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Constructed by 2nd Q.O.S. & M.

SINGLE PIER SUSPENSION BRIDGE

SINGLE-PIER SUSPENSION BRIDGE.

By BT. MAJOR R. L. McCLINTOCK, D.S.O., R.E.

IN the Bridging Manual (*M.E.*, Part III.) no direct reference is made to the "Single Pier" variant of the Suspension Bridge, *i.e.* the suspension bridge with a pier at one end only. Occasions may, however, arise when this type can be most usefully employed.

If a gap to be bridged lies between banks of about the same level, the ordinary two-pier suspension bridge would naturally be used; but if one bank is much higher than the other, the Single Pier variety can be substituted, and further, the higher bank can be utilized as the pier, thus entirely obviating the necessity of an artificial one at all.

The following diagrams exemplify two possible cases :—

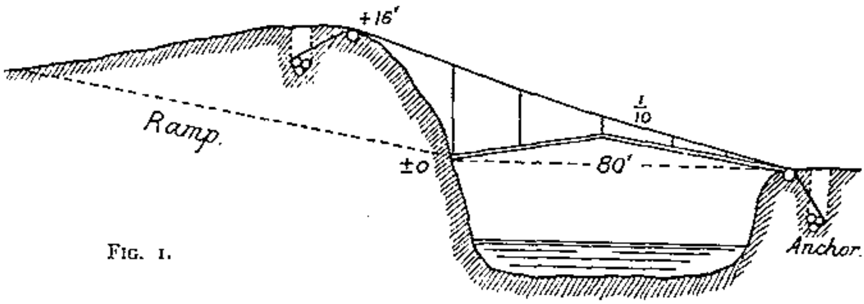


FIG. 1.

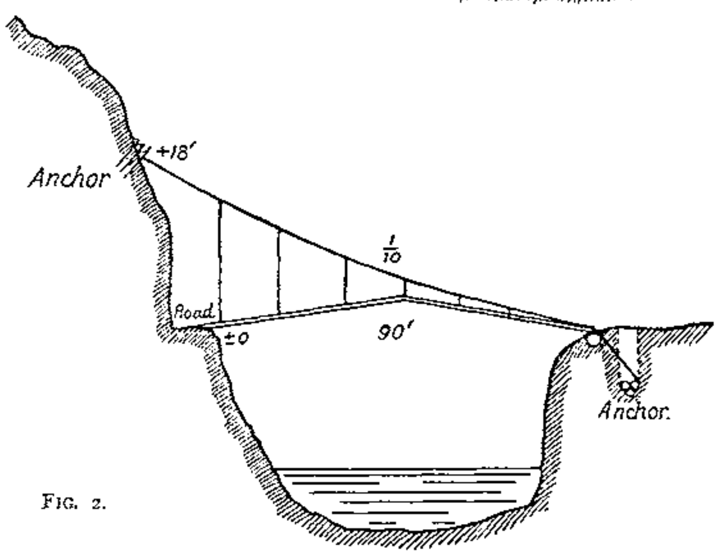


FIG. 2.

Fig. 1 represents a river with soft banks, one higher than the other. Material not being available for piers, the river is crossed on the single-pier principle, the road being brought down to the bridge level by a ramp.

Fig. 2 represents a ravine in the mountains. A road hitherto running in a cutting along the side of a high cliff has to cross to the other bank. The single-pier principle is again utilized in the construction of a bridge.

Being anxious to get some information as to the facilities or otherwise of construction, and advantages or the reverse of this single-pier type, I recently carried out the experiment of constructing such a single-pier suspension bridge of 140 ft. span. Unfortunately a gap with one bank higher than the other was not available, so one wooden pier had to be used instead; the principle, however, is identical.

The attached photographs show the bridge from each end.

The details of the bridge were :—

Span, 140 ft.
Dip, 1/10.
Camber, 1/30.
Pier, 28 ft.
Number of bays, 14 of 10 ft. each.
Load, roadway, 90 lbs. ft. run.
„ Infantry in file, 420 lbs. ft. run.
Total load on bridge, 32 tons.
Cables: three 3-in. steel cables stopped together with wire at 1-ft. intervals on each side of bridge.
Anchors: (*a*) at pier end, three 12-in. diam. logs 12 ft. long, sunk in ground 2 ft. to upper side of log; pull in this case at 1/2·5; (*b*) at non-pier end, three similar spars, but sunk 3 ft. to upper side of log, the pull coming in this case at 1/1.

This bridge was calculated for throughout and treated generally as half a bridge of double the span, *i.e.* 280 ft.

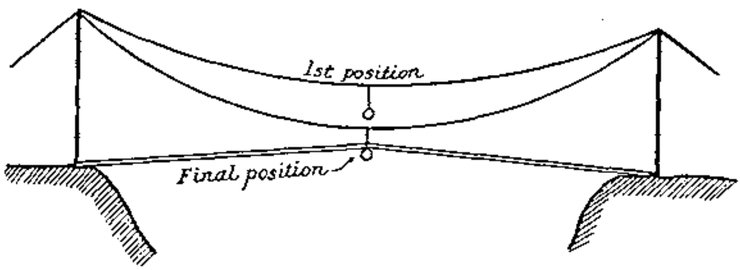
REMARKS.

The construction of this type proved just as easy as that of the ordinary two-pier pattern, with the exception of one item.

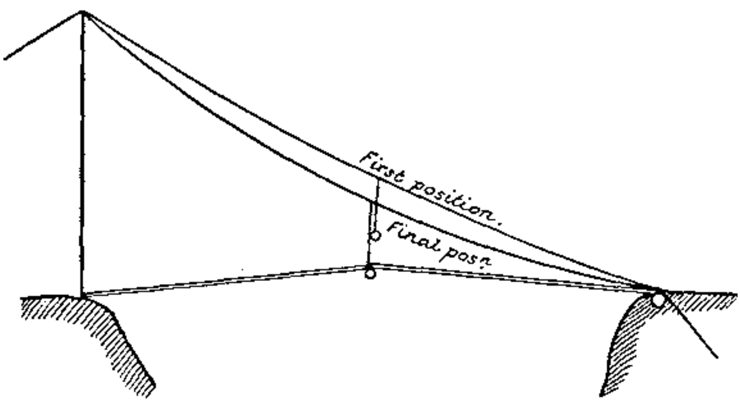
In the ordinary bridge it is usual, when making fast the cables to the anchorages and before putting on the slings and roadway, to haul up the cables a further empirical amount beyond the calculated dip. The *Manual* suggests that a 1/10 dip should be hauled up till it is 1/11; but I find that 3 ft. in 140 works out about right. This difference is to allow for (1) the cables stretching and (2) anchors, etc., 'coming up' a little as they take their bearing under the stress of the load. If the cables are therefore hauled up until the centre transom is the necessary 3 ft. above what ought to be its final position, the bridge when loaded usually settles down to its calculated place.

In the case of the two-pier bridge this extra hauling up is quite simple, as the centre transom hangs from the lowest point of the parabola of the cable, and there is the whole of that large bight to draw from. In the single-pier bridge, however, the centre transom does not hang from the lowest point of the cable, for that is fixed at the shore transom. It hangs from a point on the parabola vertically above the centre point of the span, and owing to there being much less slack available to draw against, a far greater effort is required to raise it the additional 3 ft.

The following diagrams will explain this difficulty more clearly :—



Two-Pier Bridge.



Single-Pier Bridge.

In spite of the above difficulty, the single-pier suspension bridge is often likely to prove extremely useful; and it has one additional advantage over the two-pier pattern in that it is a good deal stiffer when completed, especially at the non-pier end.

SOME CONSIDERATIONS ON HOME DEFENCE.

By MAJOR F. G. FULLER, R.E.

COLONEL HICKSON, in two interesting articles in the March and July numbers of the *R.E. Journal*, invited discussion on a subject which closely concerns us as Royal Engineers, namely that of defending our coasts. In these articles the author advanced some very revolutionary ideas, which, if accepted, would necessitate the complete recasting of our system of Coast Defence.

The subject has always been extremely controversial, and one on which, as 'Forts' said in his contribution, "individuals should have liberty to theorize." On the other hand, in considering a new theory, it is very advisable that we should have a clear conception of the considerations which have led to the adoption of our present system, and we should also be on our guard against any natural bias which we, as Engineers, may feel in favour of fixed defences. It is intended in the following remarks to give a short outline of some of the conditions, many of them peculiar to this country, which govern the scale of our defensive preparations.

The first point we must always bear in mind is, that we are dealing with the defence of an Empire not that of a Kingdom, and that the problem of defence therefore is not a local but an Imperial one.

The Empire has more than once been aptly compared to the human body, with its heart in the United Kingdom and its limbs spread over the different portions of the globe. Its arteries follow the trade routes, and must be looked upon as an integral part of the system, for though a blow at the heart deals the Empire its most vital injury, it can equally be destroyed by severing its numerous members and by cutting its arteries.

