormwater tank is rather larger than recommended by the Royal Commission, and holds one-third of the average daily dry-weather flow, or 25,000 gallons. It does not appear necessary in so small a works to follow out the suggestion that this tank should be divided into two. An overflow weir is provided from which the excess stormwater over three times the dry-weather flow goes direct to the stream. The occasion when this overflow weir is in use will be rare, and it will only come into operation after a storm has lasted for some time, and consequently the quantity of impurity is in a diminishing ratio and the streams are swollen with the heavy rain. At such a time the discharge of a dilute and partially settled mixture of stormwater and sewage will probably not be injurious. As has been previously explained, the provision made for treating stormwater is considerably more than that suggested by the Royal Commission. The settled stormwater, up to three times the dry-weather flow, is discharged into the outlet channel from the septic tank to the sprinklers.

After the stormwater tank has been in use it will be necessary to empty it, and for this purpose a floating arm is provided. The liquid taken by the floating arm will have received a very complete settlement, but it will sometimes not be fit to turn into a small stream without some further treatment. In a place where there is considerable fall between the tanks and the filters it could be passed through the filters if a suitable time for doing so were chosen; but the ground levels as shown on the drawings do not admit of this. It is supposed that in these works a small area of land (from $\frac{1}{4}$ to $\frac{1}{3}$ of an acre would be sufficient) has been laid out for land filtration, and that the effluent from the floating arm will be discharged on to this land before passing into the stream.

The arrangement of sludge pipes and valves is clear from the plan. The sludge gravitates to the sludge disposal area, where it is either dried and disposed of to farmers or buried in trenches in the ground.

*Percolating Beds.*—The four filters have in wet weather to deal with six times the dry-weather flow, or 450,000 gallons a day. In dry weather they are to purify a septic tank liquor, which will probably contain from 10 to 15 parts of suspended solids per 100,000. For such an effluent a fairly coarse size of material would be desirable, in order to prevent clogging. A suitable material would be furnace clinker 1″ to 3″ diameter. Such a filter would be capable of purifying the average dry-weather flow at the rate of about 80 gallons per cubic yard per day, or, in this case, as the filters are 6′ deep, 160 gallons per square yard. The stormwater up to three times the dry-weather flow, coming through the septic tank, could be purified at twice this rate, or 320 gallons per square yard per day; and on the comparatively few occasions when it would be necessary to treat a mixture of septic tank liquor and stormwater from the stand-by tank up to six times the dry-weather flow this could be filtered at the rate of 500 gallons per square yard. In order to treat 75,000 gallons at the rate of 160 gallons per square yard, 468 square yards of filtering material would be required; for 225,000 gallons at the rate of 320 gallons per square yard per day, 703 square yards; and in order to deal with 450,000 gallons at the rate of 500 gallons per square yard per day, 900 square yards would be necessary. Each of the four filters will therefore have to be of an area of about 225 square yards, or a diameter of 50′.

The form of construction of the filters is clear from the drawings. The circular walls are of brickwork 9″ thick at the top and 14″ thick below the plinth course, strengthened by steel bands in segments bolted together. In some filters the walls are perforated with numerous holes to improve the aeration of the bed; it is however doubtful if these holes have any great effect, and the filters shown can be well aerated without them.

*Automatic Sprinklers.*—All the filters will in the general way be in use simultaneously, and there may thus be a variation in the quantity of sewage distributed over the beds, from a normal 83 gallons per square yard per day in dry weather, up to an occasional 500 gallons per square yard in times of heavy rain storms. This possible variation presents some mechanical difficulty.

The type of distributor shown on the drawings gets over this difficulty in an ingenious fashion. Each sprinkler is fed from the central distributing chamber through an automatic syphon. In order to prevent some of the beds from doing more than their fair share of the work, the four syphons are connected to one air outlet pipe, and are arranged so that all discharge at the same time. Provision is made for cutting out one or more of the beds if necessary without disturbing this arrangement. The syphons are so adjusted that when the sewage is coming down at less than a certain rate (in this case about 200,000 gallons per day, when all the syphons are in work) they discharge at a greater rate than the inflow, and consequently work intermittently. With the ordinary dry-weather flow, the syphons would discharge for about 5 minutes, and then rest for about 8 minutes. When the flow of sewage increases beyond the rate of 200,000 gallons per day the syphons would act continuously. Up to this point only two out of the four arms of the sprinkler would have been in use, but an increase beyond the 200,000 gallons would cause the sewage to rise in the distributing chamber, and also in the bases of the sprinklers, until the level of an orifice overflow weir inside the latter was reached. This orifice connects with the other two arms, which are known as "compensation arms," and the four arms working together would be capable of taking the whole of the quantity of 450,000 gallons a day. The rates and times of working the sprinklers would be as follows:—

| Flow of Sewage, at Rate of | No. of Arms in Use. | Periods of Discharge. | Period of Rest. |
|---|---|---|---|
| 75,000 galls. per day | 2 | 5 minutes | 8 minutes |
| 200,000 ,, ,, | 2 | continuous | |
| 450,000 ,, ,, | 4 | ,, | |

There are several other types of circular sprinklers, many of which frequently give good results, but those described appear to adjust themselves more readily to considerable variations in the discharge than the others. It is claimed that the intermittent discharge of the dry-weather sewage has the effect of to some extent preventing growths on the surface of the filters, and also that the effluent is better nitrated.

*Underdrains and Humus Pits.*—The underdraining of the filters is an important consideration. The underdrains shown are semi-circular stoneware drain tiles, arranged radially and discharging into a circular channel running round the filters. It is important that the lower part of the filters should not be liable to become waterlogged, and that means should be provided for a free passage of air through the interior of the beds.

The suspended solids which work their way through the filters are deposited in the humus pits. From these the effluent pipes connect with a junction chamber, from which a pipe discharges into the stream.

*Conclusion.*—Although the writer has confined himself in the last part of this paper to describing one particular form of sewage treatment, under certain arbitrary conditions, it is not suggested that this must necessarily be the most perfect scheme that could be devised even in the circumstances selected. It is merely intended to show a method of dealing with ordinary sewage, which experience and modern sanitary science have shown to be a comparatively efficient one. To enter into detail as to all the processes of which it would be possible to make use would fill a book of encyclopædic dimensions, and could not be attempted in a paper of this kind.

The operations necessary in dealing with sewage cannot under the most favourable circumstances be anything but more or less unpleasant ones. The idea that the sewage works can become pleasure resorts, at which the employees are engaged in transforming foul liquids into pure drinking water, is one that can be only fostered by interested persons for the benefit of credulous deputations from local authorities. The best that can be reasonably expected is that crude sewage should be purified to such an extent that no danger to health will follow its discharge into the stream, river, or tidal estuary, which is its natural outlet, and that the process should be carried on without causing any nuisance or inconvenience to persons living in the neighbourhood of the works.

How far existing works fall short of perfection, even when judged by these standards of efficiency, an inspection of any dozen disposal works selected at haphazard would at once show. The reasons why there have been so many failures amongst sewage schemes—more in proportion than amongst any other kind of engineering works—can be understood from a study of the history of the subject. Amongst others the following causes have contributed :—(*a*), Ignorance of the elementary principles on which these works should be designed; (*b*), the notion that sewage disposal could be made a profitable operation; (*c*), the misleading statements made by persons financially interested in certain processes; (*d*), the extravagant ideas formed by enthusiasts about a new process; (*e*), generalizing too freely from experiments made on a small scale or for an insufficiently long period; (*f*), the prejudice, ignorance, and lack of intelligence of some local councils and their officials, and the interference of such people with the work of their technical advisers; (*g*), bad management and neglect of the works; (*h*), dishonest and incompetent engineering.

This forms a fairly long list, but it could probably be extended. It is to be hoped that with the gradual spread of a more exact knowledge of the principles of sewage disposal, and of its limitations, these failures may continue to become fewer. In the meantime those concerned in this question can only adopt a cautious and conservative attitude and work slowly along the lines of progress which have already been laid down, in the direction of the attainment of the perfect system of sewage purification which may possibly in some remote future be arrived at.

# *THE R.E. HEADQUARTER MESS.*

(*Continued*).

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

In the south annexe the principal pictures consist of three full-length portraits of "Chinese" Gordon, the Duke of Cambridge, and Lord Kitchener. The portrait of Gordon—which is reproduced both as the frontispiece to the second volume of Porter's *History of the Corps*, and also in A. Egmont Hake's *Events in the Taeping Rebellion*—was painted by Mr. Val Prinsep, R.A., in 1867, and represents Gordon—then a Captain, R.E., and Brevet Lieutenant-Colonel—as a Mandarin wearing the Yellow Jacket, a distinction which was bestowed on him by the Emperor of China, after the suppression of the Taeping Rebellion in 1864.

None of our Corps heroes has attained to so high a position in the public estimation as General Gordon. Certainly no soldier since the time of the Duke of Wellington has been so transfigured in the national imagination. His statue in Trafalgar Square, the cenotaph in St. Paul's Cathedral, and the epitaph by Tennyson in Westminster Abbey, bear sufficient witness to this fact. Nor has the Corps to which he belonged been behindhand in doing honour to the national hero. In addition to Mr. Val Prinsep's fine portrait, we have in front of the Institute Onslow Ford's statue, a replica of which was set up in Khartoum in 1902. A bronze bust and a head and shoulders portrait are also in the Mess, and a plaster cast of the recumbent figure in St. Paul's Cathedral occupies the south side of the vestibule of the R.E. Institute. In fact there are at Chatham fewer effigies even of Sir John Burgoyne—best-beloved as he is of all our Corps heroes—than there are of General Gordon.

An interesting set of Gordon relics, including the famous Yellow Jacket, is preserved in the R.E. Institute. These will doubtless eventually find a fitting resting place in the R.E. Museum, which it is hoped may before long become more than a pious aspiration.

The literature about Gordon is very voluminous. The *Encyclopædia Britannica* contains an article by Sir Charles Watson, K.C.M.G., C.B., R.E., in Vol. XXIX., p. 31. The *Dictionary of National*

*Biography*, Vol. XXII., p. 169, contains another by Colonel R. H. Vetch, R.E. Many books about his Chinese exploits have been written, from Andrew Wilson's *Ever-Victorious Army*, published in 1868, to Egmont Hake's *Events in the Taeping Rebellion*, published in 1891.

His career in the Soudan has been still more frequently recorded. One at least of these books—*Colonel Gordon in Central Africa, 1874—1879*, by George Birkbeck Hill—was published during his lifetime in 1881, and since his death at Khartoum, in 1885, many more have been given to the world. He has not yet—like Stonewall Jackson—found a biographer whose *Life* throws all others into the shade. Doubtless succeeding generations will each require their own special version of his career and character, for, like Napoleon, Nelson, and Lee, his striking and commanding personality is certain to fascinate mankind for many an unborn generation.

The portrait of the Duke of Cambridge is by Hermann Herkomer. His Royal Highness was Colonel-in-Chief of the Corps as well as of the Royal Regiment of Artillery, from 1861 to his death in 1904.

He was born on the 26th March, 1819, and in November, 1837, was commissioned Brevet Colonel in the Army. During the Crimean War he acted as Lieutenant-General Commanding the 1st Division, and in 1856 he succeeded Lord Hardinge as General Officer Commanding-in-Chief. In 1862 he became a Field Marshal. In 1887 his title was changed to Commander-in-Chief, an appointment which he held until 1895. No one who ever attended the Corps Dinners—at which he constantly presided until within a very few years of his death—is likely to forget his cheery and humorous speeches, full of a certain blunt common sense, displaying as they always did an unfailing interest in the Corps.

On the 20th November, 1896, a year after his retirement from the Army, His Royal Highness presided as Colonel of the Corps at a dinner given at the Headquarter Mess in honour of Sir Herbert Kitchener and the R.E. officers employed under him in the Dongola Expedition. After the toast of the evening had been duly honoured, Field Marshal Sir Lintorn Simmons rose to propose the health of the Duke. "The fine portrait on the wall of the Mess," said Sir Lintorn, "will bring him to the minds of all of us, and will habitually recall the strong friend we have always had in His Royal Highness during the time he was Commander-in-Chief." In the course of his reply the Duke said he could only hope that in years to come, when he had passed away and they looked on that portrait, they would remember that they never had a sincerer friend and well-wisher to the Corps, or the British Army generally, than the individual who for 40 years ruled over and organized the Army.

On the 8th November, 1898, the Duke again presided at a dinner given at Chatham to Major-General Lord Kitchener, after the brilliant conclusion of the Soudan Campaign. In the same year it was decided that a picture of Lord Kitchener should be painted for the Chatham Mess. The picture was painted by Mr. A. S. Cope, and is now hanging in the south annexe.

On the 23rd July, 1902, the Duke of Cambridge presided for the third time at a complimentary dinner to Lord Kitchener, on his return to England on the conclusion of the South African War. The dinner on this occasion was held at the Hotel Cecil. In the course of his remarks the Duke said: "I do not think that in the list of British officers there is one, except the Duke of Wellington, who has rendered finer service to his country than Lord Kitchener."

In addition to the full-length portraits of General Gordon, the Duke of Cambridge, and Lord Kitchener, there are smaller portraits in the south annexe of Colonel Landmann, Colonel Sir Frederick Chapman, Colonel Sir John Bateman-Champain, another of General Gordon, and lastly one of General Sir John Ardagh.

Lieut.-Colonel George Thomas Landmann (1779—1854) was the son of a German who had served in the French Army as *aide-de-camp* to the Duc de Broglie during the Seven Years' War. In 1777, on the invitation of George III., Isaac Landmann assumed the position of Professor of Artillery and Fortification at the Royal Military Academy. This position he held for 38 years, until his retirement in 1815.

His son was born at Woolwich in 1779, entered the Royal Military Academy as a cadet in 1793, and obtained his commission as a Second Lieutenant in 1795. In 1806 he was promoted Captain, and in 1808 he joined Sir Arthur Wellesley in the Peninsula. He was present as C.R.E. at the Battles of Roleia and Vimiera on the 17th and 21st August, succeeding Capt. Elphinstone, who was wounded in the former battle.