Thus an effective system of defence must protect the body as a whole, and not merely act as a shield to protect the heart.

No one will dispute the fact that the protection of the various portions of the Empire and the trade routes connecting them can only be effected by means of a preponderating Navy. As this is the first essential, we should enquire, before considering any local means of defence, to what extent the Navy affords protection to the locality under consideration.

We are at present concerned with the protection of the heart and its converging arteries of communication. These can only be safe while we hold command of the sea in home waters; and thus it is necessarily a fundamental principle of Admiralty policy that sufficient force shall at all times be maintained in home waters to ensure the command of those seas.

Moreover, it has for very many years been the accepted policy of the Navy to assume the offensive on the outbreak of war—to seek out the enemy's fleet and to destroy it, for it is upon this principle that command of the sea is established and maintained, and thereby protection afforded to the body of the Empire as a whole.

It may at first sight appear that the two principles of Naval policy enunciated above are contradictory, but a little consideration shows that this is not so. If the bulk of our Navy concentrates against an enemy's main fleet, wherever it may happen to be, a very small naval force will provide a sufficiency of power to maintain the command of the sea in home waters; for it would obviously be fatal to an inferior Naval Power in touch with our fleet to make a detachment of any considerable size in order to threaten our supremacy in the Channel.

If we are fighting the navies of allied Powers the question is not quite as simple. But the principle remains—that as long as we can maintain a superior naval force at sea, the only chance the allied fleets have is in concentration, and therefore the only detachments we need expect them to make will necessarily consist of vessels incapable of taking their place in the line of battle.

To summarise the conclusions;—A preponderating Navy is essential to the existence of the Empire, and the first principle of its action must be a vigorous offensive to maintain the command of the sea in home waters.

This command of the sea precludes an enemy from launching an extensive oversea expedition against our shores, and so obviates an expensive system of coast defence to protect us against actual invasion.

It may be argued that the fleet may be annihilated and that we should have a second line of defence, a coat of mail in fact, to protect the heart of the Empire should our weapons of offence be shattered. The answer to this is, that money is better spent in increasing our naval force, so as to render the British Isles absolutely secure and at the same time afford protection to the whole Empire, rather than on an elaborate system of fixed defences that would only shield one portion of the whole, however vital that portion might be.

If, however, the Navy is to assume the offensive against the enemy's main force, it is necessary that our fleets should concentrate, and for this reason it is not possible for the Navy to prevent small hostile naval detachments from reaching our shores. These detachments might damage us either by delivering a naval attack upon our coast fortresses or ports or by a landing attack in the nature of a raid. Hence the conclusion arrived at is, that our defensive measures on the coast need only be such as are required to protect us against these forms of attack.

From these considerations it is possible to determine the scale upon which our Coast Defences should be designed.

First and foremost, our Naval bases and strategic harbours must be rendered absolutely secure: it is unnecessary to elaborate this principle.

Next, as regards any other special point upon the coast, the scale of defence should be based on an estimate of the amount of damage it is necessary to inflict on an enemy to deter him from attacking that particular spot, having in view the importance that he may attach to the objective, either on account of its value to us or of its potential value to himself. It is upon this estimate and upon the extreme value that an inferior Naval Power must place upon its armoured ships, that the scale of armament of our ports has been based.

With regard to the general run of the coast line, it is difficult to see what an enemy could hope to gain by landing a small force at any of the numerous places along the shore where such a landing is practicable. Our method of meeting such a contingency should be by means of mobile troops, which would also be available for offensive action should our command of the sea become absolute. It should not take the form of an expensive cordon of coast defence batteries, which would only be available for the specific object for which they had been erected.

If these arguments be accepted, we are forced to the conclusion that a continuous system of end-to-end Coast Defence would be superfluous and, far from being economical, would be costly and unjustifiable.

I am afraid most of these remarks will be considered platitudes, for they have often been advanced, and with most of them no doubt Colonel Hickson will most heartily agree. The point where our arguments diverge, and from which we arrive at diametrically opposite conclusions, is the purely naval question as to the extent to which our fleet will be tied to our shores in order to maintain command of the sea in home waters. Colonel Hickson bases his argument, that a continuous system of Coast Defence would be economical, upon the assumption that the Navy requires to be liberated for offensive action overseas and, presumably therefore, that it is tied to our shores for defensive reasons.

This assumption cannot be justified. It has been the accepted naval policy, certainly since the time of Nelson, to assume the offensive on the outbreak of war; and we have been given no hint that the Government or the Admiralty contemplate any change of policy in this respect.

History teaches us that almost all great naval victories have been won by a vigorous offensive, and naval writers never cease trying to drive the lesson home to us.

Thus Mahan quotes Monk as having set the keynote of English naval policy with the words "The nation that would rule the sea must attack." He also quotes a speech in Parliament by Pitt, in which the great leader says "Defensive war is the forerunner of certain ruin." That is to say, both our tactics and our strategy must be offensive and it is the business of the nation to maintain the fleet on a scale that renders such a policy possible.

So far we have assumed that the system of end-to-end Coast Defence advocated would prove effective if carried out as proposed. It may however be worth while to investigate this point briefly.

The suggestion is that heavy batteries should be erected at intervals of ten miles or so along the coast. It may perhaps be assumed that these batteries would prevent an enemy's ships from approaching our shores by day; but Colonel Hickson acknowledges that this would not be the case in foggy weather or at night, and accepts the possibility of a temporary landing being effected under these conditions. He states, however, that "destruction would await the raiders on the weather clearing." This seems to assume a great want of enterprise on the part of the raiders. Is it not more probable that the raider would rush and destroy our batteries? It may be argued that the batteries would be rendered impregnable, but this would cost money and men.

Napoleon undoubtedly rendered the coast of the western Riviera practically impregnable in 1796 by means of innumerable batteries; but these, being within shot of one another, cannot have been more than a few hundred yards apart and were thus probably effective both by day and night. In order to adopt the same system we should require batteries of medium armament at close intervals between our heavy batteries.

But are we right in assuming that Napoleon trusted entirely to his batteries? Is it not reasonable to assume that, in the case of a line of communication which was vital to him, he also held troops of all arms in reserve to deal with raiders should they succeed in rushing the fixed defences? If this be conceded, we come to the conclusion that, to adapt Buonaparte's system of defence to modern conditions, we should require a continuous line of works with armament and garrisons commensurate with those we have adopted for our coast fortresses. Those interested can calculate our requirements in men and material.

So far we have considered the question purely from the point of view of economy, as it was from this standpoint that Colonel Hickson developed his argument.

There are, however, many considerations affecting the life of a nation that are of much greater importance than economy, and we should do well to examine briefly the more general aspects of the question.

A nation that has assumed the burthen of a world-wide Empire has derived many advantages from its burthen, and it is useless to deny that there are other nations willing and able to relieve it of its load the moment it shows signs of feeling exhausted. It has expanded by war and has grown in riches and power at the expense of its neighbours, and it is only by successful war that it can retain what it has. In other words, defence and successful war are synonymous terms.

Successful war can only be carried out by striking the adversary. It cannot be waged by a Navy alone. Although, as stated, the Navy will assume the offensive on the outbreak of war, yet it is in fact a defensive arm. An Empire that is content to defend itself by its Navy or by fixed defences, and has no weapon with which to strike back at its foe, is foredoomed to defeat.

The adoption of a continuous line of defensive works round the British Isles might well prove disastrous. It would encourage the nation in the fallacious belief, that it can rest secure within an impregnable line and that the duty of its citizens is limited to the grudging provision of funds for the necessary war vessels and defensive works. It would soothe to slumber the wakening conscience of the race in regard to its responsibilities, individual and collective; and thus would probably sound the death knell to our rising hopes of some day seeing the military forces of the nation placed upon a footing in some measure adequate to our imperial needs.

To realise these hopes, it is necessary to base our Defensive measures as far as possible upon *the development of our Imperial resources for Offence and to grudge every penny spent upon forms of Defence which do not add to those resources.*

REPORT ON DEEPENING THE DEEP WELL AT SHOEBURYNESS IN 1906–07.

By Bt. Col. W. R. Stewart, R.E.

The circumstances which necessitated the deepening of this Well are stated in a report from C.R.E., Shoeburyness, to Chief Engineer, Thames and Medway Defences, dated 16th October, 1906, and the Diagram "A" which he forwarded with it is attached in explanation of the following details.

The result of the report was that in a letter Eastern 1/76 (F.W. 2) dated 2nd November, 1906, the War Office allotted £850 for deepening the Well. Allotment of Funds.

The proposal which had been made for the deepening was to carry the work out during the winter months, while the demands of the Garrison and the S.E. & C. Railway Company were at their lowest; and during the time in which the deep well was laid off, to depend for the supply upon the shallow well. Proposals for Deepening.

It was not without considerable opposition on the part of the Medical authorities that the shallow well was permitted to be used for a domestic supply. Apart from medical grounds, its capacity to supply both the Garrison and the Railway Company for the time estimated for deepening operations, viz. 6 months, was very doubtful, and reliance was not placed on it without considerable apprehension. This apprehension happily proved groundless.