In consequence of his knowledge of Spanish he was in 1809 granted a commission as Lieutenant-Colonel in the Spanish Engineers. In 1810 he was made a Colonel of Infantry in the Spanish Army, and in April served at the Siege of Matagorda. In 1812 his health broke down and he was invalided to England. He is the author of several chatty volumes of recollections, which give an excellent idea of the lighter side of military life at the time of the Peninsular War (see *Dictionary of National Biography*, Vol. XXXII., p. 51).

The portrait was presented by Mr. Edward J. Castle, Q.C., formerly an officer of the Corps, and an account of its presentation is given in the *R.E. Journal* of 1st May, 1889, Vol. XIX., p. 113.

General Sir Frederick Chapman, G.C.B. (1815—1893), obtained his first commission in 1835 and retired from the Service in 1881. He was a Captain in the Corps in 1854 at the time of the Crimean War, and at the Battle of the Alma he was serving as senior Engineer officer with the 1st Division, commanded by the Duke of Cambridge. In October he was appointed to the command—as Director—of the British Left Attack. The first artillery position in the first parallel of this attack was always known as "Chapman's Battery."

On the 22nd March, 1855, when Major John William Gordon, Director of the Right Attack, was severely wounded, Chapman became Executive Engineer for the whole siege, under Sir Harry Jones. He served throughout the siege with great distinction, was made a Companion of the Bath, an Officer of the French Legion of Honour, and was awarded the third class of the Turkish Order of the Medjidie.

From 1860 to 1865 he held the position of Deputy Adjutant-General, Royal Engineers. In 1867 he was appointed Governor of Bermuda, and from 1870 to 1875 he was Inspector-General of Fortifications. In 1872 he became a Colonel Commandant of the Corps. He was promoted K.C.B. in 1867 and G.C.B. in 1877, and died in London in 1893.

A biographical memoir by Lieut.-General C. B. Ewart, C.B., occurs in the *R.E. Journal* for 1893, Vol. XXIII., p. 153 (see also *Dictionary of National Biography*, Supplement, Vol. I., p. 413).

An interesting account of Colonel Sir John Underwood Bateman-Champain's services, written by Major-General Sir Robert Murdoch Smith, K.C.M.G., occurs in the *R.E. Journal* for March, 1887. There is also an excellent account of them in the *Biographical Notices of Officers of the Royal (Bengal) Engineers*, by Colonel Sir Edward Thackeray, K.C.B., V.C., and in the *Dictionary of National Biography*, Supplement, Vol. I., p. 139.

Sir John Bateman-Champain (1835—1887) obtained his commission in the Bengal Engineers in 1853. He served with much distinction during the Indian Mutiny at the Sieges of Delhi and Lucknow, and in numerous engagements throughout the period of the Mutiny until its suppression in 1858.

The work however with which his name will always be associated is the construction of the first telegraph line to India through Persia. The officer who was originally placed in charge of this work—Colonel Patrick Stewart, of the Bengal Engineers—died before the completion of the difficult task, and Capt. Champain had the satisfaction of finishing what seemed at one time an almost impossible task. His extraordinary tact and power of persuasion enabled him to overcome the political difficulties in Persia, and his energy and ability for getting the full work out of his subordinates surmounted all the material obstacles.

In 1870 Colonel Champain assumed sole charge of the Indo-European Government Telegraph Department. Until shortly before his death, in 1887, he was constantly at work in connection with the Department. Journeys to Russia, Turkey, and Persia, alternated with work on international committees for organizing and regulating the whole system of international telegraphy.

His Knighthood was granted him in 1885 for "Services during many years in connection with the telegraph to India." He had a remarkable personality, and was much beloved by the members of the Indo-European Telegraph Department, by whom his portrait was presented to the Mess.

Major-General Sir John C. Ardagh, K.C.M.G., K.C.I.E., C.B., LL.D. (1840—1907), was commissioned on the 1st April, 1859.

In the winter of 1861, in consequence of the seizure of the Confederate envoys, Messrs. Mason and Slidell, on board the British steamer *Trent* by Capt. Wilkes, commanding the United States frigate *San Jacinto*, a British force amounting to about 10,000 men was despatched to Canada. The weather in the Atlantic during that winter was exceptionally stormy, and many of the hired transports were unable to face it. One of these transports, the *Victoria*, conveying the 96th Regiment and a detachment of Sappers, under the command of Lieut. Ardagh, after putting back once, nearly foundered on the second attempt, and was only kept afloat by the exertions of the troops.

The following is an extract from a letter from the officer commanding the 96th Regiment to the Quartermaster-General, dated on board steam transport *Victoria*, Plymouth Sound, 12th March, 1862:—

I would beg leave also to call attention to the valuable assistance rendered by Lieut. Ardagh, of the Royal Engineers, and the men of the detachment under his command, in repairing and cleaning the pumps as they became unserviceable and in performing the necessary work about the ship.

The following memo. by the Quartermaster-General conveyed the approval of the Duke of Cambridge to the D.A.G., Royal Engineers:—

The enclosed extract from a report made by Colonel Scovell, commanding the 96th Regiment and the troops on board the *Victoria*, steamer, who re-embarked on board that vessel at Cork for Canada on the 13th ultimo and put into Plymouth on the 12th instant with leaky condition of vessel and disabled engines, in consequence of having experienced severe weather, is transmitted for the information of the Deputy Adjutant-General of the Royal Engineers.

"His Royal Highness was much gratified to hear of the valuable assistance rendered by Lieut. Ardagh, of the Royal Engineers, and the men under his command whilst encountering difficulties and dangers of no ordinary kind, and it is requested that His Royal Highness's approbation of their praiseworthy exertions may be conveyed to Lieut. Ardagh, R.E., and the men of the Corps under his command."

(Sd.) P. G. HERBERT,
*Quartermaster-General.*

HORSE GUARDS, S.W.,
*March 20th*, 1862.

This Order was read out on parade at Chatham—a high distinction for a subaltern of three years' service.

The distinction gained by Ardagh at this early stage in his service was maintained throughout his career. In 1868 he was nominated Secretary of a Committee appointed to inspect and report on the fortifications in course of construction under the Defence Act of 1860. After the issue of the report of the Committee, he received the thanks of the Secretary of State for the satisfactory manner in which he had performed his duties.

In 1873 and 1874 he was at the Staff College, and on completing his course he was sent to the War Office for duty in the Intelligence Department. For the next eight years he was constantly employed in important diplomatic and intelligence work in connection with the politics of the Near East. He was awarded a C.B. in 1878 for his services at the Congress of Berlin, which he attended as a subordinate of Sir Lintorn Simmons, who was acting in the capacity of technical military adviser to Lord Beaconsfield.

For a few months in the early part of 1882 he acted as Instructor in Tactics at the S.M.E.; but the Egyptian crisis of that year required his presence near the centre of disturbance, and in July he was engaged in placing Alexandria in a state of defence against the troops of Arabi Pasha, and in September he was present at the Battle of Tel-el-Kebir.

In 1884 and 1885 he was employed, under Sir G. Graham and Sir F. Stephenson, in the Suakim and Nile Campaigns. In 1886 he was employed in connection with the settlement of the financial arrangements between England and Egypt. For his services in this connection he received the thanks of the Treasury. In 1887 he was appointed Assistant Adjutant-General at the War Office for Defence and Mobilization.

In 1888 he became Aide-de-Camp to the Duke of Cambridge, and later on in the same year he was selected by the Marquess of Lansdowne, the Governor-General of India, for the post of Private Secretary. This position he held until Lord Lansdowne completed the term of his Vice-Royalty in 1893. In the following year he was appointed K.C.I.E.

In 1895 he was appointed Commandant of the School of Military Engineering, and in the following year he was selected for the important position of Director of Military Intelligence at the War Office.

On the 18th February, 1896, he was married to Susan, widow of the third Earl of Malmesbury, by whom the portrait now hanging in the Mess was presented to the Corps.

He held the appointment of Director of Military Intelligence for five years, years of incessant and arduous work, more especially as they included the period of the South African War. At one time there was an idea that the British Government had not been sufficiently informed as to the state of preparation for war of the Boer Republic, and this notion, if correct, would have implied blame to the Intelligence Department. But the publication, first by American newspapers, and then by the *Standard*, of the contents of "Military Notes on the Dutch Republics of South Africa"—a secret work compiled by the Intelligence Department, a copy of which had fallen into Boer hands after the action of Talana—and the evidence given before the Royal Commission on the War in South Africa, proved conclusively that Ardagh had carried out his duties in the most thorough manner. He had, indeed, in spite of a very limited staff and inadequate funds, kept the authorities at the War Office fully informed both as to the condition of affairs in South Africa, and the military resources of the Boers, and also as to the number of troops necessary for the defence of the Colonies. These he estimated at 40,000, while the force requisite for carrying war into the enemy's territory he fixed at 200,000, as has been made public in the *Times*. After the printing of the "Military Notes" by the *Standard*, copies of the original work were, at Ardagh's request, laid upon the table of both Houses of Parliament.*

Ardagh was retired from the Army under the age clause of the Royal Warrant on the 9th August, 1902, but continued to be employed by the Foreign Office, and was nominated in the same year British Member of the Permanent Court of Arbitration at the Hague.

In June, 1906, he was appointed Senior British Plenipotentiary at the Conference for the revision of the Geneva Convention of 1864 "for the amelioration of the condition of wounded in armies in the field." Practically all his proposals are embodied in the new Convention.

He died on the 30th September, 1907.

Colonel Sir Charles Watson and Lieut.-Colonel J. E. Edmonds have written an appreciative memoir of his life in the *R.E. Journal* for November, 1907. The memoir closes with the following words:— "There are but few officers of the Royal Engineers who have had so interesting a career as Ardagh, or who have done better service for the State; but the constant calls upon his services for special work

* *R.E. Journal*, November, 1907, p. 304.

gave him little time for rest, and the uninterrupted strain somewhat affected his health. Ardagh has shown an example of self-restraint and devotion to duty which may be of help to others in times of trial. Infinite patience, whether in the performance of his work or as regards the shortcomings of others, was one of his most marked characteristics, while his absolute straightness and simplicity of nature gained him the love of all who were intimately acquainted with him. A man of great general knowledge and of varied experience, he thought deeply before he spoke or wrote, and had rarely occasion to alter what he had said or written. In every respect Ardagh has shown throughout his life a bright example of what a Royal Engineer officer should strive to be."

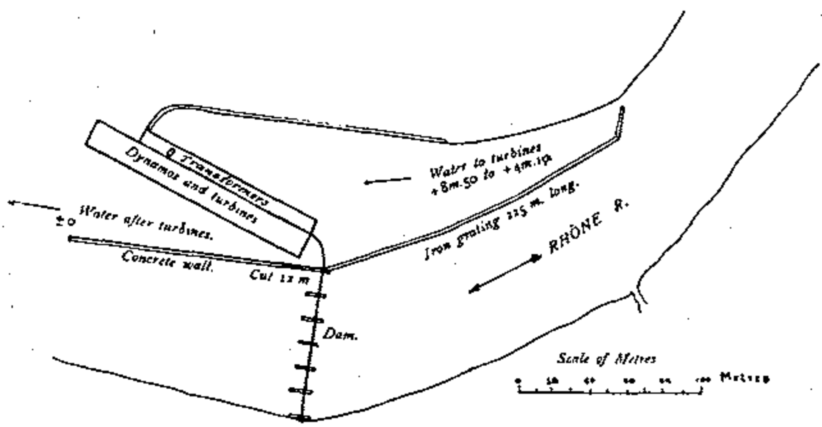
# TRANSCRIPTS.

## THE ELECTRICAL SUPPLY OF GENEVA.

From *Notes et croquis techniques sur Genève.*

THE river Rhône supplies the town of Geneva with both water and electricity, and it is proposed in this article to describe the latter installation, viz., that of Chèvres.

The accompanying sketch shows how the buildings are disposed and also how a head of water is obtained.




The fall varies from 8m.50 in winter to 4m.50 in summer. The dam built across the river serves to obtain the necessary head. It consists of seven concrete columns 17 mètres long, 3 mètres thick, and 9m.50 above the river bed. Each of them is further raised 5 mètres for a length of 4m.50, to carry a bridge from which the water gates in the intervening spaces are handled. The river bed is covered with concrete to a depth of 1 mètre between the piles, and is covered by beams 10 centimètres thick, protected by metal. The lower part of the piles is likewise armoured with metal plates 3 centimètres thick, to protect them against wear by the impact of stones, etc., when the water is high.

The actual dam, between the piles is composed of water gates 8·50 mètres high and 10 mètres thick, reinforced by nine powerful parabolic rafters as they may have to support a maximum pressure of 360,000 kilogrammes. To facilitate the handling of these gates, which weigh 50,000 kilogrammes each, they are made to slide on roller bearings and are moreover each counterbalanced by two boxes full of scrap-iron, which allows of their being raised or lowered with the greatest ease by two men. This system is due to an English engineer, Mr. Stoney.

The water escaping over the dam is separated from that issuing out of the turbines, by means of a concrete wall 130 mètres long, 4 mètres high, and 2 mètres thick at its base. It was found at first that a difference in level of 60 centimètres existed between these two streams of water, and accordingly a cut, 12 mètres broad, was made in the wall, to bring them to the same level and increase the head of water. The suction caused by the water escaping through this narrow opening actually draws in through the cut more water than would be absorbed by the mere difference in level, and—by thus causing an additional increase in head—has raised the power of the turbines by 800-h.p. when the river is very full.

The water enters the turbines by a canal 120 mètres long and 40 mètres broad, which however gradually gets narrower. The bed of this canal is of concrete. A grating, with bars 9 mètres long and inclined at 45° to the horizontal, prevents any logs, or other materials floating on the river, from entering the canal and blocking it up. This grating is 225 mètres long and rests with one end on the right bank of the river. It is supported on a wall 2 mètres above the river bed, whose foundations in some places are as deep as 5·70 mètres below the bed.

Piles are driven into the river above the grating to direct heavy floating bodies away from it towards the dam, over which they can escape.

The building containing the dynamos is 137 mètres long and 12·50 broad. It contains 15 alternators, which have an average horse-power of 1,000, *i.e.*, varying from 1,200 in winter to 800 in summer, and four continuous current machines of 150-h.p., worked by three turbines, serve as exciters to the alternators.

Owing to the great variation in the height of the fall (8·50 mètres to 4m.30) a special type of turbine was necessary. Two turbines and the alternator are on the same vertical shaft. The speed of the turbines depends upon the height of the fall, and the diameter of the dynamo depends upon its angular velocity, the problem being therefore to use the same dynamo with a varying head of water. This is solved as follows:—

In winter, when the waters are high, only the lower turbine works. It is divided into three superimposed wheels of different radii and gives an efficiency of 75 per cent. with a head of 8m.10, the power being 1,200-h.p.

In summer the head falls to 4m.30 and the power of the lower turbine is reduced to 400-h.p. The water is consequently allowed to work the upper turbine, whose power is 400-h.p., and only differs in construction from the lower one in diameter and by its apex angle. A total horse-power of 800 is thus obtained.

The 15 alternators produce a two-phase current (of 47 cycles per second) at a voltage of 2,750. The four continuous current exciters consist of three dynamos giving 750 amperes at 115 volts, and one dynamo giving 1,000 amperes at 115 volts.

The switchboard is divided into three parts:—

(1). For the exciters.
(2). For the alternators which feed the underground network at 2,750 volts.
(3). For the overhead network at 5,500 volts, provided by eight transformers, which are directly connected to some of the alternators.

A loss of 10 per cent. is allowed for, and the voltage at the end of the lines is taken as 2,500 and 5,000 volts.

The energy produced is distributed in two networks:—

(1). The underground at 2,750 volts.
(2). The aerial at 5,500 volts.

The latter can in case of need be used to help the former, as it is joined to it.

The underground network of the town and its surroundings is 6 kilomètres long, and at every kilomètre a transformer is installed to supply the local requirements.

Electricity is supplied by this system to private houses:—

(1). By means of a three-wire single-phase network at 2 × 120 volts.
(2). By means of a three-wire two-phase network at 550 volts.

This latter supplies the arc lamps of the town with 550 volts at 40 amperes, a transformer being situated in the pedestal of each arc lamp.

The aerial network feeds:—

(*a*). Some chemical works near Chèvres with a 2,750-volt supply.
(*b*). The main lines for the distribution of electricity with 5,500 volts.

One of these lines is joined to an auxiliary steam-generating station, which is used to supplement the Chèvres installation when the waters are low.

Four transformers of 400 kilowatts are situated in this generating station. Their primaries at 5,000 volts are fed by the aerial network, and their secondaries at 2,500 volts by the underground one, and thus either system can reinforce the other. Another line supplies electricity 14 kilomètres away, whilst a third, 7½ kilomètres long, feeds a chemical factory at La Plaine.

The whole length of the aerial network is 47 kilomètres, that of the underground 58, that of the secondary lines at 120 and 550 volts, 125 kilomètres.

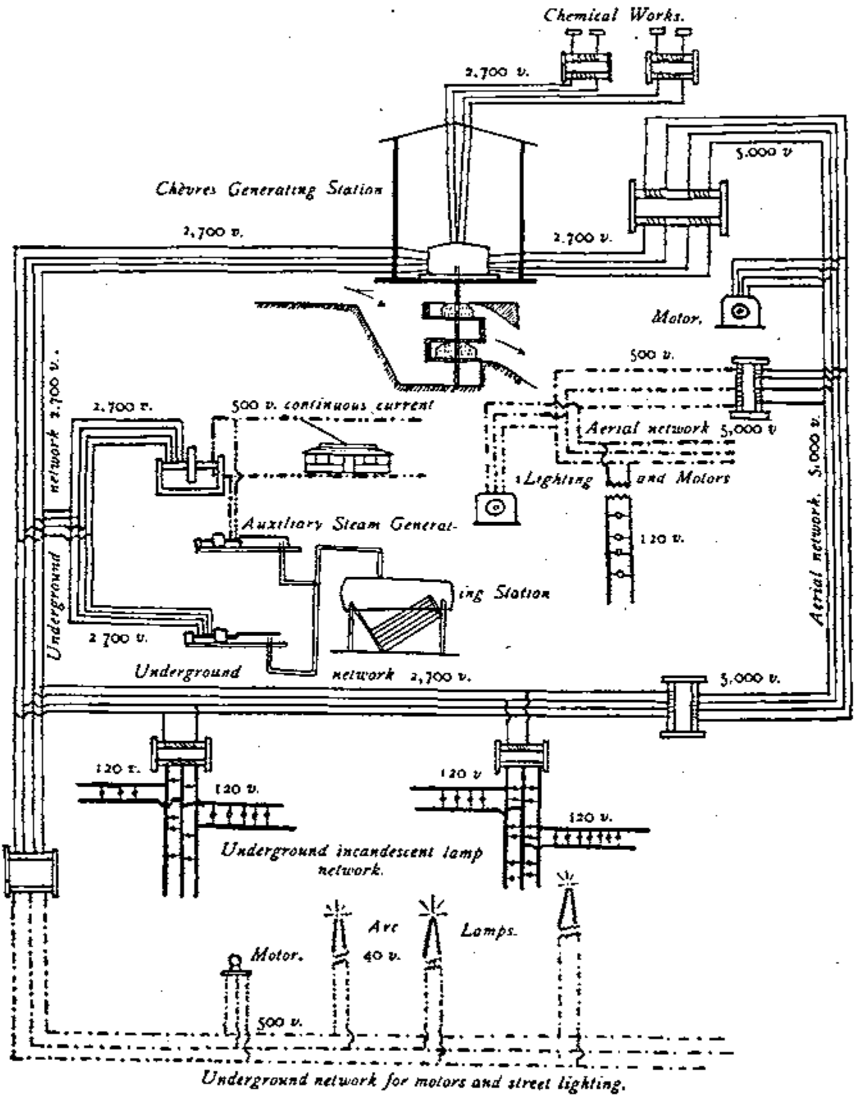
In July, 1906, electricity was supplied to:—

137,200 incandescent lamps (of about 50 watts each).
352 arc lamps for street lighting.
449 private arc lamps.
123 motors of a total of 62-h.p., fed by the 120-volt line.
228 motors (1,363-h.p.), fed by the 550-volt line.
31 motors (6,985-h.p.), fed by the high-tension line.
880 transformers (total 8,000-h.p.) on the various lines.

The building of this installation cost the town of Geneva 10,000,000 francs, but the sale of electricity brings in, together with the water supply, 1,630,000 francs annually to the town and constitutes a large share of its annual income.

A. H. SCOTT.

DISTRIBUTION OF ELECTRICITY IN GENEVA.



# THE PROTECTION OF THE RAILWAY IN TRANS-AMUR.

From the *Voënnyi Sbórnik.*

The war with Japan was waged at a distance of some 10,000 versts from European Russia, the only available line of communication being the Siberian Railway and the newly constructed Eastern Chinese Railway. The inhabitants of the country through which the latter passed, favoured the Japanese cause, but nevertheless throughout the campaign the line was preserved intact. The troops employed for its protection were those of the Trans-Amur Frontier Guard; they were in part the original body recruited for the defence of the Chinese Railway whilst it was being constructed in 1897—1901. Many men and officers eager for a life of adventure and enterprise joined this force from different parts of Russia.

The Trans-Amur military district was organized in a fashion adapted to the object of its existence. The fundamental unit was a detachment consisting of the three arms—usually 3—5 companies, 3—5 sotnyas, and a horse mountain battery. The strength of each detachment varied in accordance with the importance and extent of the portion of railway guarded by it.

The commander of a detachment was a staff officer with the powers of a regimental commander, and he was responsible for the security of his section of the railway, including all structures and telegraphs. He had two field officers as assistants, and another who acted as staff officer for the whole of the artillery for administrative and supply purposes. For discipline three detachments were united under one brigade commander, who had the powers of a divisional commander. He was assisted by an officer of the general staff and by a field officer whose duties were administrative. The officer commanding the whole district had the powers of the commander of an independent army corps; he was however later in the war subordinated to the commander-in-chief in Manchuria.

The normal establishment of the Trans-Amur Frontier Guard appears to have been 55 companies, 55 sotnyas, and 7½ batteries, divided into 12 detachments and 4 brigades, the strongest of which consisted of 18 companies, 18 sotnyas, and 3 batteries. This brigade protected a most important extension of the line, namely, Harbin to Kai-yu-an and the river Sungari from Harbin to the Amur.

The infantry and cavalry were both armed with carbines, and the latter in addition had also swords and, in some cases, lances. The guns were 77 and 57-mm. and fired fixed ammunition. The troops were increased in number on several occasions during the war.

There was a naval department in the district during the war for controlling the steamers and for managing the guardships stationed at barriers on the large rivers.

The Eastern Chinese Railway cuts both Manchuria and the western part of Mongolia in half; from the frontier to Harbin the line traverses the vast salt plains of Mongolia, pierces the Khingan ridge, and emerges on to the desert flats. The most important structures on this section are the Khingan tunnel and the Nonni Bridge. The line from Harbin to Vladivostók lies in very sparsely populated and intersected country; the largest works in connection with it are the Mudadzyan Bridge and the group of Daimoi tunnels. From Harbin to Tiehling the line traverses the Manchurian plain, and thence to Tashihchiao follows the valley of the Liao. The southern branches pass through the richest part of Manchuria. There are two large bridges over the Sungari, and numerous smaller ones, such as those over the Chingho, Hunho, etc. In the northern part of Manchuria the inhabitants were favourable to the Russians, but in the south they were hostile.

The headquarters of the 12 detachments were fixed at places ot some importance, such as the Nonni Bridge. The length of line guarded by each detachment was divided into sections for the mounted and dismounted men concurrently; the one did not as a rule coincide with the other. To the more important works, such as bridges and tunnels, special garrisons were allotted and officers were detailed as their commandants.

A dismounted section of the line was divided into sub-sections of about 5 versts in length, guarded by pickets housed in temporary defensible barracks built alongside the permanent way, and 4 to 5½ versts apart. Close observation of the railway and telegraph was carried out by patrols.

The mounted sections furnished 5 to 30 horsemen to the commandants of important works; the remainder were kept at stations and intermediate posts within the limits of the section, as standing pickets which sent out mounted patrols usually at night time along the railway, and twice a week into the country on both sides of the line.

At the outbreak of war, the means existing for the defence of bridges and other buildings appear to have been meagre. The garrisons at bridges were, in summer, accommodated in tents, and in winter were provided with mud huts. Barracks at the stations, and temporary barracks at intermediate posts, had been completed, but the majority of the former were used as hospitals and the garrisons quartered in mud huts. The boundary walls only of the temporary barracks were bullet-proof. They were made of brick and had two small bastions at opposite corners for flanking fire. Loopholes at first were badly made, being at a convenient height for an opponent, but later on they were improved.

At the middle of the campaign, the defences at the Khingan tunnel took the form of two bullet-proof walls for artillery and rifle fire above the entrance and exit, and of two temporary bullet-proof buildings holding 50—60 men each. At either end of the tunnel, on a level with the track, was a wooden blockhouse to hold 8—10 men.

At the large bridges, such as those over the Nonni and Sungari and other navigable rivers, booms were constructed with guardships moored near them.

Towards the middle of the campaign the defensibility of bridges was much increased by the addition of obstacles, such as wire entanglements, wolf pits, and pointed stakes, which were usually made to a width of 28′ to 35′. In winter, ditches in the ice with wire entanglements in front of them were constructed along the bridges, and besides this each pier had its own ditch and entanglement. For firing along the river beds, rough parapets on the decking of the bridges were made with sandbags.

Projectors were rigged up to illuminate the booms in connection with the defences of the four largest bridges. In the case of smaller bridges a line of kerosene lamps was placed on the ice. All garrisons at bridges and other posts were connected by telegraph and telephone, and were well provided with rockets and signalling apparatus.

An official work entitled "Regulations for the Preservation and Defence of the Eastern Chinese Railway" was issued, and contained detailed instructions to provide for every possible contingency. A handbook writen in simpler language was used by the lower ranks.

Much attention was paid to the *morale* of the Trans-Amur troops, whose spirit appears to have been excellent in spite of the trying circumstances in which they worked. They were always well provided with food and clothing. A special paper called the *Trans-Amur Leisure Hour* was published, and three local papers were sent regularly to the officers. Spiritual needs were not disregarded; a church coach was continually travelling up and down the line.

The defence of the line was not entirely passive; small bodies of troops were concentrated at various places, and made expeditions as occasions offered.

About the time of the retreat after Liaoyang, the number of troops guarding the line was much increased and averaged 10 men per verst for the whole line, and 21 men per verst for the southern branch (*i.e.*, Harbin southwards). After Mukden a further increase was made, and the average then was 22 men per verst for the whole line, and 39 men per verst for the southern branch.

Numerous instances are given of the work of the troops in guarding the line and of attacks on bridges successfully repulsed.

A. H. BELL.

# *NOTICES OF MAGAZINES.*

## JOURNAL DES SCIENCES MILITAIRES.

### *November 1st*, 1908.

Under the title of "Automobilism from a Military Point of View," this number contains suggestions as to employment of motors in the future. Their use by generals and their staffs, with motor-cyclist escorts, is considered certain. Despatches will be carried by motor cyclists instead of cavalry. Infantry carried in motor wagons will be able to rapidly reinforce threatened points; engineers can be brought to their work, such as bridge building, without the fatigue of marching; raiding parties will be able to get at the enemy's line of communications much more easily by moving rapidly round his flank.

A short account of the German machine-gun regulations follows. The organization is in 13 six-gun batteries. Each battery is divided into three sections, each under an officer. As a general rule machine guns are not to be employed singly.

The Japanese infantry tactics are illustrated by an extract from a report on the 6th Division. Close communication is maintained between infantry and artillery, and there is no firing till the infantry reach decisive range. They then dig a small trench and open a heavy fire. An assault is to be expected in most cases. Obstacles are destroyed by night. Cold steel only is used in night attacks.