The work on the deep well was commenced on 8th November, 1906, by the removal of 77′ of the top part of the 11″ bore-pipe, which projected upwards into the well and is now of no use, being above the level to which the water has risen for several years past. Commencement of Work.

The raising and lowering of men and materials was done throughout the operations by a steam sapper and a wire hauling rope passing over a pulley fixed to a beam over the well mouth. Men were raised and lowered on a boatswain's chair sliding on a pair of guide wires stretched taut from top to bottom of well. Raising and Lowering Men and Materials.

Lighting was supplied by candles. Lighting.

By the 23rd November the bore-pipe and stagings had been removed, and the breaking up of the cement false bottom (8′ 6″ above real bottom of well) was commenced. Cutting through False Bottom.

Plugging Bore-pipe.

The bore-pipe was plugged at a point 244′ below ground level by a plug formed after the pattern of a drain stopper, *i.e.*, of two cast-iron discs with a central washer of india rubber. This was lowered down the bore-pipe suspended from a length of 2″ pipe inside which was inserted a 1″ wrot-iron pipe, the top end of the latter being provided with a screw thread. The outer pipe was connected to one disc of the plug, the inner pipe to the other; and by screwing a nut down the threaded portion of the inner 1″ pipe until it pressed upon the end of the outer 2″ pipe, the necessary compression was produced between the discs of the drain stopper, thus squeezing out the india rubber between them and forming a tight plug in the bore.

Gas met with.

When a hole had been cut through the false bottom, there was a rush of gas, which caught fire from the lighted candles and burnt with a blue flame for about 15 seconds.

Gas of a similar description was occasionally met with during the subsequent sinking, but appeared to be harmless to the well sinkers.

Ventilation of Well.

A No. 1 Roots blower was erected, and delivered air continually day and night to the foot of the well; and at this stage of the proceedings the men were able to work there comfortably.

Use of Well during Preliminary Operations.

Up to 4th December the bore-plug was loosened each night, and the water entering the well was pumped into the Barrack supply tank.

Final Laying Off of Deep Well.

On 4th December, the false bottom having been removed, and the 8′ 6″ of sand and dirt between it and the real bottom having been cleared out, the cutting through of the real bottom of the well was commenced.

From this date up to the 15th May, 1907, the deep well bore-pipe remained plugged, and the shallow well became the sole source of supply of the Garrison and Railway, giving an average supply of about 80,000 gallons in 24 hours. Pumping was continuous throughout the 24 hours for the above period.

Breaking through Well Bottom.

The breaking through of the concrete bottom of the well was completed by 18th December. It was 3′ 6″ thick and of very hard concrete.

The bore-plug was lowered and fixed another 110′ down on 19th December.

Water met with.

As soon as the concrete bottom of the well had been cut through, water was met with. This came up round the outside of the bore-pipe and was small in quantity.

Sinking Pump provided.

In order to deal with the water met with in sinking, a Tangye's sinking pump had been ordered as soon as funds for deepening had been allotted.

Installation of Injector.

As this pump had not yet arrived, and as the water met with was small in quantity, it was decided to install an injector to keep the well dry.

A "D" size Penberthy injector was therefore fixed at the bottom of the well, steam being carried down to it from the steam sapper, and its delivery being connected to the 7″ rising main.

This worked very well, and easily lifted all the water required to ground level, 170′ above its position.

After having cut through the concrete bottom, a stiff firm clay was met with (as had been expected from the section). Method of Building in Steining.

This clay stood so well that it was found possible to undercut the whole thickness of the existing steining, piece by piece, and build under it, and it was not necessary to have recourse to a curb.

The bricks used for steining were Blue Staffordshire, radial, set in half Portland cement and half sand.

The method first employed was to dig down and remove all the clay at the bottom of the well to a depth of 5′, but not undercutting the steining. Method of Sinking.

When this removal was completed, the steining was undercut at one part of the circle to its full thickness (*i.e.* 9″) and to a width of 18″. (Vide plans and sections attached).

In the space thus obtained, a pillar of brickwork, 5′ high, 18″ wide, and 9″ thick, was built up to the under side of the steining. Pillar Method of Supporting Steining.

Four such pillars were built up in succession at four opposite points of the circle; and when the steining was thus supported in four places, the intermediate portions of clay between the pillars were cut away and the remaining steining built in between them.

By this method a section of 5′ in depth of deepening and steining could be completed in about 6 days; and by 2nd February the steining had been carried down to a depth of 16′ 6″ below the former bottom of well. Rate of Progress.

Up to this date the work had proceeded without a hitch, and the injector had succeeded in keeping the well free of water.

Its use, however, had had the effect of raising the temperature of the well considerably. Steam of 120 lbs. pressure had to be used for the height of lift required. The water discharged from the injector into the rising main, being of high temperature, had raised the water contained in it also to a high temperature; so that the whole length of this 7″ main (about 170′) was converted into a very efficient radiator, and never had a chance to cool down. Use of Injector raises Temperature of Well.

It is doubtful whether the use of the injector could have been continued much longer for this reason, even if all had gone well; but on the night of 3rd February an event occurred which made the conditions much worse, and shortly afterwards entailed the abandonment of the injector as a water lifter, and eventually led to much trouble and delay.

On that night the injector became clogged and failed to work; and the attendant in charge, instead of reporting the matter at once, kept his steam on all night, in hopes of getting it to start again. Failure of Injector.

The result was that on the morning of the 4th February the well was found to contain about 6′ of nearly boiling water, beneath which the injector was submerged, and the temperature of the well was above 100°.

Increasing Difficulty of Work owing to Heat.

The fitters were able to descend the well and work for short periods. In the course of the day they managed to raise the injector and get it going again, and by the following morning they had succeeded by its means in emptying the well again. But from this time forward it was impossible to keep the temperature of the well below 110° to 112°.

Means of improving Ventilation tried without Success.

The blower was kept going day and night (its 3″ delivery being carried down to the bottom of the well) without any appreciable result.

Bags of ice were lowered down, but were converted to water before they reached the bottom.

The blower was reversed so as to suck air out of the well; but, though it drew up a strong stream of hot air from the well for many hours, the temperature remained the same.

A canvas windsail, 9″ in diameter and 100′ long, was put down the well and lowered to various depths.

An inspirator was fixed at top of the well so as to draw up air through a 3″ pipe from the bottom. Other expedients were also tried, but by no means could an up-and-down draft be obtained or the temperature lowered.

It is presumed that this was due to the fact that the well is of the shape of an elongated bottle, the shaft for 115′ down being 6′ in diameter, and below that depth domed out to 9′ in diameter. The hot air therefore was no doubt imprisoned in the wider portion at the bottom and could not escape by the narrower shaft above.

From the 3rd to the 10th February every effort was made to lower the temperature by improved ventilation, the use of the injector being continued. But it became apparent that conditions were getting no better, and that the injector kept up the temperature as fast as the blower, etc., lowered it.

Decision to abandon Injector.

It was therefore decided to abandon the injector and to lower the sinking pump (which had by now arrived).

Description of Sinking Pump.

This pump was of Messrs. Tangye's special pattern—14″ cylinder, 6″ ram, 12″ stroke, and was a somewhat bulky piece of machinery, weighing about 30 cwt. Its delivery was 6,000 gallons per hour, a capacity which, after experience, proved to be enormously in excess of requirements; but it was decided to have a large pump, as the amount of water likely to be met with was unknown.

Water met with.

As a matter of fact the greatest amount of water met with during sinking never exceeded 400 gallons per hour.

Sinking Pump Lowered and Slung.

The size of this pump made the work of lowering it down the well (encumbered as it was with the bore-pipe, rising main, roller guides, pump rods, etc.), a work of some difficulty. But by the 11th February, it was lowered and slung by means of a Tangye's differential tackle from the pump stage (170′ down); and the work of connecting the steam, exhaust, and delivery pipes to it was completed by the evening of the 14th February.

Increasing Heat Difficulties.

During this process it had been necessary to keep the injector steadily at work to prevent the water flooding the well. The heat had consequently been maintained at such a height as to make it impossible for any of the men to work for more than short periods at a time, and for certain of the men to be able to descend the well at all.

Starting of Sinking Pump.

The moment when the injector could be abandoned and the sinking pump used instead had therefore been eagerly looked forward to, and those responsible for the work were anxiously gathered round the well mouth when steam was first turned on to the pump.

Failure of Pump.

So when it merely gave one stroke and did no more, the disappointment was most acute; and when the fitters who descended to examine the pump reported that they could not get it to work at all, the condition of affairs was somewhat serious. Its failure to work would necessitate the continuance of the use of the injector to prevent the pump becoming submerged, and yet the use of the injector was daily bringing nearer a condition of affairs under which the men would be unable to work in the well at all.

Overhaul of Pump under Difficulties.

The overhaul of the pump was promptly commenced. But as the men employed upon this had to work slung by ropes alongside a pump which had been recently under steam and was also slung, and in a temperature of over 100°, the work was necessarily slow.

By the 18th February, it had been taken to pieces and put together again, without, however, any apparent defect being discovered. At 1 a.m. on that day it was got to work, and in 18 minutes cleared out 7 hours' accumulation of water in the well.

This evidence of its powers when in the mood gave all concerned much encouragement, and the injector was then dismantled and preparations made for continuing the sinking.

Second Failure of Pump.

On the 21st February, however, the pump again failed, and could only be induced to work when the hand lever was operated.

Cause of Failure.

Another overhaul therefore became necessary. The seat of the trouble was eventually found to be in the ports leading to the by-passes, which had become blocked through minute portions of scale from the inside of the steam pipes. These steam ports are exceedingly small and require periodical clearing by a wire.

Pump Working Satisfactorily.

The detection and correction of a defect of this sort, though an easy matter under ordinary conditions, assumed a very different complexion under those which existed on this occasion; and it was not until the 24th February that the pump was got going again satisfactorily.

Narrow Escape of Military Mechanists.

During this period the conditions at the foot of the well had been continually getting worse. On the night of the 21st February, the two Military Mechanists, while at work on the pump, were overcome by the heat and probably by foul air, and were only able to signal to have themselves hauled to the surface and to place themselves in the slings before they lost consciousness; they arrived at the well mouth in a half fainting condition. Happily no harm happened to them, and they speedily recovered.

Existing Conditions impossible for further Work.

It was now recognised that conditions in the well were such as men could not be asked to face, and involved grave risk of loss of life; and it was decided to instal air pressure in place of steam.

Hire of Air Compressor.

In anticipation of the probability of this becoming necessary, correspondence had previously been entered into with the Inspector of Iron Structures relative to the hire of an air compressor; and it had been ascertained that a suitable one could be obtained on hire from the Rand-Ingersoll Company.

Description of Air Compressor.

A request to the Inspector of Iron Structures very quickly completed the negotiations. Arrangements were made for the hire of a Class "A" Air Compressor (code name "Algina"); cylinders $14'' \times 14\frac{1}{4}'' \times 14''$ stroke; piston displacement capacity 385 cub. ft. of free air per minute; suitable for an air pressure up to 100 lbs.; cost for two months £50, including carriage both ways from Glasgow, where the nearest available machine then was.

The desirability of abandoning the pump altogether and substituting an air lift had been considered; but the idea rejected, as it was decided that the substitution would necessitate many structural alterations and lead to further delay.

Air Compressor installed and Working Successfully.

The compressor was duly received at Shoeburyness on 28th February. By 4th March, it had been erected and connected to the pump, which worked excellently from the very first trial, under an air pressure of 40 lbs. per square inch.

While installing the air pressure, the steam pump was kept going twice a day; but, except one man who went down to start it, no men were permitted to go down the well.

Heat Difficulties removed by Air Installation.

The installation of air pressure immediately removed all heat difficulties. The exhaust was discharged into the well and kept it pure, and the temperature was lowered from over 100° to 62°.

Beyond a complaint that the air supplied had a flavour of oil, no further trouble was experienced; and the machinery ran without any serious hitch till the end of the operations.

Sinking resumed.

Sinking was resumed on 6th March for the first time since 5th February.

Quickened Method of Procedure.

Owing to the great delay that had taken place in the work, it was decided that sinking the steining by the pillar method was too slow.

The process adopted for the future was to dig out the well bottom to a depth of 5′, and to undercut a 5′ quadrant of the steining and build that in at once, while the excavators proceeded to undercut a quadrant of the same length at another part of the circle.

Work went on day and night without cessation.

By this means the remaining 33′ 6″ of sinking and steining required to complete the deepening was executed by April 6th, one day having been occupied in lowering the sinking pump to correspond with the increased depth. Completion of Steining.

The work throughout the operations was a good deal hampered by the presence of the timber frames of a former shaft, which had been carried down round the bore-pipe, while the well was under construction, in order to effect some repairs to the bore-pipe. Former Shaft met with.

After the repairs to the bore-pipe had been completed, the shaft had been filled in and the timbers left. According to the drawings it goes down some 215 feet below the old bottom of well.

In putting in the concrete bottom to the well the following procedure was adopted to prevent the bottom being burst up from underneath, as the upward pressure to be expected was that due to from 70 to 80 feet head of water. Precautions in putting in Bottom.

The interior of the old shaft was excavated for 6′ in depth, and then filled in with sand bags, containing ballast, and blocks of old concrete. Into this filling was inserted a vertical length of 6″ pipe (vide sections and plan attached) down through which the suction pipe of the pump was carried.

A cast-iron flange was bolted round the bore-pipe as shown in the section. The object of this was to support the concrete in the centre, and also to prevent leakage where the bore-pipe passed through the concrete.

On the 8th April concrete to an average depth of 18″ was filled in round the 6″ pipe and round the bore-pipe.

During the filling in of concrete the pump was kept going slowly, so as to prevent the water rising and percolating through the concrete. As soon as it had set sufficiently to remove the fear of the cement being washed out, the water was allowed to rise over it.

After this had stood for 48 hours, a blank flange (previously prepared) was bolted on to the pipe through which the suction pipe had passed, and into this flange was screwed a 1″ pipe fitted with a cock.

A rail was placed across the blank flange from side to side of the well to give additional support.

Another 18″ of concrete was then placed in position, burying everything except the cock on the 1″ pipe.

Sand bags were placed over the concrete, and the water allowed to rise through the 1″ pipe and through a 1″ hose into a canvas bag, into which the suction pipe of the pump was inserted and from which it drew.

This was completed on the 10th April, and the water allowed to accumulate in the well.

On the 12th April the depth of water in the well was 28′; and it was kept at about that depth by occasional pumping till the 15th April, when the well was pumped dry and the cock half closed.

On the 18th April the well was again pumped dry and the 1″ cock closed entirely and the pipe plugged.

Except for a few pinholes in the steining the well was found to be quite tight, and the pinholes were soon afterwards closed. The bottom and sides were then found to be perfectly tight and the result most satisfactory.

Disconnecting Sinking Pump.

The work of disconnecting and raising the sinking pump and dismantling the air compressor commenced on 18th April, and was completed on the 21st April.

Dismantling Air Compressor.

The compressor was packed ready for despatch on 22nd April.

After the sinking pump had been removed, water accumulated in the well at the rate of about 9″ a day, and by the date when pumping was resumed it stood about 17′ in the well. It was ascertained, however, by careful observation, that none of this came through the sides or bottom of the well, but that all came by leakage past the plug in the bore-pipe from which it reached the well through the orifices in the latter.

Lowering Delivery Pumps.

The work which remained to be done was to lower the pumps and pump stage to their new position (30′ from bottom of well), to make and connect the extra pump rods, and to add the necessary lengths of rising main.

For this purpose the pumps were loosened from the stage and slung by chains from the top. The stage, which consisted of 2 pairs of girders crossing each other, was lowered girder by girder to its new position, and the ends of the girders fixed to cast-iron corbels previously built into the steining for their support. The pumps were then lowered on to the stage and fixed.

Five pairs of girders, carrying the guides for the new lengths of pump rods, had then to be fixed on to similar corbels in the steining, and the new pump rods made and fixed.

Finally the new rising main was fixed.

The non-arrival of material delayed this part of the work to a certain extent, but it was finally completed by 11th May, and the pumps started to work again on that day.

Disinfecting and Cleaning.

Three days were occupied in disinfecting, washing down, and cleaning the well, and on 15th May it was passed by the Medical Officer and taken into use for domestic purposes.

Labour.

The work was carried out by civilian labour under R.E. superintendence, the work down the well being paid for at time-and-a-half rate day or night.

Cost.

The cost to the public, from first to last (including hire of air compressor), was £841, as nearly as can be ascertained. But as the work was carried out in conjunction with other portions of the scheme, it is not possible to give exact figures.

It must be noted, however, that in making out the estimate, it had been intended to take full advantage of all pumpers, drivers, stokers, fitters, etc., available from the Royal Engineers establishment, and this procedure was adopted.

The value of the portion of the labour of the establishment men employed on the well was approximately £260 during the 6 months' operations; so that had these men not been available, the total cost of the work would have amounted to £1,100.

Accidents.

The only accident of any importance during the sinking (beyond that to the Mechanists reported on page 290) occurred to one of the labourers in the early morning of the 2nd April.

Going on shift at 2 a.m. that day, he was being lowered down the well. He had omitted to comply with the strict injunctions, issued to all men, to tie themselves in the boatswain's chair with the lashing provided for the purpose. When about 15′ from the bottom of the well, he fell out of the chair and to the bottom. He was badly shaken, but no bones were broken.

Improved Supply.

The result of the operations has been that the supply has been enormously increased.