### *November 15th*, 1908.

"Automobilism from a Military Point of View" is continued. The replacement of horsed wagons by motor vehicles is suggested for cavalry transport. Much reconnaissance duty might be done by motor cars, possibly armoured and carrying machine guns. Such cars could also be used to increase the fire power of cavalry. A short history of armoured motor cars follows. Modes of employment include the removal of wounded from the battlefield, and, in exceptional cases, the replenishment of ammunition there. The suggestion is made that by using a motor a general could personally examine the state of affairs in battle without exposing himself unjustifiably. Short descriptions of several types conclude the article.

There are two articles on the Manchurian War, and the Russian generalship comes in for severe criticism. The commanders anchored themselves to positions; the officers were not sufficiently educated; the artillery buried itself in its works to such an extent that it could not open fire when targets appeared at unexpected points. The great lesson of the war is the importance of training men in hand-to-hand fighting. The second article deals with infantry tactics—the Japanese tactics seeming to be very similar to our own.

The Swiss use the Maxim type of machine. With the cavalry it is carried on pack horses, and used from a tripod carriage. One eight-gun battery is attached to each cavalry brigade, and there is a suggestion of using these guns with the infantry also. A special carriage enables the gun to be fired by a man lying down, and experiments are being made with an equipment to enable a man to carry the gun on his back. The use of machine guns in recent wars has not been quite satisfactory, and our methods in South Africa are adversely criticized.

In the December number of the *Journal* there is nothing of special interest to sappers. Opinions on the reorganization of the artillery and infantry have been collected from a large number of officers, and the following are some of the ideas suggested:—(1). The brigade is an obsolete organization. Divisions of four 4-battalion regiments should be formed under a general and an assistant general. (2). All infantry in France should have the same 3-battalion organization. There should be no special fortress regiments. (3). Several suggestions are made to reorganize the whole army on the system of every unit containing three of the next smaller unit. (4). The present arrangements for war, adopted in 1875, should be replaced by a system which does not assume defeats at the outset as unavoidable. (5). Good officers cannot be had without good pay. On the frontier an extra allowance should be given. (6). Engineers should be organized in 2-battalion groups. One battalion should be with the field army and the other should feed the reserve formations. (7). A table is given showing the percentage of colonels in each arm. The number of generals are proportionate to the number of colonels—Infantry, 1·45 per cent.; cavalry, 2·75 per cent.; artillery, 2·15 per cent; engineers, 3·5 per cent. (8). A 6-gun battery divided into two sections of three guns each is proposed. (9). Experiments on the power of pom-poms for piercing gun shields are called for.

In an article on the "Decisive Attack" the instructions contained in the official regulations are enlarged upon. These instructions are rather vague. The aim of the decisive attack is to seize a position defended by the enemy and follow up this success until victory ensues. Stress is laid upon the necessity of acquiring a fire superiority, which is considered to have been obtained when, from any cause, only a small portion of the enemy's firearms remain fit for use. The close co-operation of artillery with the infantry is absolutely essential. It is desirable that the artillery should obtain an advantage before the infantry gets to decisive range.

Some extracts from the diary of a French captain in the Morocco campaign follow. They give a good idea of the experience of an eye-witness at Casablanca.

H. L. Woodhouse.

NATURE.

*November*, 1908.

WINDMILLS AND WATER-WHEELS (*p.* 4).—Natural sources of power are discussed in a volume by R. S. Ball. The author uses the word "natural," to describe those sources of power which provide us directly with mechanical energy without any intermediate transformation, such as combustion or the like; and the two particular supplies of energy to which attention is directed are wind power and water power. It is rather surprising to be told that the demand for windmills was never so great as it is to-day, or the trade of the manufacturer of such motors never so brisk. On the other hand, evidences of the utilization of the water powers of the world are everywhere abundant, the chief agent in this being the development of electrical technology.

Chapter I. deals with general principles, such as the distinction between "power" and "energy," efficiency of machines, units, etc. Chapter II. is concerned with water power and modes of measuring. The fundamental theorem of Bernouilli, which says that the sum of the pressure head, the velocity head and the height above datum level is constant at all points in a pipe running full of water, is discussed, as are also weirs, etc.

Subsequent chapters deal with the different kinds of water-wheels and hydraulic turbines, their general design, theory, and regulation. Descriptions of several typical installations, working under such widely different conditions as heads of 2′ and of 2,000′, are given. The modern, or "American," windmill forms the subject of the last two chapters. Constructional details are given, as well as particulars of tests on the power developed and the cost thereof when applied to different industrial purposes. The book can be specially recommended to those readers who, while not being specialists in the particular branch dealt with, desire to obtain a general survey of the subject.

SOLAR VORTICES AND THEIR MAGNETIC EFFECTS (*p.* 20).—It has been found that when a sunspot is near the middle of the solar disc, the direction of the light, from the spot, is along lines of force which are at right angles to the plane of the vortices in which the electric currents are encircling. If now the sunspot be on the limb of the sun, the light from the spot is along the lines of force, or in the plane of the circulating electric currents. The observations of both these longitudinal and transversal effects indicate conclusively that sunspots are very intense magnetic fields—a most important discovery.

CAISSON DISEASE (*p.* 40).—Men who have been working in compressed air either under water in diving dresses or diving bells, in caissons used in preparing foundations for bridges, etc., or in making shafts or tunnels through watery ground, are liable to a variety of symptoms known as "caisson disease." These symptoms, which come on only at, or shortly after, the return to atmospheric pressure, vary in severity, from pain in the muscles and joints to paralysis and even death. These attacks are due to the fact that air (chiefly nitrogen) which has been dissolved in the fluids and tissues of the body while under-pressure, may on decompression be liberated in the form of bubbles, which produce local or general blocking of the circulation or other injuries. If decompression is effected slowly, the mass of air which had been taken up could escape by diffusion through the lungs, and thus bubbling could be avoided. The phenomenon is, in fact, that of decompressing soda water by pushing in the stopper; the problem of the prevention of caisson disease, is how to push it in so slowly that the gas can escape without forming bubbles, and without the loss of so much time that the primary object of the manœuvre is frustrated. The duration of the exposure to high pressure is of the utmost importance. The rate of decompression must be adjusted to the height of the pressure and the duration of exposure; what is safe after one hour at 60 lbs. pressure would be waste of time if the pressure had been 30 lbs., or the time of the exposure only 10 minutes.

THE ECLIPSE OF JANUARY, 1908 (*p.* 70).—An expedition from the Lick Observatory went to Flint Island in the Southern Pacific, to observe the total eclipse of the sun of January 3rd. This island is in latitude 11° S., and is 450 miles N.W. of Tahiti. The weather on the morning of the eclipse was extremely sensational, rain falling in torrents between five minutes before and three seconds after the commencement of totality, but happily the clouds dispersed and the remainder of the eclipse was observed in a comparatively clear sky.

In the intra-Mercurial planet research two sets ot cameras were employed, each set so arranged as to include an area 9° broad and 28° long in the direction of the sun's equator. Three hundred star images, going down to the 9th magnitude, were recorded. And all have been identified. It now seems certain that no planet brighter than the 7th magnitude exists nearer the sun than Mercury.

Observations on the Corona show that in all probability its brightness is mainly due to reflected ordinary sunlight, diluted to some extent by the emissions from incandescent particles, and possibly also by some small amount of "luminiscence," such as produces the Aurora.

THE SURVEY OF AFRICA (*p.* 103).—The whole history of this geodetic work is a curious inversion of the general order. Usually it is the complaint of the map-maker that, whereas it is not difficult to get money from the Government for the immediate practical work of mapping, it is a more laborious task to persuade them or the necessity for a liberal expenditure upon the fundamental geodetic triangulation. In South Africa the exact reverse of this has been the case, and we have the anomalous position of a complete triangulation system without the resulting maps. Even now it is only in the case of the Orange River Colony, and partially in Cape Colony, that any of the maps of the country are based upon the geodetic points.

The base measurements have been carried out with "invar" wires hanging freely, at a constant tension, between low tripod supports. Five bases, totalling a length of 70 miles, were measured. Each was gone over with the wire three times, and the apparent probable error with an inexperienced staff was only 1 in 7,000,000. Sir D. Gill maintains that with a trained staff a base can be measured in this way with an actual error of less than 1 in 1,000,000, or about 1″ in 15 miles. The rate of progress averaged 475 yards per day, and the cost was about £153 per mile of base. The horizontal angles were observed with the 10″ Repsoll theodolite, the probable error of a single angle being found to be only 0″·30 with eight changes of zero.

W. E. WARRAND.

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## NEUE MILITÄRISCHE BLÄTTER.

ARMY AND SPORT.—In the issues of 9th and 23rd November, 1908, Hauptmann v. Scheibert discusses the value of sport for the soldier. He points out that the Japanese possess all the good qualities required in a soldier, "enthusiastic courage and tenacious bravery, utter disregard of death and thoughtful circumspection, steadfastness in bearing great exertions, true discipline and unconditional confidence in his leader, combined with the greatest power of initiative." Only a portion of these qualities are the inheritance of this race, but even these are strengthened and increased by the peculiar education of the Japanese nation. The Japanese of the middle and upper classes grow up accustomed to the use of arms—champions at feats of arms being regarded as national celebrities. Sporting exercise such as football, athletic sports, and gymnastics is practised everywhere. The training is directed to cultivating coolness and self-control. Added to this the Japanese are thorough monarchists and loyal to the 2,000-year-old dynasty of their rulers. The parting word, as the son left home for the war, was never "Come back safe and sound," but "Die for our country." Though almost every family in Japan must have suffered the loss of some near relatives during the late war, their grief was never seen outside the closest family circle, whereas the failure of any military undertaking was at once noticed throughout the country. All these qualities and self-reliance are to be obtained by cultivating sport.

The writer of the article quotes General v. Blume's "Foundations of Our Defensive Power," in which military exercises for schoolboys are described as useless if they are not—as in the upper classes of cadet corps and in the N.C. officer preparatory schools—conducted in all earnestness, and with the same thoroughness as in the army, but modified with consideration for the physical development of the youth. "Vain is the idea that the proper military training of the man can be facilitated by playing at soldiers when a boy. It effects no useful purpose, but still it flatters the vanity of youth and awakes in it a ready conception of military duty." When the period of service arrives the absolutely necessary drill effects its object, but, unless supplemented by gymnastics, camps, and individual combats, is to a certain extent injurious to the soldier's liveliness of mind, quick perception, and utilization of surprise situations, capacity for independent decision, in fact to just those qualities which appear desirable and attainable by games and sport. It is thus far more important for the education of the youth before entry into the army to form these moral qualities, as well as to develop his physique, than to occupy him with a "dead" military drill which does more harm than good. . . . "Leave all playing at soldiers quietly on one side, except a few necessary march movements, forming fours, etc., in order to be able to march decently to and from the playing field."

The effort is repeatedly made to revive German games. They are played keenly for a half-hour, but do not rouse the enthusiasm that football and cricket do. While German games are forsaken as wearisome when the gymnastic lessons are over, these English games have so much power of attraction that they are played with pleasure and keen interest long past the gymnastic lessons, not only by youths but by grown men. The writer therefore urges the importance of these games, together with German and Swedish gymnastics and swimming. The English system of schoolboy camps is recommended, as also are tours through the country, not so much for the purpose of learning how to pitch a tent or to cook, but much rather in order to learn how to do without things, to work for each other, the joy of service, and strengthening of patriotic self-reliance, "of which we Germans are just so sorely in need."

The writer concludes by saying that a youth brought up on these lines without playing at soldiers, but with a strong body and a fresh spirit, will produce splendid material for the army, a firm framework for the mass of modern armies, which is continually growing flabbier. This invigorating "skeleton" to an army is a powerful factor for victory. The first Napoleon would never have been able to conduct his campaigns of 1813, 1814, and 1815 in the way he did with the rapidly-raised recruits had not his numerous veterans given bone to that flesh and enabled the army to accomplish such extraordinary efforts. The proper training of the manhood of a nation is the first step towards victory.

It is interesting, in this connection, to consider this German opinion with reference to the new scheme of preliminary training in the Officers' Training Corps for our reserve of officers for the Regular Army. According to the German view it would appear that the ordinary school training of our public school boy leaves nothing to be desired in providing the framework on which to build the officer, while military training proper cannot usefully be commenced until the cadet joins the senior division of the Officers' Training Corps at the university.

The German view however contemplates the standard attained by the very thorough training of the German officer. Though we may aim at this standard in the case of the special reserve officers, it does not seem possible to expect it from officers of the Territorial Force, and it is therefore more especially for these that the senior division of the Officers' Training Corps at universities would appear to be fitted if we are to accept the German argument, which, further, confines the utility of the instruction in the junior division of the Officers' Training Corps at public schools to inculcating the groundwork of a military spirit. It may also be supposed that the exclusion of "dead" military drill from the instruction of the boy, as advocated by the Germans, does not preclude instruction in signalling and musketry, both of which it would seem possible with advantage to teach to the public school boy. Signalling, when learnt young, is less easily forgotten, while experience with enlisted boys has already proved that trouble taken with them over musketry instruction is well repaid.

E. G. WACE.

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## REVUE DE L'ARMÉE BELGE.

*July—August*, 1908.

The *rôle* of sappers is discussed in this number of the magazine. How much should the sappers do in the construction of fieldworks in war, and how much should be left to the infantry? The Belgian Regulations, it is pointed out, are very vague on this subject, with the natural result that sappers are falsely employed in one of the three following ways:—(*a*), Either they are made to construct works which should have been made by the infantry; or (*b*), they are used as supplementary infantry and their technical training not made use of; or (*c*), they are completely forgotten.

To remedy this state of affairs it is suggested that the following principles should be inserted in the Field Service Manuals:—

(1). The divisional engineers should be employed in the construction of works which are intended to improve the general situation of the division, such as important demolitions, obstructions, and the improvement of communications.

(2). When on the defensive, the trenches should be made by the troops destined to occupy them, aided by a few sappers when redoubts or magazines have to be constructed.