The valve "F" (Diagram A) still (June, 1907) gives about the same amount of flow as it did in October, 1906; but when it was (as formerly) at the bottom of the well, it speedily got drowned and the supply fell off very rapidly.

To obtain the necessary daily supply for the Garrison under former conditions it was therefore necessary to keep the well almost empty, and run the pumps dead slow throughout the 24 hours—a most uneconomical and unsatisfactory arrangement, and one which courted risk of failure of supply.

Under present conditions this valve, having 58′ of well beneath it, flows at its maximum delivery till that space is filled, and a large amount of water can therefore be stored.

It is found that at present (June, 1907) the valve fills the space below it and up to 3′ above it (containing approximately 24,000 gallons) in 8 hours; and that if no pumping then takes place, the water will eventually rise to a height of about 20′ above it in a further 10 to 12 hours.

A storage of about half the day's supply (say 25,000 gallons) can therefore be collected at night, and this the pumps can lift in about 2½ hours. After an 8 hours' rest, another half day's supply has collected. So the pumps need only perform two 2½-hour spells during the day.

New Valve.

A new valve has been fixed in the bore-pipe 15′ below valve "F" (Diagram A), but it is not necessary at present to use this.

It is hoped that with this valve and with the future possibilities of tapping the bore-pipe at lower levels if required, which the deepening has rendered possible, the well will give the necessary supply for several years to come.

RÉSUMÉ OF OPERATIONS.

1906.	8th November to 23rd November	Removing bore-pipe and stagings.
	to 4th December	Cutting through false bottom and clearing well.
	to 18th December	Cutting through real bottom.
1907.	to 8th January	Plugging bore, fixing injector and overhead gear.
	to 2nd February	16′ 6″ of deepening and steining completed.
	to 6th March	Trouble with heat, and substituting air for steam.
	to 6th April	33′ 6″ of deepening and steining completed, making 50′ in all.
	to 15th April	Filling in bottom.
	to 22nd April	Dismantling pump and air compressor.
	to 11th May	Lowering pumps to new position. Pumps started 11th May.
	to 15th May	Cleaning well. Supply restored.

SOME NEW TYPES OF FILAMENT LAMPS.

By LIEUT. A. LLOYD OWEN, R.E.

FOR several years electro-technicians and chemists have been applying themselves to the production of a really economical incandescent electric lamp, with the result that the industry of lamp manufacture is now face to face with great changes.

The high consumption of current by carbon filament lamps has always been one of the greatest deterrents to the universal use of electric lighting. As some of the new types of filament lamps that have been placed, or shortly are to be placed, upon the market have undoubtedly come to stay, I think we shall see a very great increase in the near future of the use of the electric light.

A series of articles, dealing mainly with the comparative efficiencies of various forms of filament lamps that have been experimented with, has lately appeared in *The Electrician* and in *The Engineer*, and a short summary of the results of the experiments and tests which have been described in these technical papers may be of interest to those readers of our Journal who have not had the opportunity of studying the articles in question.

It is my intention to deal with each type of lamp separately, and to give as briefly as possible a description of their characteristics.

TANTALUM LAMP.

The Tantalum lamp has already gone beyond the stage of preliminary experiment, and is now being placed on the market at a comparatively low cost.

The current consumption is about 1·9 watts per candle-power, but these lamps have not yet been manufactured for use with voltages beyond 110. The life may be taken as at least 400 hours for a 25-c.p. and 600 hours for a 50-c.p. lamp. The lamp is not so sensitive to fluctuations in voltage as the carbon lamp, owing to the specific resistance of tantalum rising with the temperature.

A Tantalum lamp can be used in any position, an advantage which is not shared by some of the other new types of filament lamps.

The filament, however, is fragile, especially after it has been in use for some 400 hours. A peculiarity with regard to this is worthy of note. If the broken end of a filament that has fractured makes contact with another portion of the filament, the lamp immediately lights up again, and a welding at the junction takes place. This welding is said to be generally strong. Whether this first fracture of the filament should be taken into consideration in the life test is a matter of opinion. If the lamp, by further usage, quickly repairs itself, I do not think the primary breaking of the filament should weigh very heavily against it as a weakness.

Until very recently the Tantalum lamp had not been made suitable for use with alternating currents, owing to some change, probably crystallisation, in the physical nature of the filament. This disadvantage has now to a great extent been overcome, although the life of a lamp on an alternating current circuit is less than on a continuous current circuit.

Tantalum being a very hard metal and very ductile in the pure state, the filaments are made by "drawing out" from a sheet that has been hammered down from ingots.

OSMIUM LAMP.

The Osmium lamp has the disadvantage of being more expensive than the tantalum, and of only working with low voltages. The highest voltage used so far is about 50, which means burning the lamps in series for the voltage that is generally supplied by power companies.

Another disadvantage is that at full incandescence the filament becomes soft and tends to bend, therefore necessitating the lamp being used in a suspended position.

I have read a very favourable account, however, of the satisfactory employment of these lamps for street lighting in Exeter. The lamps were fitted to the tramway poles and, notwithstanding the vibration, had an average life of over 1,000 hours, and with a comparatively small decrease in the candle-power. The lamps have been considered such a success in Exeter that the subscribers in the town are rapidly purchasing all the Osmium lamps they can get.

The current consumption is about 1·5 watts per candle-power, and the diminution in candle-power after 1,000 hours running is only 10 or 15 per cent.

Osmium is a very hard, though not a ductile, metal. It is, I believe, a kind of quartz. The filaments are prepared in a different manner to the tantalum process; the general idea seems to be as follows. The metal is brought to a fine smooth powder, mixed with an agglomerant, and squirted. The squirted filament is dried and baked, and, if an organic agglomerant has been used, heated electrically to eliminate the carbon.

NERNST LAMP.

Of the new filament lamps that have been devised the Nernst lamp is one of the few that can be employed with 200 volts pressure. Nernst lamps are seen a great deal in use nowadays. Their current consumption compares very favourably with that of the carbon lamp, being about 2·2 watts per candle-power, and the life is averaged at 600 hours. There is a drop of about 70 per cent. in the candle-power after 1,000 hours running.

At first they could not be used with alternating currents, but a suitable modification of the filament was accidentally discovered that allowed such currents to be employed. The lamp is rather expensive.

ZIRCONIUM, IRIDIUM, AND HELION LAMPS.

These three types of lamps are dealt with together, as they are still more or less in the experimental stage.

The latest type of Zirconium lamp is said to have an average life of 500 hours and to consume 1 watt per candle-power. They are shortly to be brought on to the market adapted for voltages of 110. A lamp, called the Zircon-Wolfram, the filament of which is a compound of zirconium with tungsten introduced, has shown a high efficiency. They are at present manufactured for 100 and 200 volts, with a consumption of about 1·2 watts per candle-power. The filament is not fragile, and the lamp is suitable for use with alternating currents. The process of producing the filament is similar to that described for the Osmium lamp.

Iridium lamps, being so far only manufactured for voltages up to 24, do not require any special notice. They are said to consume something from 1 to 1·5 watts per candle-power, but I have found no satisfactory reports of efficiency and life tests.

The filament of the Helion lamp consists of carbon coated, by electrical heating, with silicon. The efficiency of the lamp is about 1 watt per candle-power, and life tests have ranged over 500 to 1,200 hours.

A remarkable characteristic of this lamp is that continual over-running does not produce any great change in the candle-power or injure the filament. The filament is capable of welding itself together in the case of a fracture, as in the Tantalum lamp.

TUNGSTEN LAMP.

Tungsten lamps are manufactured by four different processes, all of which are, I believe, dependent upon "squirting."

(*a*). *First Process.*—Lamps made under the first process have been experimented with in Munich. Designed for 110 volts, they have given illuminating power of 38·9 to 45·7 candles, with a consumption of about 1·1 watts per candle-power.

(*b*). *Second Process.*—A 55-volt lamp gave 35 candle-power illumination, at 1·1 watts per candle, with a diminution of only 7·6 per cent. in the illumination after 917 hours continuous running.

This test was made in Vienna.

(*c*). *Third Process.*—Lamps manufactured under this process, called Osmin lamps, gave (in Munich) at 1·05 watts 57·23 candle-power with 110 volts. At a further test (in Vienna), after 1,776 hours they were still burning with 1·09 watts.

(*d*). *Fourth Process.*—Lamps manufactured under the fourth process, and styled Osram lamps, are said to have an average life of over 1,000 hours, after which time there is *no diminution of the illuminating power.* After 500 hours burning the current consumption of a 25-c.p. lamp was 1·12 watts per candle-power, and of a 32-c.p. lamp 1·08 watts.

Tungsten filaments, like those of osmium, become soft at full incandescence, and until recently the lamps have only been manufactured for fixing in a pendant position. Burning through has seldom any great effect on the life of the lamp, as subsequent welding takes place, though this welding is not so strong as in the case of the tantalum lamp.