(3). The commander of a company of sappers should never be told in detail how to subdivide his command; he is the best judge in this matter, and can tell off his company, once he has seen the various tasks to be carried out.

(4). Both in attack and defence, the divisional C.R.E. should take part in the preliminary reconnaissance of the position.

(5). The divisional C.R.E. should not be also the commander of the divisional company of engineers, as the latter is too busy with arranging the work of his company to be able to grasp the situation thoroughly and decide what the company must do.

The proportion of engineers in the Belgian Army is 1 sapper company, 267 strong, per division of 18,096 foot soldiers, *i.e.*, 1·5 sappers per 100 infantry. This does not include technical troops, such as telegraphists, balloonists, etc.

A telescopic spade, designed by Lieuts. Brouyère and Spaak, is also described. As a result of the Russo-Japanese War it has been decided that each Belgian soldier shall carry an entrenching tool, two-thirds being shovels, and one-third axes, saws, and pickaxes. This shovel, which has a telescopic handle 60 cm. long when closed and 1 mètre when pulled out, claims the following advantages over the usual implement carried by continental troops:—

(1). Perfect solidity—being made of steel. Its weight is 1,100 grammes.

(2). A great diminution in fatigue owing to the length of the handle (1 mètre) when opened out.

(3). A considerable increase in efficiency, for the same reason.

(4). Saving of time.

(5). It can be used for field kitchens, as two spades, with the mess tins hung from them and a fire underneath, form an ideal field kitchen.

The most recent organization of the Dutch Army is given, and is as follows:—

(1). *Headquarters*, of which the details are secret.

(2). *Field Army.*—Headquarters; 4 divisions and 1 cavalry brigade; 1 division is composed of 1 squadron hussars; 1 company cyclists; 3 infantry regiments, *i.e.*, 15 battalions or 60 companies; 1 field artillery regiment, *i.e.*, 2 groups equalling 6 batteries or 36 guns; 1 infantry ammunition column and 1 artillery ditto; 1 company pioneers; 1 telegraphic section; 1 bridging section; 1 section of transport and supply troops; 1 section medical troops.

In case of war, the war minister can raise a cavalry brigade consisting of:—

4 regiments cavalry = 12 squadrons;
2 batteries horse artillery;
1 cavalry and 1 artillery ammunition column.

If the cavalry brigade is not raised, a cavalry regiment of 4 squadrons is placed at the disposal of each infantry division.

In peace time an infantry regiment has only 4 battalions, in war time 6, of which the 5th joins the field army and the 6th the fortress troops. Each field artillery regiment also has a reserve battery, which is at the disposal of the war minister.

The following troops are also attached to the army headquarters:—

1 section railway troops;
1 telegraphic section;
1 pontoon section;
1 brigade sanitary troops.

(3). *Fortress Troops.—i.e.,* Headquarters.

12 infantry battalions = 48 companies;
3 regiments fortress artillery = 30 companies;
1 regiment coast artillery = 10 companies;
1 corps of cupola artillery = 4 companies;
1 corps of torpedo troops = 2 companies;
4 companies sappers;
Telegraphic units and medical troops;
23 "landweer" battalions of 4 companies each;
44 "landweer" fortress artillery companies;
4 "landweer" engineer companies.

(4). *Troops for Territorial Defence.—*

25 "landweer" infantry battalions;
4 batteries reserve field artillery;
The colonial reserve.

(5). *Depôt Troops of the Regular Army.—*

12 depôt battalions infantry = 48 companies;
2 depôts of hussars;
4 depôts of field artillery;
4 battalions of depôt fortress artillery = 16 companies;
1 depôt of pontoonists;
1 engineer depôt;
1 depôt of administrative troops.

The cavalry and engineer depôt troops are alone existent in peace time; the other depôts merely have a staff of officers and N.C.O.'s.
The strength of the various units is as follows:—

1 division = 18,800 men, 2,500 horses, 560 vehicles;
1 cavalry brigade = 2,500 men, 2,570 horses, 150 vehicles;
*i.e.,* Field army = 78,000 men, 13,000 horses, 2,450 vehicles;
Fortress troops = 68,000 men and 70 horses;
Territorial troops = 31,000 men, 1,320 horses, and 370 vehicles;
Depôt troops = 1,200 men, 36 horses;
Grand total = 180,000 men, 14,500 horses, 2,800 vehicles.
And on war footing, 1 battalion = 1,050 men and 21 officers;
1 squadron = 5 officers and 150 men;
1 battery = 6 guns;
1 field company sappers = 3 officers and 170 men.

There are also interesting articles on the following subjects:—The Russo-Japanese War; the Greco-Turkish War of 1897; the *rôle* of cavalry in war—with special reference to Napoleonic cavalry; the military education of young officers; trial of armour and cupolas; the Defence Committee of Holland.

A. H. SCOTT.

## Revue du Génie Militaire.

*November*, 1908.

The Central Battery Telephone System.—This system has been in use for some years in England, America, Belgium, Italy, etc., but is only now being introduced into France. The author describes two separate installations which are used with a central battery. He also gives the details of a third installation, which he considers would be suitable for a military telephone exchange.

The Fourth Arm in Conjunction with the Others.—The author gives a short historical review of the way in which field fortification has been used in the Franco-Prussian War, American Civil War, and the Russo-Japanese War. He points out that it has been successfully employed by both defender and attacker for the purpose of economizing men, and thereby increasing the number available for either a turning movement or a counter-attack. In the event of another Franco-German war the line of the frontier—200 kilomètres—would correspond approximately to the length of front of the forces engaged. He therefore suggests that the frontier zone should be prepared and organized as a single defensive position.

The Maintenance of Gas and Water Mains.—An account of a method of locating leaks in gas and water mains. The pipes are divided into short sections by valves. In each section there are one or more taps, to which a pressure gauge may be fitted. Leaks are tested for by closing the valve at each end of a section and noting the pace at which the pressure falls. A rapid fall indicates a serious leak in the section.

J. E. E. Craster.

## Revue Militaire des Armées Étrangères.

*November*, 1908.

An article, on the use of "skis" in warfare, is given in this magazine. "Skis" and "Canadian racquets" are indispensable in winter for progress in hilly countries, and the following is a general comparison of the advantages of each. A Canadian racquet is of insignificant cost, requires little care, is easily attached to the boot, and allows the soldier to carry the regimental haversack. Moreover, no special training is required to teach its use, and 20 men with racquets before a column will open out a road for the remainder to walk on in boots.

The ski is very expensive, requires constant care, is very difficult to fasten to the boot; the ski-er cannot carry a haversack and leaves practically no trace on the snow. Moreover, it can only be used by specially trained men, who cannot march close together. The maximum speed available however is 10 kilomètres per hour, as against 7 to 8 per hour with a racquet.

The tactical uses of these two forms of locomotion are as follows:—

(1). A small number of ski-men will act as scouts and orderlies, marching independently of the other troops, and acting as cavalry.

(2). A larger number of troops on racquets will be in the advanced guard for closer reconnaissance, and to open up the road for the troops behind, who will not be supplied with them. France, Germany, Russia, Sweden, Norway, Austro-Hungary, Switzerland, and the United States, all train troops in the use of the ski.

In Norway ski-ing is learnt whilst at school. In winter but few troops are under arms, and consequently little is done of a military nature, but the Sports Union organizes races which are semi-official. There are two companies of cyclist-ski-men who use either means of locomotion, according to the time of the year.

In Sweden, as in Norway, much is carried out by sports clubs, but men in the infantry are also trained in the winter, *i.e.*, all officers (30 per regiment), 20 N.C.O.'s, and about 240 men per regiment.

In Russia ski training is much used and regular competitions officially organized in each military district. In the St. Petersburg district four men per company are regularly trained, as are also four to eight men per squadron, or sotnia, of cavalry. There are no official instructions as to the course, which is organized by officers regimentally.—(*To be continued*).

The review of the new *Felddienstordnung, 1908*, and the study of the Russo-Japanese War are continued.

In Austria a volunteer corps of motorists and motor cyclists has been recently raised. To belong to this "Motor-Korps," recruits must be Austrian or Hungarian citizens, possess a motor of at least 16-h.p., and a driving license. They get 15 crowns per diem for peace training and 1,000 crowns (£40) indemnity on the outbreak of war. Their preliminary training consists of three periods of 10 days per annum for four years. The motor cyclists must also be Austro-Hungarian citizens and possess a motor cycle of at least 5-h.p., or a small car of 8—14-h.p., or a light motor cycle of 1½-h.p. Their pay is 15 crowns per diem for small cars or six per diem for a motor cycle. War indemnity, 1,000 or 300 crowns, according to vehicle. They are organized by groups in military divisions. Both corps wear a grey uniform with yellow boots and gaiters, and carry a revolver and field glasses.

A light grey uniform has recently been adopted by the Austrian Army, a distinctive feature of which is that the officers' uniform is just like that of the men, with the badges of rank on the collar.

A grey-green uniform has also been adopted by the German infantry and experimentally by the cavalry.

A. H. SCOTT.

## Rivista di Artiglieria e Genio.

*September*, 1908.

New Regulations for Pioneers in Austria-Hungary.—*L'Armeeblatt* of the 3rd September has an article on the reorganization of the pioneers in the Austro-Hungarian Army. According to the new regulations the pioneer troops will consist of 15 battalions, numbered progressively 1 to 15. Each battalion in peace time consists of five companies, of detachments for a complementary company, and of an office for material (*Zeugreserve*). In addition No. 1 Battalion has detachments of submarine miners and pontoniers.

The pioneer battalions provide detachments at the disposal of the director of military works, and also for isolated services at the various establishments.

The battalions stationed in garrisons have their 5th company permanently detached, either in the forts or in their vicinity. The pioneers are instructed in the following technical services:—

(*a*). *For all the Companies.*—The construction of such works of field fortification as require the use of special tools; the construction and destruction of roads and works of communication of every kind; railway construction and the destruction of railways and bridges; all works relating to the employment of explosives; technical works of greater importance, which may be required for an army in the field, either in camp, in cantonments, or on the march.

(*b*). *For the First Four Companies of each Battalion.*—Construction of military bridges; works required for the attack of fortified places.

(*c*). *For the 5th Company of each Battalion.*—Works relating to the attack and defence of fortified places, especially with regard to obstacles, works of approach, and mines; the placing in a state of defence of fortified places; construction of military bridges to a limited extent.

The submarine and pontooning detachments receive special instruction according to their denominations.

A captain to each battalion is posted for special employment. He assists the commander of the battalion generally, and is also charged with the following details, viz.:—Giving instruction in the official schools of the corps and attending the collective instruction of the officers and cadets of the battalion; directing the school for non-commissioned officers; assuming the command of a company which for any reason may have been deprived of its title for more than four weeks. The captain for special employment ought not to remain in this position for more than two years, during which time he should take part in the exercises of the troops, whether military or technical.

The equipment of the pioneers consists of the infantry sword for the officers, for the cadets doing duty as officers, and for the quartermasters; repeating rifles (M. 95) with sword bayonet for all the men in the fighting line; revolvers (M. 07) for the officers, and cadets doing duty as officers, for the medical officers, and for all the non-commissioned officers armed with the infantry sword; the pioneer sword for the non-commissioned officer of stores, for the armourer, and for men detached on special service in peace times.

The organization of the pioneer troops is as follows :—

(1). For the first four companies of each battalion: 5 officers, 107 men.
(2). For the 5th company of each battalion: 5 officers, 104 men.
(3). For the office of stores: 1 officer, 9 men.
(4). For the complementary company: 2 officers, 7 men.
(5). For the detachment of submarine miners taken from the 1st Battalion: 1 officer, 28 men.
(6). For the pontoon detachments taken from the 1st Battalion: 5 officers, 105 men.

The complete strength of a battalion in peace time is 33 officers, 550 N.C.O.'s and men, and 11 horses. To provide the detachments of troops under the military works department the battalions also allot 32 N.C.O.'s and 110 pioneers. The pioneers allotted for special employment are distributed to the following offices:—War minister; inspectors-general of engineers and pioneers; inspectors of pioneers at Vienna, Graz, Linz, Budapest, and Cracovia; special military technical courses; military technical committee; camp at Bruck; military schools of instruction, etc.

The organization of the 15 pioneer battalions consists of 2 colonels, 5 lieut.-colonels, 8 majors, 85 captains of the 1st class, 36 captains of the 2nd class, 183 lieutenants, 152 sub-lieutenants, 30 cadets doing duty as officers. The superior officers, the captains, and the adjutant-major are mounted.

The inspector-general of pioneers—in addition to inspections—is entrusted with the direction of all the technical administrative service relating to the pioneers, the cadets' school, and the pioneers' parks. He is the consulting officer of the Minister of War, and gives advice on all questions relating to the pioneer services, their organization and technical instruction.

The inspector-general of pioneers cannot issue orders which would be contrary to the regulations; he can only repress errors or abuses which would be detrimental to the service and which he observes during his inspections. He especially assists at the more important technical exercises of the pioneers. He refers to the War Minister all questions relating to the promotion, transfer, and personal changes of the officers and cadets of the pioneer battalions.

At Vienna, Linz, Graz, Cracovia, and Budapest five inspectors of pioneers are stationed. Each of these inspectors has three pioneer battalions; at Vienna the inspector also has charge of the park. The companies detached from their battalions are inspected by the inspector of the district in which they are stationed.

In communications relating to the service the inspectors should not in any case constitute themselves as an intermediary organ between the superior officers and the pioneer battalions. It is their particular duty to exercise an intense influence on the instruction of the officers and cadets, and on the economic distribution and expenditure of war material.

REORGANIZATION OF GUNPOWDER AND EXPLOSIVE SERVICES IN FRANCE.—A decree dated 26th June established a new order for the services of explosives (*gunpowder and saltpetres*). All the establishments for gunpowder and explosive services are placed under the immediate direction of the Minister of War; their technical direction is entrusted to the corps of *engineers for powder and saltpetres*, assisted by a permanent *personnel* of *technical agents for powder and saltpetres*. The powder manufactory at Bouchet alone remains under the direction of artillery officers.