One interesting point concerning this Tungsten lamp is whether the lamp, when used with low-frequency alternating currents, shows any advantage over the carbon lamp in the matter of flickering. Experiments have been conducted—though, I believe, very limited time was at the disposal of the experimenter—which tend to show that in circuits of low-frequency alternating currents the Tungsten lamp will be less suitable than the standard lamp of to-day, owing to flickering.

CONCLUSION.

It is perhaps necessary to give in conclusion the figures that are generally accepted for carbon filament lamps.

Voltage.	Initial Candle-Power.	Initial Wattage Efficiency.	Drop in Candle-Power after 1,000 Hours.
100	16	3·6	20 per cent.
200	16	4·3	20 per cent.

Comparing these figures with those of the new types of filament lamps that have been given, it is very evident that the days of the carbon lamp are numbered. One cannot readily say at present which of the new lamps have come to stay; but the Tungsten lamp has possibly the greatest future, shared perhaps by the Zircon-Wolfram of which we are sure to hear more shortly.

I have only endeavoured to give a very short outline of the great strides that are now being made in the manufacture of filament lamps, and of the direction which experiment is taking.

The subject is an interesting one, especially to those of us in whose work the study of electricity forms a great part.

MEMOIR.

MAJOR-GENERAL SIR JOHN C. ARDAGH, K.C.M.G., K.C.I.E., C.B., LL.D.

JOHN CHARLES ARDAGH, who was the son of the late Rev. W. Johnson Ardagh, vicar of Rossmire, Ireland, was born at Comragh House, Waterford, on August 9th, 1840. He received his early education at the Endowed School in Waterford, and entered Trinity College, Dublin, in 1857, with the intention of going into the church. But he soon decided to take up a military career, and, leaving the ordinary university curriculum, joined the class of Professors Galbraith and Haughton in order to prepare for entrance into the Royal Military Academy, Woolwich. He passed in 1858, having taken the first place at the entrance competitive examination, and was again first at the final examination. His commission as Lieutenant in the Corps of Royal Engineers was dated 1st April, 1859.

After completing the course of instruction at the Royal Engineer Establishment, Chatham, Ardagh was ordered to Pembroke Dock for duty in connection with the new fortifications which were then in course of construction under the Defence Act of 1860. Here he had an opportunity of showing his capacity both as regards assisting in the designs and in superintending the execution of the works, and his ability was soon recognized by the officers under whom he served. He remained at Pembroke until 1862, when the action of the United States Government in the matter of the *Trent* steamer necessitated the despatch of a British military force to Canada, and Ardagh was selected for service in connection with the construction of a line of telegraph through the colony of New Brunswick to the St. Lawrence. He embarked with a party of sappers on the transport *Victoria*, which was chartered to convey the 96th Regiment to Canada. The vessel met with severe storms in the Atlantic, and would probably have been lost had it not been for the exertions of Ardagh and his sappers, who constructed temporary pumps and managed to keep the ship afloat until her captain succeeded in bringing her to the Azores. For his good services on this occasion Lieut. Ardagh was thanked publicly on parade by order of the Commander-in-Chief.

On his return to England, he served at Chatham for a short time, and was then ordered to Newhaven for duty on the defence works. After two years he was sent to Portsmouth for employment on the Spithead forts and the fortifications of the Isle of Wight; from whence he was again transferred to Newhaven, where he remained for several years. He was principally responsible for the design and construction of Newhaven fort, and showed much ability in the invention of an equilibrium drawbridge leading to it, of which he wrote a description for the *Royal Engineers Professional Papers*, New Series, Vol. XVII.

In 1868 Ardagh was nominated as Secretary of the Committee, of which Admiral Sir Frederick Grey was President, 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 this Committee, Ardagh received the thanks of the Secretary of State for War for the satisfactory manner in which he had performed his duties. In 1869 he accompanied Sir William Jervois on a tour of inspection of the defence works at Halifax and Bermuda, and, during the same year, acted as Secretary of a Committee, of which Colonel Collinson was Chairman, which reported on the defence of the southern and eastern coasts of England from Portsmouth to the Wash. In 1871 Ardagh was sent to Malta for a few months, and was promoted Captain on August 3rd, 1872. Just prior to his promotion he went up for the competitive examination for entrance to the Staff College, and joined that institution in February, 1873, where he remained for the usual two years' course. He passed the final examination in December, 1874, and obtained special mention in German, Italian, and a number of other subjects. On completion of the Staff College course he was ordered to the War Office for duty in the Intelligence Department, of which the Chief at that time was General Sir P. Macdougal.

In 1876 Ardagh entered upon that series of services in connection with the Near East which formed so large a portion of his life work, as during that year he was selected to accompany the Marquess of Salisbury to Constantinople. At this time affairs in South-Eastern Europe were in a critical condition. In April, 1876, an insurrection had broken out in Bulgaria, and had been suppressed with considerable severity by the Turkish troops; in June the violent death of the Sultan Abdul Aziz, by suicide or murder, was followed by the assassination of the Turkish Ministers for War and Foreign Affairs, and in July there was a declaration of war by Servia and constant conflicts in the Balkan Provinces. War between Russia and Turkey was imminent, notwithstanding the efforts by the western powers of Europe to prevent or postpone it. A conference of the six great powers met at Constantinople in December, 1876, and proposed reforms for Turkey, but no satisfactory result was arrived at and war was declared by Russia in April, 1877. Ardagh was in Turkey during this trying time and was able to render valuable assistance to the British Ambassador, for which, on his return to England he received the thanks of the Commander-in-Chief, the Secretary of State for War, and the Secretary of State for Foreign Affairs. At the end of the same year he was sent on a special mission to Italy and did not resume his duties at the Intelligence Department until March, 1878. But his stay at the War Office was of short duration as, in the following June, he was appointed one of the technical military advisers, under General Sir Lintorn Simmons, to assist Lord Beaconsfield and Lord Salisbury at the International Congress, which assembled at Berlin to settle the terms of peace between Russia and Turkey and the future organization of the Turkish provinces. Here Ardagh's knowledge of Turkey and of Eastern affairs were of great value, and, on the conclusion of the Congress, his services were acknowledged by the award of the C.B. (Civil Division). In September, 1878, he was again ordered to Turkey as assistant to Colonel Home, R.E., who was the British Representative on an International Commission appointed in connection with the terms settled at Berlin. Peace had been arranged between Russia and Turkey, but much work had to be done in the delimitation of the boundaries of the new territories, and, as usual, a great deal of the settlement of the details devolved upon officers of the Royal Engineers. The duty of fixing the boundary between Bulgaria and Eastern Roumelia was taken by a Commission upon which Colonel Home represented Great Britain. The work was begun in the latter part of 1878, but on the approach of winter the party returned to Constantinople early in December, when Ardagh received the pleasant intelligence that he had been promoted to a brevet majority on the 30th November for his services in Turkey. Shortly afterwards Home contracted typhoid fever and had to return to England, and died in London in January, 1879, deeply regretted by all his friends. His place as British Commissioner was taken by General E. Hamley, and Major Ardagh continued to be senior assistant. The work of the Boundary Commission was continued during the greater part of 1879, and the last meeting of the Commissioners was held on September 24th, after which Ardagh made a tour in Asia Minor and the Crimea, returning to England by way of Moscow and St. Petersburg. After his arrival in London, he received the thanks of the Foreign Office for his services in connection with the Bulgarian Boundary Commission.

In June, 1880, he was selected to attend the International Conference at Berlin, which met to settle the question of the Turko-Greek frontier, and, in May, 1881, was sent to Constantinople for the further conference on the same subject, when a convention was agreed to as regards the boundary between the two countries. Immediately afterwards Ardagh was chosen as British Commissioner on the International Commission appointed to delimit the boundary. The work was not easy, as the Turkish authorities put considerable difficulties in the way of progress, and, on the other hand, the officer in command of the Turkish escort was shot by brigands, probably

Greek, at Dervendista. But Ardagh worked quietly along, and the marking out of the boundary line was completed on October 16th. He was highly commended by Lord Dufferin, then British Ambassador at Constantinople, and also received the thanks of the Foreign Office for the manner in which he had carried out the work.

After returning from Turkey to England Ardagh continued to serve on the Intelligence Department until February 13th, 1882, when he was appointed Instructor in Military History at the School of Military Engineering, Chatham. But he had only held this post for a few months when he again returned to the East of the Mediterranean, in consequence of the Egyptian crisis which led to the war of 1882 and the occupation of Egypt by England. There had been a troubled state of affairs in Egypt since the deposition of the Khedive Ismail by the Sultan in 1879, and his replacement by his son Tewfik. This had resulted in the assumption of power by Arabi, a colonel in the Egyptian army, who had been appointed Minister of War, and who was supported by the military party. In May, 1882, the British and French fleets proceeded to Alexandria to protect the European inhabitants, and an *émeute* in that town, in which a number of Europeans lost their lives, brought matters to a head. Early in July the Egyptians began to strengthen the forts of Alexandria, which led to the bombardment of the place by the British fleet, the French fleet having previously sailed in accordance with instructions from the French Government. After the bombardment the landing of British troops was inevitable and commenced on the 13th July. General Sir A. Alison, who was selected for the command, landed on July 17th and the British force was rapidly increased. Ardagh, who had left England on July 5th, was one of the early arrivals and was entrusted with the task of placing Alexandria in a state of defence. By the 19th he had arranged so as to make it secure against any attack that could be made by the Egyptian army. No offensive action was possible until the whole of the British force had arrived, and when the army was complete it was moved round to the Suez Canal and Ismailya, in order to advance on Cairo by way of the fresh-water canal. Ardagh was left at Alexandria in charge of the Intelligence Department, but was ordered to Ismailya early in September and was present at the battle of Tel-el-Kebir. He was mentioned in Lord Wolseley's despatch at the conclusion of the campaign and was promoted brevet lieutenant-colonel. He also received the British war medal, with clasp for Tel-el-Kebir, the Egyptian bronze star, and the 4th class of the Order of the Osmanieh. After the war was over he was appointed D.A.A.G. on the staff of General Sir A. Alison, who was placed in command of the British army of occupation in Egypt.

Early in 1883, Ardagh made a tour in Palestine, and in July he went on leave to England, but immediately after his arrival in London he had to return to Cairo in consequence of the outbreak of cholera in Egypt. Those who were there at the time will remember the untiring way in which he worked during the epidemic.

Although affairs in Egypt at this period were quiet, and it was in contemplation to reduce the British army of occupation, trouble was brewing in the Soudan. This is not the place to go into these matters, or to discuss the defeat of Hicks Pasha, the mission of General Gordon, and the failure of Baker Pasha to relieve Sinkat. Suffice it to say that the defeat of Baker by the Soudanese left Souakim open to attack and necessitated the despatch of a British force for its protection. This was commanded by General Sir G. Graham, and Ardagh was attached to his staff as Commanding Royal Engineer and Chief of the Intelligence Department. He left Cairo on February 15th, 1884, landed at Trinkitat, and was present at the battle of El Teb on 29th February, where the Arabs were defeated with great loss. The British then advanced to Tokar, where he had to make all the arrangements for the removal of the Egyptians. Sir Gerald Graham and the troops returned to Souakim and had another fight with the Arabs at Tamai on March 13th, after which the country round Souakim was fairly quiet and the road to Berber was practically open. Ardagh was very strongly of opinion that an advance should have been made along this road in order to assist General Gordon, but his views were not accepted by the authorities, and the British force returned to Cairo, leaving one battalion to garrison Souakim. In consequence of the decision to advance to the relief of General Gordon by way of the Nile, a vast amount of work was thrown upon the British staff in Cairo, and of that work Ardagh did as much, if not more, than any other officer. He was appointed Commandant of the Base, with the grade of A.A.G., and had an enormous amount to do with reference to forwarding supplies and reinforcements to the front. He met all the difficulties which necessarily arose with a calm cheerfulness which was the admiration of all who had dealings with him, and there can be little doubt that his energy and untiring devotion to duty helped more than is generally known in the carrying out of the Nile expedition. At the conclusion of the campaign he was mentioned in despatches, promoted to the rank of brevet colonel, and received the C.B. (Military Division). He had thus the unusual distinction of wearing both the military and the civil C.B. He also was given the 3rd Class of the Order of the Medjidieh.

After the withdrawal of the British force from the Soudan, the frontier of Egypt was fixed at Kosheh, a place on the Nile some miles south of Wady Halfa, where a fort was built and garrisoned with a British battalion and some of the Egyptian army, while other troops, British and Egyptian, were stationed at points along the river from Kosheh to Halfa. In November, 1885, the Dervishes determined to attempt an invasion of Egypt and advanced in considerable force down the Nile. General Sir F. Stephenson, who commanded the British army of occupation, and General Grenfell, the Sirdar of the Egyptian army, proceeded to Halfa to take steps for resisting the Dervish attack, and reached Kosheh on December 29th. Ardagh accompanied them in the position of Chief of Staff. On the 30th the combined British and Egyptian force advanced and attacked the enemy at Ginniss, a village on the Nile beyond Kosheh, defeating them with great loss, and killing many of the hostile chiefs. The battle of Ginniss was a severe blow to the Khalifa, and checked the Dervish attempts at invasion for a considerable time. For his services on this occasion Ardagh was mentioned in despatches. He returned to Cairo in January, 1886.

During 1886, besides his ordinary duties, he had much work in connection with Sir H. Drummond Wolff's mission to Egypt, and also with the settlement of the financial arrangements between England and Egypt. For his services with regard to this latter duty he received the thanks of the Treasury. On January 26th, 1887, he was promoted to the rank of Colonel on the Staff, and in November of the same year was recalled to London in order to take up the appointment of A.A.G. for Defence and Mobilization. In 1888 he became Aide-de-Camp to the Commander-in-Chief, and in November, 1888, was chosen by the Marquess of Lansdowne, the Governor-General of India, for the post of Private Secretary. In 1892 Ardagh had a somewhat severe attack of fever, and proceeded on leave to England, returning to India by way of Canada, the United States, Japan, and China. He remained with Lord Lansdowne until the latter had completed the term of his viceroyalty, and stopped also for a time with the Earl of Elgin, the succeeding Governor-General, finally returning to England in May, 1894. He received the decoration of C.I.E. in 1892, and of K.C.I.E. in 1894, in recognition of his Indian services.

In 1895 Ardagh was appointed Commandant of the School of Military Engineering at Chatham, and in the following year was selected for the important position of Director of Military Intelligence at the War Office, with the rank of temporary Major-General.

Ardagh was married on February 18th, 1896, at Trinity Church, Chelsea, to Susan, widow of the third Earl of Malmesbury. He was promoted Major-General on March 14th, 1898.

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 and had, in spite of a very limited staff and inadequate funds, kept the authorities at the War Office fully informed as to the condition of affairs in South Africa, as to the military resources of the Boers, and 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.

In 1899 Ardagh was nominated as British Government Representative at the International Commission for delimiting the boundary between the Republics of Argentine and Chili in South America, and in the same year was appointed British Military Delegate at the First Peace Conference at the Hague. There he took a leading part in drawing up the "Rules respecting the Laws and Customs of War on Land," which formed an important advance in international military law, and in which only one small amendment has been made at the Second Peace Conference.

Ardagh's knowledge of international law was of great service during the South African war, as, owing to the misconduct of persons of foreign nationalities, domiciled in South Africa, or members of so-called neutral ambulances, a number of complicated cases arose. The deportation of many undesirable foreigners to Europe occasioned considerable irritation on the continent, and the Government appointed a Commission to adjudicate on the claims made by foreign powers on behalf of these persons. Ardagh was nominated as British Representative on the Commission, and succeeded by the exercise of careful diplomacy in settling a very complicated business to the satisfaction not only of the foreign governments but also of his own. For his services on this Commission he received the thanks of the Secretary of State for Foreign Affairs.

In October, 1901, Ardagh was sent to South Africa, on behalf of the Foreign Office and War Office to investigate all cases in which the subjects of friendly powers were concerned, and to settle on the best mode of dealing with claims for compensation arising in consequence of the war. He remained in South Africa until May, 1902, when he returned to England; but was shortly afterwards appointed a Member of the Royal Commission for the revision of sentences passed under martial law during hostilities, and proceeded again to South Africa. He was given the local rank of Lieutenant-General during the time he was in that country.

Ardagh was retired from the army under the age clause of the

Royal Warrant on August 9th, 1902, but continued to be employed by the Foreign Office, and in that year was selected as Member of the Permanent Court of Arbitration at the Hague, instituted in accordance with the terms of the Convention of July 29th, 1899, and was also appointed one of the British Government Directors of the Suez Canal. In December, 1902, he received the honour of being made a K.C.M.G. 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 the proposals made by him were accepted by the Conference and embodied in the new Convention. His last public duty was to act as one of the Representatives of the British Red Cross Society at the International Red Cross Conference in June last.

In 1897 Ardagh was given the honorary degree of LL.D. by Dublin University in recognition of his distinguished public services. He was elected as Fellow of the Royal Geographical Society in 1870, and served as Member of Council of that Society. He was also an Associate of the Institute of Civil Engineers.

He died on September 30th, 1907, at Glynllivon Park, Carnarvon, and was buried on October 4th at Broomfield Church, near Taunton, in Somersetshire.

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 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.

C. M. WATSON.
J. E. EDMONDS.

TRANSCRIPTS.

BRIDGING BY NIGHT, WITH UNPREPARED MATERIAL, AT STRASBOURG.*

By VON ANDERSCH, *Captain and Compy. Comdr. of 1/15 Alsatian Pioneers.*

THE Bridging in the following description was carried out at last year's spring inspection of the Battalion, and deserves close attention on account of the results achieved.

I. GENERAL AND SPECIAL IDEAS.

The following were the General and Special Ideas of the operations:—

GENERAL IDEA.