The inspectors-general are charged with the permanent inspection and surveillance, and have access to the minister charged with administration.

The inspectors-general present to the said minister all the proposals and requirements relating to the *personnel*, the machinery, and the maintenance of the establishments under them. They compile every year a report on the general working of each establishment.

In the case of a fire or an explosion, the inspector-general is called by telegraph and proceeds to the spot and institutes an enquiry.

Each establishment has a chief director, who corresponds directly with the minister. He is entrusted with the direction of the works, the *personnel*, the administration, and the supply of material. He is also responsible for all matters which concern the sanitary services of the establishment.

There are also engineers, pupil engineers, and technical agents who direct, and are responsible for, the several works. They arrange for the placing of the material in the magazines of the establishment, being careful to return any surplus; they have the disciplinary surveillance of the workmen, and are not allowed to make any alterations in the works entrusted to them without the sanction of the director.

The service of the establishments is administered by a *council of administration*, which is composed of the director as president, the managers as members, and a special agent who performs the duties of secretary, but has no vote. The council makes and verifies the contracts in writing, and controls the payments and proposals for new expenditure. The duties of accountants are performed by special agents who have completed at least 15 years' service in the establishment. A technical agent performs the duties of accountant of stores, and is specially charged with the duties of registration, consignment, and consumption of material.

All the services relating to the powder and explosives establishments are under the surveillance of the corps of administrative control of the army, according to the law of 16th March, 1882. An impending ministerial regulation will determine the rules for service in the establishments.

*October*, 1908.

INFLUENCE OF DIRIGIBLE BALLOONS ON THE ART OF WAR.—The following extracts are taken from an article published in the *Internationale Revue* (Supplement 112), and deal with the services which dirigible balloons may render to the commander-in-chief in war time.

"War," says Clausewitz, "is the region of the uncertain." Three-fourths of the actions on which war is based are always found in a mist of uncertainty more or less great. And, indeed, the experience of war teaches that the issue of events is nearly always different to that which at first we are able to foresee. In any case, those who can make their dispositions so as to surprise the enemy have much in their favour.

Now, it may be asked, if the art of war may not be modified, and if, to use the words of Clausewitz, the clouds may not be dispersed by the use of dirigibles. Under the modern conditions of the industry, the dirigible balloons, with systems rigid and semi-rigid, are able to make voyages of several hours, and, under favourable conditions, are able to explore distant regions.

While the dirigibles still require to be much improved, it is certain that in a few years they will be provided with more powerful mechanism, and at the commencement of hostilities they will pass the frontier to observe the massing of the enemy's armies, and by means of visual signalling or by wireless telegraphy will transmit notices of the results of their observations. The long columns of troops and of wagons which traverse the great high roads, the trains which pass rapidly along the lines of railway, the crowds on the bridges, and the concentration of great masses of troops, will none of them be able to escape the observation of the occupants of the car.

Firearms will not be a sufficient guarantee against this kind of exploration. The balloon is difficult to hit because it travels rapidly and changes its altitude in a few minutes. Neither rifle bullets nor shrapnel can cause very serious damage; the small holes made in the balloon by such projectiles cause only such a slight escape of gas as not to diminish the ascent to any serious extent. The chances of the balloon being struck by artillery projectiles, other than shrapnel, are so slight that they need scarcely be considered.

It must not be thought that this new means of exploration will render the task of the officer in command any easier, or that he should rely on the intelligence derived therefrom to an extent which would weaken his efforts. Now that the commanding officer cannot hope to surprise his adversary he should be prepared, with greater care and with a wider view, for any eventualities which may present themselves. Any error will be all the more serious because the enemy will not be ignorant of what has happened. Any omission on the part of the chief in command, any error of an officer of lower grade, will be known in sufficient time to enable his adversary to derive profit therefrom. War will no longer be a game of cards, but will rather resemble a game of chess—with this exception, that the number and value of the pieces will differ.

The same argument is discussed in the periodical *Vierteljahrshefte für Truppenführung und Heereskunde*, in which the General, von Blume, expresses his views that dirigibles will play a very important part in future wars, especially as regards observation. It may happen that the first lines may not be perceptible, but this will not be the case with the reserves, and the knowledge of their positions is of primary importance, because of the possibility of deducing therefrom the time, etc., of their intervention. These important masses of troops cannot escape the observations of the balloons, which will be able to communicate the results either directly, or by wireless telegraphy.

The General concludes by arguing that such a state of things will confer great advantage on the defensive, since the offensive will be deprived of its ability to surprise, which is one of the principal assets of success.

*La France Militaire* however expresses quite a different opinion, asserting that inventions of this kind, as well as nearly all progress in arms and armaments, are for the advantage of the offensive.

It is not sufficient for an army to be aware of a danger which may be in front of it, and in fact when a dirigible may signal the formation of an important mass of the enemy's troops and the commencement of its movement in a given direction, it may be too late to provide against it.

In order to be prepared at the precise moment, the intentions also of the enemy should be known, so that troops could be set in motion to defeat any object some time before it is on the eve of execution.

It will probably however be easier to organize the offensive owing to the information furnished by the dirigibles about the reserves of the defending troops, whose movements are, of course, dependent upon the intentions of the attacking force. By a simple calculation, the attack may so be able to direct its masses that the enemy may not have the time to reunite and concentrate the force necessary for confronting them.

In conclusion, the advantage seems to be with the offensive, because the dirigible allows of the attack being opened in a direction in which the dangers have been well weighed, and against an adversary who is forced to remain on guard along his entire front.

BULGARIA.—*Distribution of Mitrailleuses.*—*La France Militaire*, of the 17th October, notifies that the 144 Maxim mitrailleuses, ordered in Germany for Bulgaria, were distributed in May last to 36 infantry regiments, in each of which a company with four mitrailleuses has been organized.

A captain and an armourer—who have undergone a special course of three weeks at the arsenal at Sofia—are assigned to each infantry regiment. Besides the above mentioned, a certain number of officers for foreign service have been through special fire courses in Russia or Austria.

Before the end of the year the officers who have attended these courses, and who are intended to take command of a mitrailleuse company, will have instructed their *personnel*, consisting of two non-commissioned officers and four privates taken from each company of a regiment.

The strength of a mitrailleuse company, for two pieces only, will consist in time of peace of 2 officers, 4 non-commissioned officers, 20 men, and 12 horses per company. In war time however the companies will each have four pieces, and will form an integral part of an infantry regiment.

GERMANY.—*Automobiles for following Dirigible Balloons.*—The review, *Le Génie Civil*, extracts from the *Practische Maschinen Konstr.* of the 2nd July the following regarding an automobile designed for chasing dirigibles constructed at the *Rheinische Metallwaren und Maschinenfabrik* of Dusseldorf.

This motor, of 50 to 60-h.p., has an average velocity of 45 km. per hour. It has an armoured shield and a revolving quick-firing cannon of 5 cm. on the Ehrhardt system. The carriage, with the cannon, the ammunition, and five men, weighs 3,200 kg.

The cannon throws a grenade and a shrapnel shell, with velocities respectively of 570 and 450 mètres. The shrapnel has a charge of 40 g. and contains 128 bullets; on explosion the shell also gives 27 splinters.

The projectile is furnished with an after-effect mechanism graduated to 4,200 mètres and joined with a system of fins or blades working by centrifugal force, and which are intended to increase the laceration in the envelope of the balloon.

The greatest range is 7,800 mètres, corresponding to an angle of fire of 43°; the greatest ordinary trajectory is 2,500 mètres.

EDWARD T. THACKERAY.

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## VOËNNYI SBÓRNIK.

NOTES ON THE ARTILLERY DEFENCE OF PORT ARTHUR (*continued from February*, 1907).—This article gives a detailed account of the nature and distribution of the guns in Forts I. to III. and intermediate works at Port Arthur.

Some of the remarks made on details of construction may be ot interest.

The most serious defect in Fort II. (North Keikwansan), was the fact that the glacis was not commanded by fire from its own guns, nor from guns in any of the neighbouring works. This enabled the Japanese to get a foothold on the glacis during the August assaults, and they stayed there for 1½ months.

An apparatus was devised for throwing mines amongst the Japanese working on the glacis. The projectile was removed from the cartridge of the 47-mm. (1·85") gun, and in its place a small lead cylinder the exact size of the bore was inserted to act as a gas check; the cartridge was loaded from the breech in the ordinary way. A long staff with a mine fastened to the end of it was then shoved down the muzzle. When the cartridge exploded the lead cylinder drove the staff with the mine attached out of the gun. The greatest range obtainable was about 200 paces. The passage of gas past the lead cylinder sometimes caused the mine to explode prematurely, always with disastrous results.

Fort II. had double-storied concrete barracks along the gorge blinded with earth. The arches of the roof were about 3′ thick. Whenever a large shell struck the roof it penetrated about 1′; the remaining 2′ of thickness were shattered and a large slab of concrete, together with the shell, fell onto the floor of the barrack room below. The fuzes of the shells were not sensitive enough to explode on the first shock, but were sufficiently so to go off when the shell landed on the floor.

In one of the numerous intermediate works the magazines were roofed with two rows of 18″ square baulks placed crosswise, with two 1″ iron plates on top of them, and 3′ 6″ of earth over all. This covering was proof against all shells except those from the 11″ howitzers.

In a neighbouring work, the roofs, which were made similarly but without the iron plates and with 1′ 9″ of earth, were pierced by all shells, even those from field guns.

THE EFFICIENCY, FOR DEFENCE, OF FORTRESSES DURING CONSTRUCTION.—This article in the September number of the *Voěnnyi Sbórnik* is briefly to the following effect:—

The time taken in building a fortress is usually considerable, and is governed to a great extent by the amount which the State is prepared to spend annually on its construction. There is always a possibility of war breaking out before any works of much defensive value have been completed, although much earth may have been turned up.

History gives us many examples to show that half-finished fortifications are better than none at all, *e.g.*, Sebastopol, Viksburg, Belfort, Plevna, and Port Arthur, but it is wrong to suppose that permanent works are no longer a necessity. If a large garrison is required in a permanent work, a larger one still would be wanted in a temporary work intended to fulfil the same object. The losses of troops behind permanent works are always smaller than those of troops in semi-permanent works, whilst the losses in the attack are correspondingly larger. For example, the garrisons of "temporary" Sebastopol and of "semi-permanent" Port Arthur were practically the same—about 40,000 men; the average losses during one month of siege were, in the case of Sebastopol, 9,000 men in the defence and 5,000 men in the attack, and in the case of Port Arthur, 4,000 men in the defence and 20,000 men in the attack. If the defences of Port Arthur had been of a permanent nature the difference would have been still more marked.

The problem is how the defence of a strategical point can be carried out, so that, in the event of war breaking out before it is completed, the works already constructed will be of the greatest possible defensive value. The answer is that the system of construction should be one of successive stages, in accordance with the following conditions:—

(1). At the end of each stage the works should be completely defensible, and answer the tactical and strategical requirements.

(2). The period in which each stage is constructed should be as short as possible.

(3). Each portion of a work during construction should be capable of being improved without injuring the efficiency for defence of the whole.

(4). The most important portion of each work should be begun first.

(5). No single work in the main position should be left entirely untouched.

When it has been decided, in connection with any strategical point, which position is the one to be defended and where the works are to be, it remains to determine what portion of each work should be started first.

Four main ideas have to be considered—communications, field of fire, cover, and obstacles. The first two are virtually disposed of when the site for the work is selected. As regards the other two, it is well known that a defender's losses are mostly caused by shell-fire during bombardments, and the existence of bombproof barracks is therefore of primary importance. The losses in Sebastopol per 40 lbs. of shells discharged by the enemy were, before and after the construction of bombproof casemates, as 10 to 2 respectively. The presence of obstacles has the effect of keeping the attacker longer under the fire of the defender, forces the attacker to make special efforts to destroy them, and also acts indirectly in favour of the defender, who, knowing that his obstacles are good, does not expose himself in so great numbers as he otherwise would do, when an assault is being made. In Sebastopol there were enormous losses among the reserves, who had frequently to be kept concentrated at threatened points. Bombardments last as a rule much longer than assaults; good casemates are therefore of much greater importance than obstacles. Besides, there is no better obstacle nowadays than a rapidly developed and overwhelming fire, and this can only be counted on when troops are safely housed till the last possible moment in casemates in close proximity to the parapet. It follows therefore that the first portion of a fort to be constructed should be the bombproof barracks.

This fact has long been recognized in Germany, and is evidenced by the fortifications at Breslau, Marienburg, and Grandenz, which consisted of lines of bombproof barracks for infantry, surrounded, in the last two cases, by simple field parapets.

Russian practice is introducing an essential improvement on the German, in that the casemates are to serve not only as safe dwelling-places in time of war, but as barracks in time of peace.

Simultaneously with the construction of casemates, works of low profile, capable of being developed into something of a more permanent nature, would be thrown up.

In the October number the writer gives an example of a fort, which he has designed, capable of being constructed in three years in several successive stages. The bombproof barracks are first built; they are reckoned to hold 126 men in peace time and 300 in war. At the same time a low field parapet is thrown up round them.

By successive stages the parapet is increased in size, the ditches deepened, caponiers added, etc., until at the end of the third year the fort is complete with counterscarp galleries, tambours, palisades, and countermine galleries.

At the end of each stage in its construction, the fort has been rendered capable of defence in a degree proportional to the time and money spent on it.

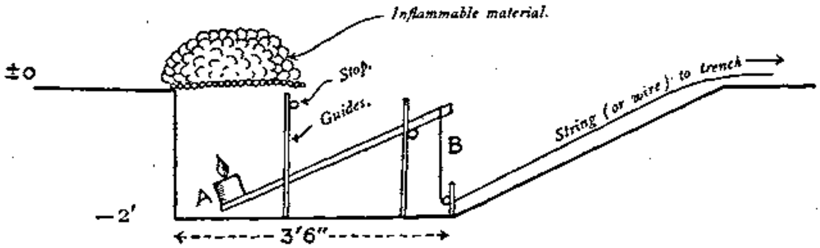
A. H. Bell.

## *CORRESPONDENCE.*

### A MECHANICALLY OPERATED FLARE.

DEAR SIR,

Colonel Roper, in his article dealing with the defence of a position at night, referred to the use of mechanically operated flares as an adjunct to obstacles. The following is a brief description of one which was tried in 1907, with perfect success, on the annual fieldworks course of the 21st Company.




A lamp A is fastened to the end of a stick arranged as shown in the diagram. A string B is fastened to the other end of the stick, is brought round a smooth horizontal piece, and thence led away to the fire trench. Inflammable material is laid above, and so arranged that when the string is pulled the flame of the lamp is lifted into the midst of this inflammable material. A jam or tobacco tin makes a first-class lamp, and the whole arrangement comprises nothing which cannot be usually found on the spot. The lamp is lit at dusk and should burn through the night. Nothing can be seen from the front, and there is nothing to get out of order. The details of this flare were explained to me by Major Dobbie, of the Indian Army, who informed me that it had been made by native troops on manœuvres.

Yours faithfully,
W. G. S. DOBBIE,
*Capt., R.E.*

The Editor, *R.E. Journal.*

# PLAN OF VERANDAHS, S.W. CORNER OF No. 21, MARRIED QUARTERS, NEW B.I. LINES, AHMEDNAGAR.



SHOWING DETAILS OF FERRO-CONCRETE WORK.

*Scale for Ground Plan, Front Elevation Side Elevation, and Cross Section—3.3" to 1"*

*Scale for Details—15" to 1"*

*NOTE.—The dowels, shown as ½" diameter and jagged as lewis bolts, are more conveniently made of ⅜" steel rod, not jagged, but bent slightly to act as spring, so as not to fall out of holes. These dowels to be bedded in cement mortar, flushed into the holes.*

## MOULDS FOR FERRO-CONCRETE BRESSUMMERS. PLATE II.

*Scale— 15' to 1".*

Fig. 1.

### Mould Ready to Receive Armour.

— Plan. —

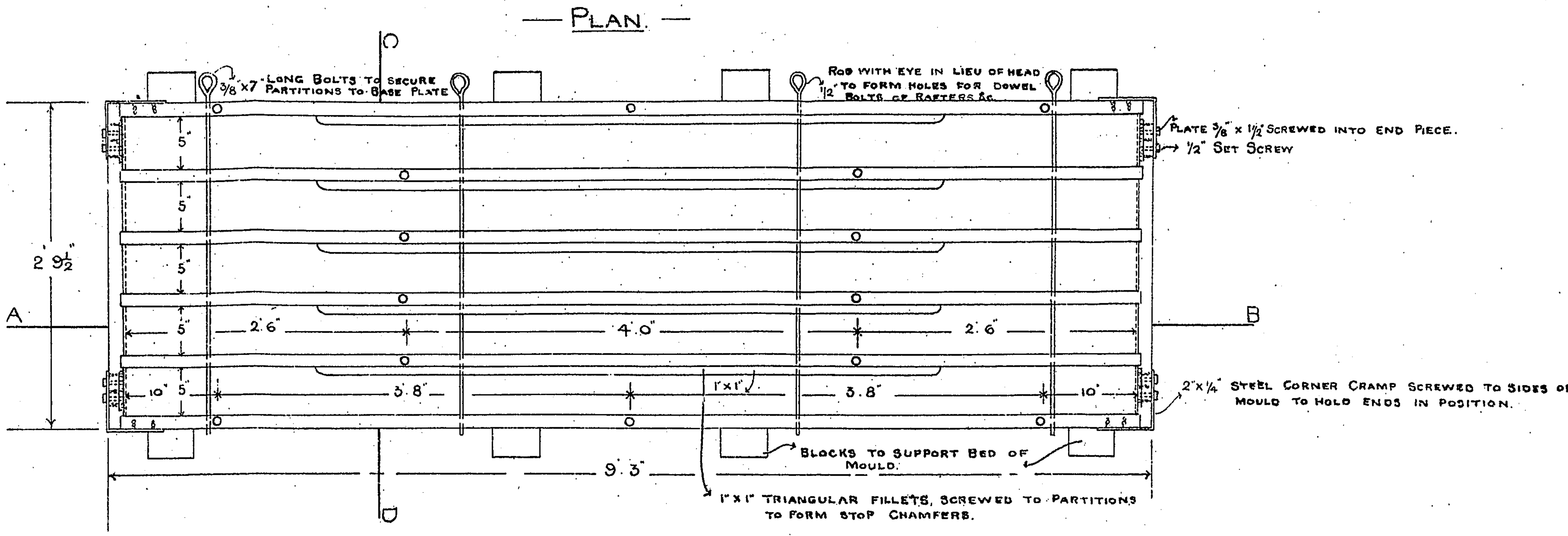



Fig. 2.

### Section on A.B.

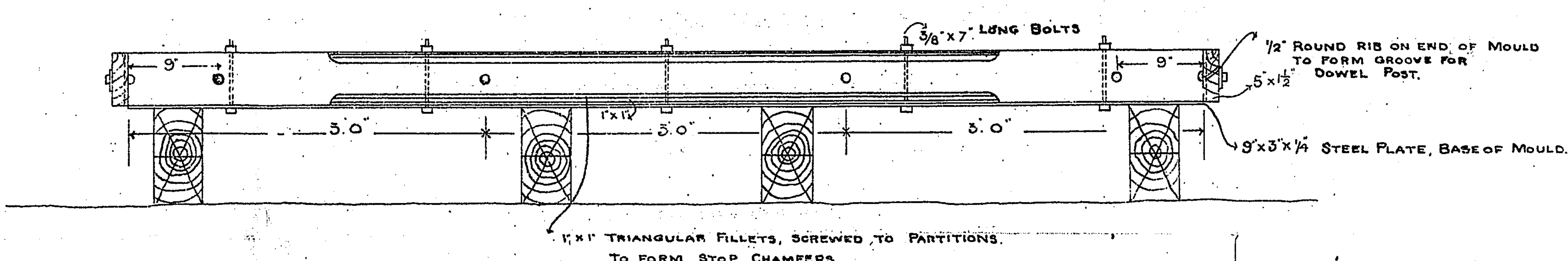



Fig. 3.

### Side Elevation

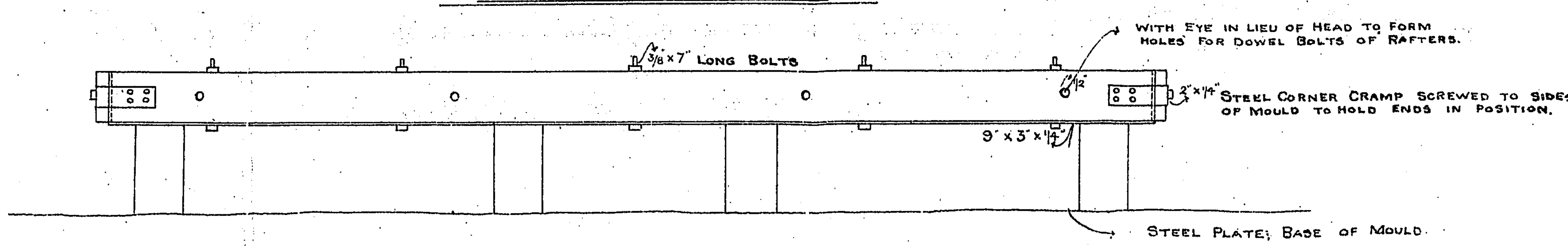
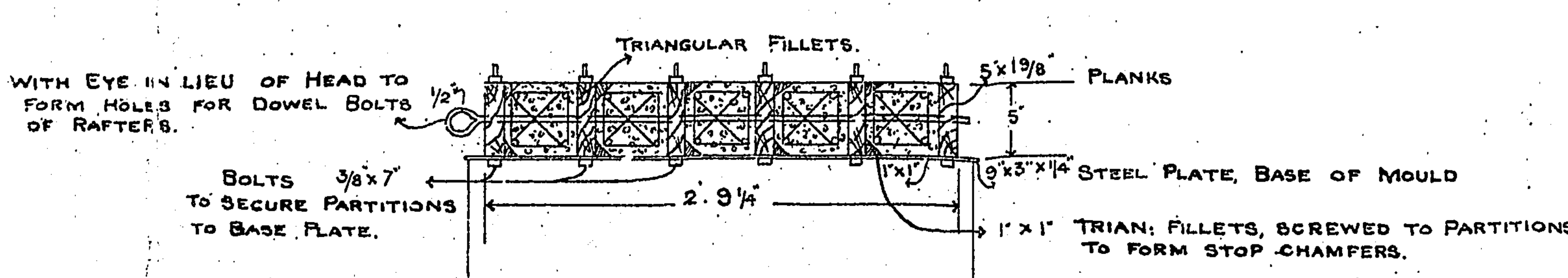



Fig. 4.

### Section on C.D. showing Mould filled.



SEWAGE DISPOSAL WORKS FOR A SMALL TOWN

SECTIONS.

PLATE II.

# MOULDS FOR FERRO-CONCRETE RAILING POSTS AT EAST RIDGE, AHMEDNAGAR.

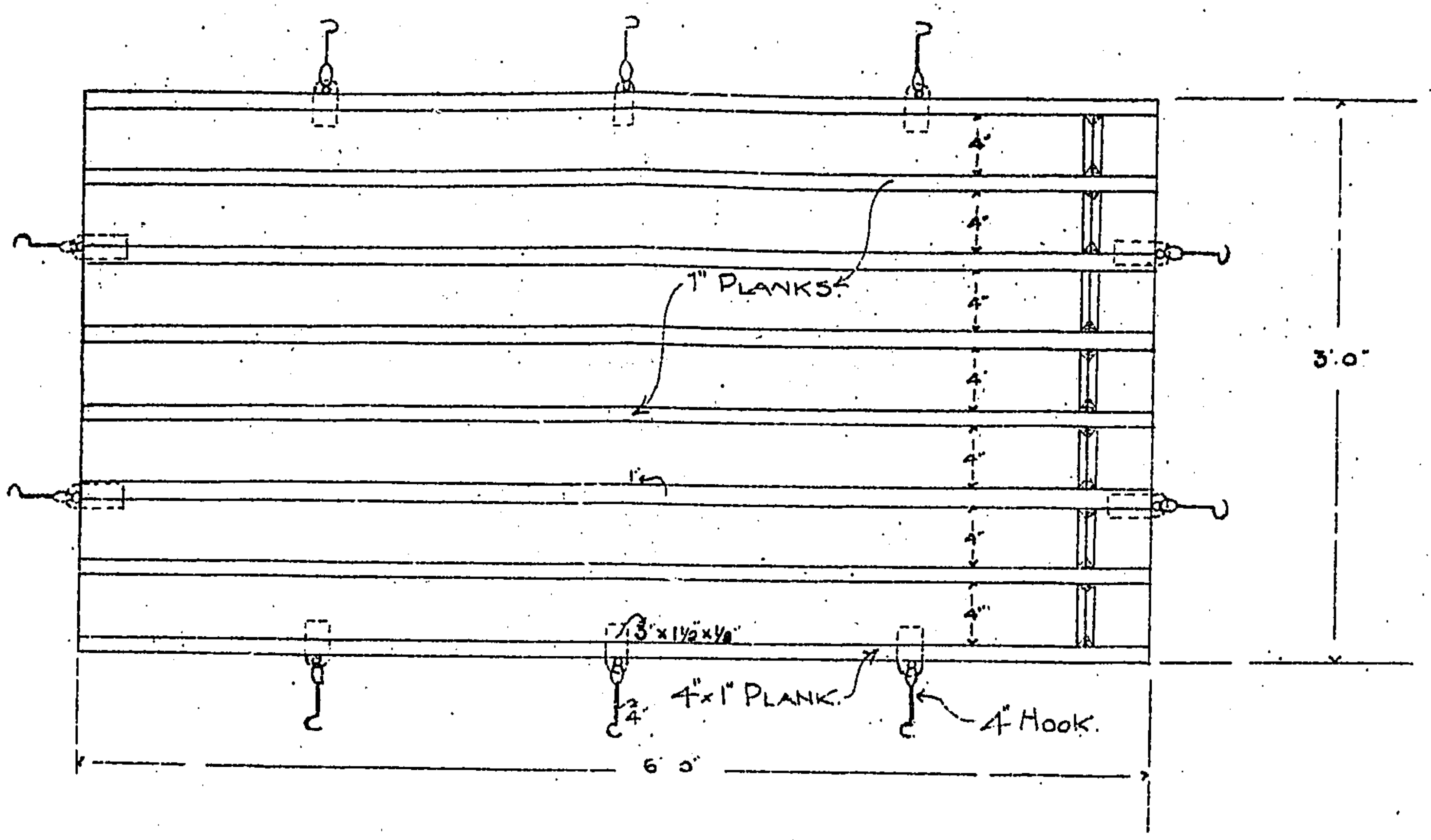
PLATE I.

*Scale—16" to 1" for Figs. 1, 2, 3, 4 and 6.* *Scale—8" to 1' for Fig. 5.*

## FIG: 1.

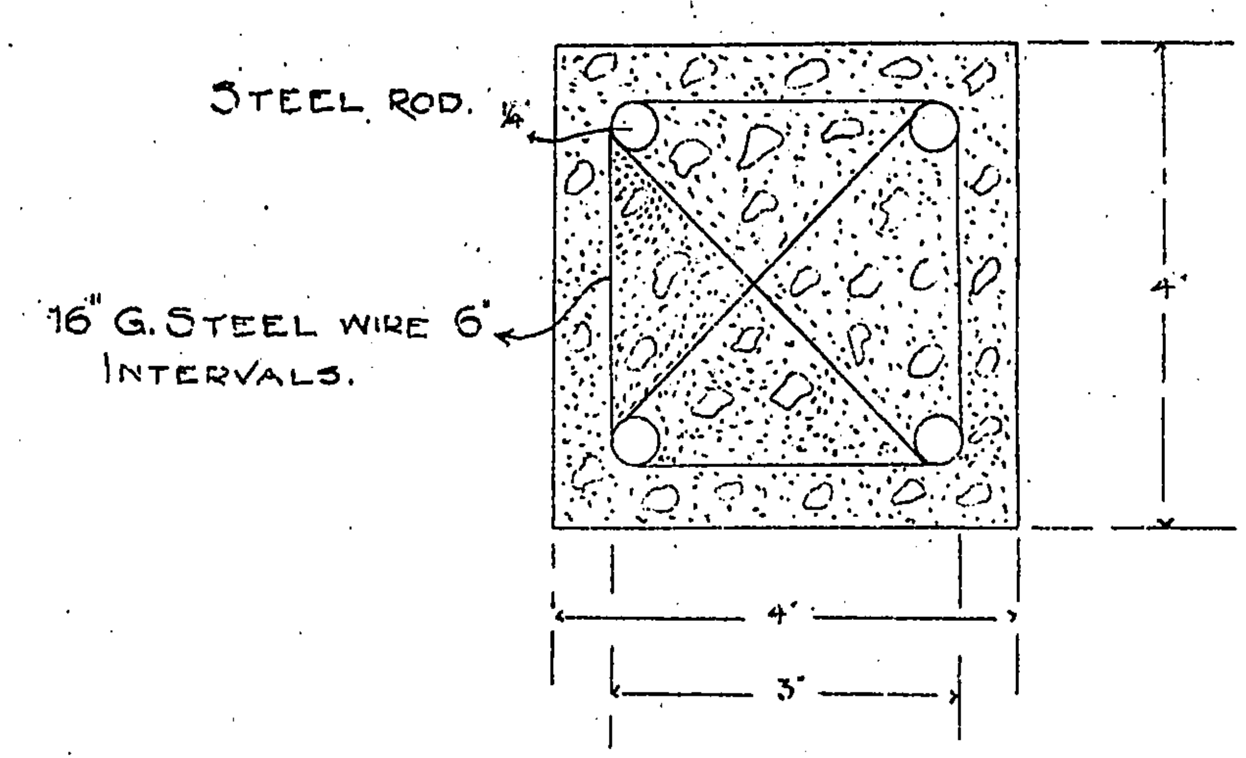
### PLAN OF STEEL BASE PLATE

SHOWING ARRANGEMENT OF PARTITIONS, ENDS REMOVED.




## FIG: 5.

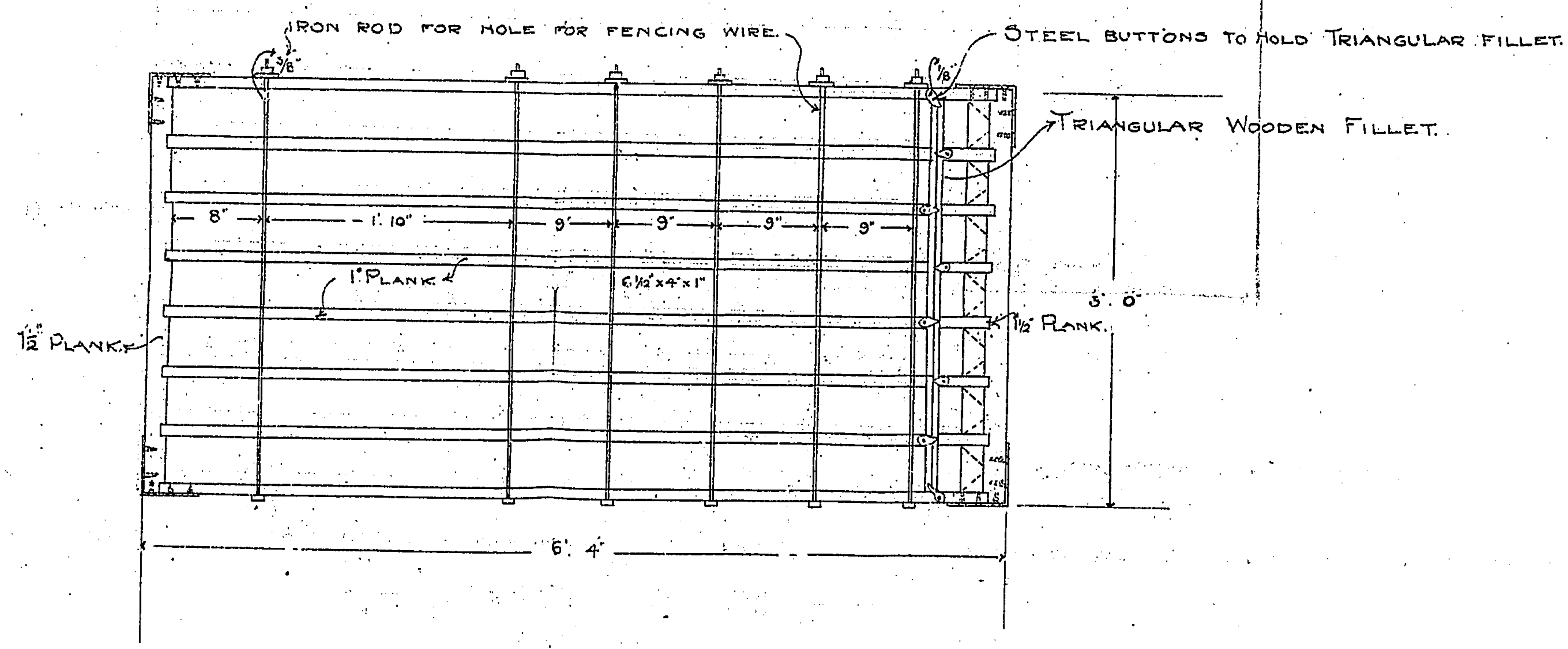
### SECTION OF POST.




NOTE—PARTITIONS MAY BE HELD SECURE DURING RAMMING BY BOLTS THROUGH BASE PLATE.

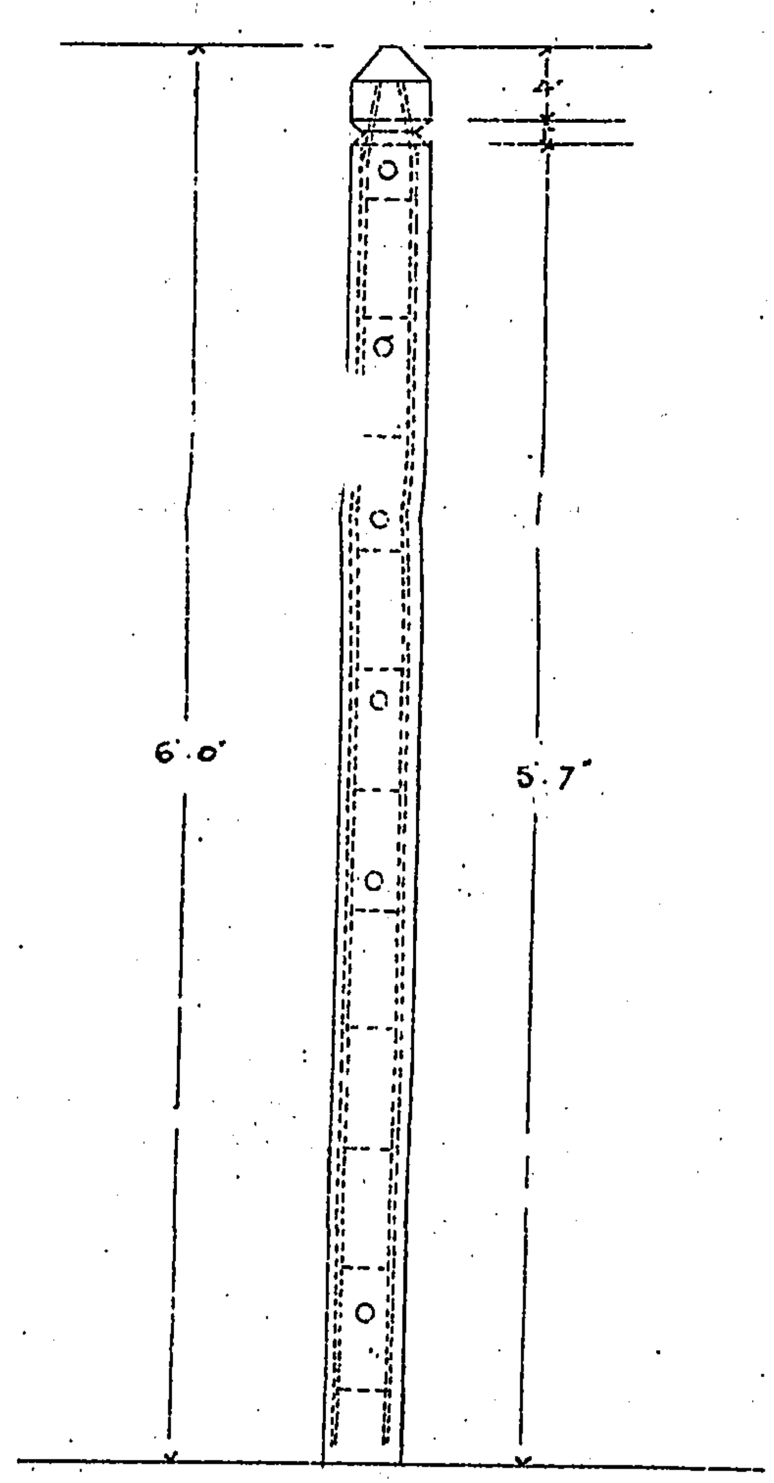
## FIG: 2.

### PLAN OF MOULD.



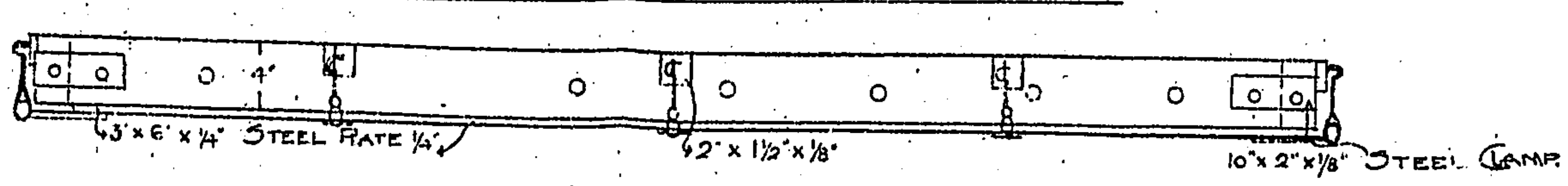

## FIG: 6.

### ELEVATION OF POST.



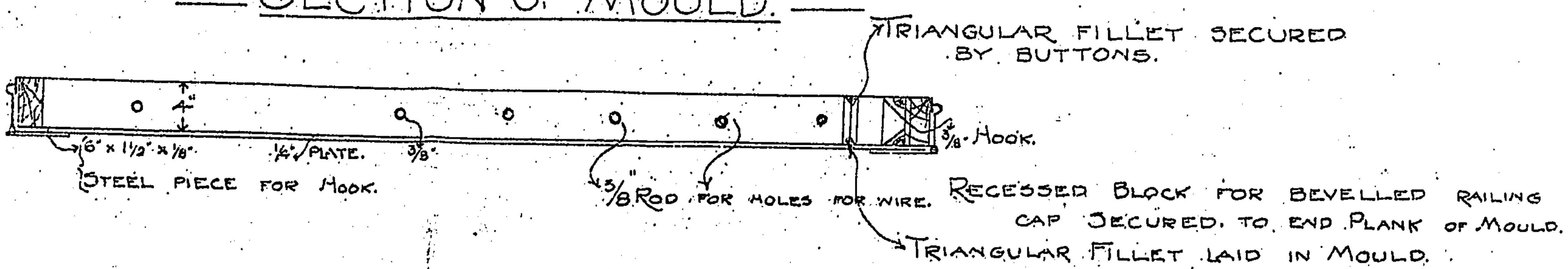

## FIG: 3.

### ELEVATION OF MOULD.




## FIG: 4.

### SECTION OF MOULD.



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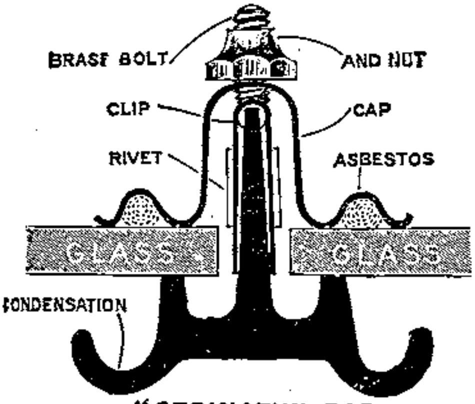


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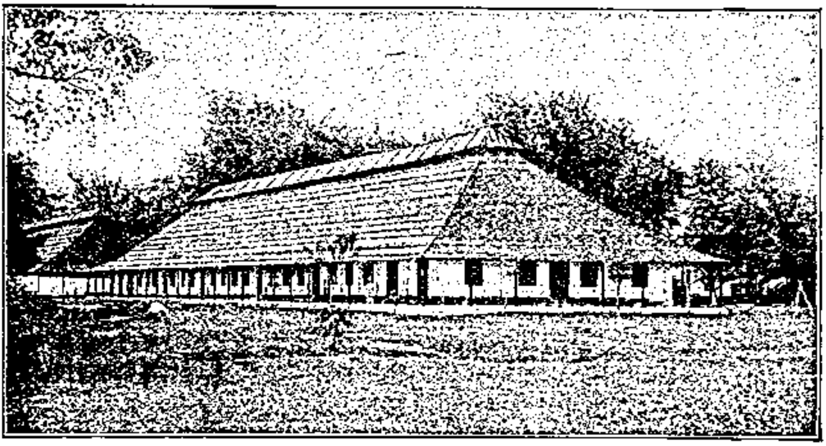

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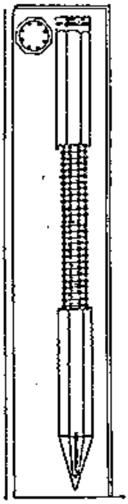

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