A Blue Besieging Force has taken the south front of the line of forts at Strasbourg. The Red Garrison is continuing the defence energetically in a prepared intermediate position—(right) Fort Bismarck—north bank of the Breusch R.—new railway embankment—Musan—pumping station of the waterworks—the Rhine† (left).

SPECIAL IDEA, RED.

By the 10th of April the attack on the intermediate position is so far advanced that an assault may be expected at any moment. The artillery of the left detached wing (Kehl-Strasbourg railway to the Rhine) was mostly in position on Sporen Island (between the main stream and the Lesser Rhine on the west), and was nearly silenced. A howitzer brigade, which so far had suffered little, had remained in position on the left bank of the Lesser Rhine, about 500 mètres south of the Kehl railway, behind the high embankment.

The O.C. Section intended to withdraw this brigade at early dawn on 11th April to a new position on Sporen Island. But as the bridges leading over the Lesser Rhine were finally destroyed by the Blue artillery during the afternoon of the 10th April, it became necessary to build a military bridge immediately. For this purpose the Governor sent a Pioneer Company from the Pioneer Reserve to the O.C. Section.

* From *Kriegstechnische Zeitschrift*, No. IV., 1907.

† The Rhine runs south to north along the east side of Strasbourg.

II. SECTION ORDERS.

The O.C. Section issued the following orders:—

RHEINLUST, 10. 4. 06, 7.30 P.M.

SECTION ORDERS.

1. The enemy, whose artillery has this afternoon finally destroyed the previously badly damaged bridges across the Rhine, is so far advanced with his attack that the assault is momentarily expected.
2. The troops of the Section remain for the present in the Intermediate Position. They will, however, make preparations immediately for a quiet retirement on Sporen Island, and there come into action again with flanking fire.
3. The 3rd Howitzer Brigade, now stationed on the left bank of the Lesser Rhine, will move over this before daybreak, by a bridge which will be made, to a new position on Sporen Island, for which the O.C. Brigade will choose a site. The result of his inspection will be communicated to me.
4. The Pioneer Company attached to me from the Pioneer Reserve will build the bridge to-night with the practice material of the 19th Pioneer Battalion, which lies near the Lesser Rhine. The bridge must be available from 5.30 a.m. onwards, and is to be prepared for demolition after the passage of the howitzer brigade.
5. The Pioneers belonging to the Section will select a site for a Work to cover the bridge under the protection of the railway and river embankments; and they will construct the work and defend it with the help of the 1/II. Reserve Infantry Regiment.
6. O.C.s 1/II. Reserve Infantry Regiment, Howitzer Brigade, Company from Pioneer Reserve, and Engineers of the Section, will report to me at 10 p.m. at the intersection of the railway and river embankments.

(Signed) A.,
Colonel Comdg. Section.

III. PRELIMINARY RECONNAISSANCE, ETC.

1. ALARM OF THE PIONEER COMPANY, AND CONSEQUENT MEASURES.

At 8 p.m. the order of the O.C. Section reached the O.C. Pioneer Company of the Pioneer Reserve, which was quartered in the barracks. The Company was at once alarmed, and marched out with a strength of 4 officers (including O.C.), 12 N.C.O.s, and 98 men. It reached the practice ground of the 19th Pioneer Battalion near the Lesser Rhine at about 9 p.m.

While the Company got ready for work, and tools were issued from the depôt under the supervision of an officer according to the instructions of the O.C., a reconnaissance of the watercourse and of a site for the bridge was made by the senior subaltern.

At the same time the O.C. had the available materials sufficiently tested, so that he might decide on the method of construction when he had received the reconnaissance report.

2. RECONNAISSANCE.

(*a*). *Description of the Channel.*

The stream, which is at this time of the year nearly dry, has a width from bank to bank of 157′, while the width of the water is only 115′.

The greatest depth of water was 2′ 11″, but it was generally less. The great difference between the width of the water and the width between the banks made it obviously necessary to raise the roadway considerably above water-level; the height above water-level was about 10′ 10″. The banks—really parallel mounds—are regularly faced with squared stones to below water-level; the bottom is coarse gravel.

(*b*). *Description of the Site.*

When we consider the first position of the howitzer brigade and the new position to be taken up on Sporen Island we notice for the site of the bridge the prolongation of a raised road, which is at the same level as the top of the banks, while the surface of Sporen Island lies about 3′ 4″ below that of the road.

The approach to the bank on the near side is also favourable for the howitzers, as the top of the bank for about 110 yds. up and down stream of the proposed site is pitched with stones. The site lies to the side of and in rear of the right wing of the position of the howitzers, so that it would not be affected by fire aimed at them. The site certainly lies somewhat inconveniently for the bridging material, as it would have to be carried 220 yds., but against this can be set the suitability of the site for bridging and the ease of dismantling.

(*c*). *Description of Material and Tools available.*

Except for a number of pontoons, which were stored in the supply canal of the pumping station, no boats were available.

As to timber, round and square spars of the most varied strength and length, planks $1\frac{1}{4}''$ thick, and poles of every size, were to be had in considerable quantities. The square scantlings, $7'' \times 7'' \times 19'\ 6''$, were specially suitable for road-bearers; and the $7\frac{3}{4}'' \times 9\frac{3}{4}'' \times 16'\ 6''$ as standards.

Carpenters' tools, especially those most required for temporary bridge work without wrought joints, were stored in plenty in the depôt, and were completed by a few hand pile-drivers and a pile-driver from the Pontoon equipment. This latter pile-driver, which consists of three sections bolted and screwed together, can be taken to pieces, when each section forms a light, handy pile-driver of about 77lbs. weight (*Fig.* 1).

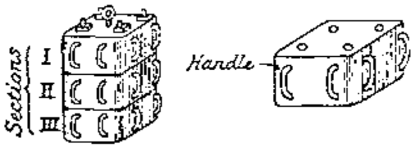


FIG. 1.

(d). Sketch of the Design.

Acting on the above reconnaissance, and bearing in mind the materials available, the design was got out so that the conditions of the Orders could be fulfilled.

The demand was for a bridge to carry weights up to 3 tons (wagons 3 tons, howitzers $2\frac{3}{4}$ tons); so that it would be no good to use anything but very strong supports, *i.e.* pile or trestle piers. Considering the height of the bridge above water-level, and that owing to the shallowness of the water the use of boats carrying the Pontoon pile-driver was almost impossible, the combination of double pile-piers driven by hand and trestles fixed on them was found to be the most practicable.

The use of the $7'' \times 7'' \times 19' 6''$ baulks as road-bearers determined the position of the piers at $16' 5''$ apart. The subsequent fixing of suitable centre supports under the baulks reduced the span considerably, so that a margin of safety was attained.

The available scantlings of $7\frac{3}{4}'' \times 9\frac{3}{4}''$, as well as the spars of $7\frac{3}{4}''$ diameter, worked in well with the $16' 5''$ spans.

A rough sketch of the design was made in accordance with the above, and work was begun at 9.30 p.m.

According to orders, the O.C. Pioneer Company sent a short report to the O.C. Section, who approved of the arrangements which had been made and already begun.

IV. DETAILS OF THE CONSTRUCTION.

1. STAGING FOR PILE-DRIVING.

The next thing to do was to erect a staging for use in driving the piles, so arranged that as far as possible all the pile-piers could be taken in hand at the same time, utilising a quantity of men with the 5 hand pile-drivers and the 3 sections of the Pontoon pile-driver. Trestling available from the Pontoon equipment came in usefully.

By utilising a floating platform of pontoons a 7-bay trestle bridge was built, 38 yds. long, with a temporary decking at $4' 1''$ above water-level (*i.e.*, $14''$ above the tops of the legs of the pile-piers), so that the pile-drivers might be used easily and with advantage upon the legs, which at first stood a good way out of the water.

The distribution of the Company for this part of the work was as follows:—

Party with floating platform ...	1 Off.,	1 N.C.O., 14 men.
Trestle party	1 "	1 " 10 "
Baulks		1 " 10 "
Chesses		1 " 16 "
Totals	2 Off.,	4 N.C.O.s, 50 men.

The remaining 1 officer, 8 N.C.O.s, and 48 men were at once set to bringing up the available standards, shore-baulks, and material for making crosspieces and trestles.

It may seem strange at first that the Company was not detailed by sections. The O.C. deliberately refrained from adopting this course, as the bridging was a special piece of work in which it was necessary to make use of the most suitable men in the right places, the more so that last year's recruits were new to the work.

This part of the work took 30 minutes (9.30—10 p.m.).

2. BUILDING THE DOUBLE PILE-PIERS AND SHORE-ENDS.

Table of working parties:—

Near shore-end	1 Off.,	1 N.C.O.,	16 men.
Far shore-end	1 "	2 "	16 "
Seven pile-driving parties, for pile-piers	1 "	7 "	42 "
Timber party, for making the trestles		1 "	14 "
Making crosspieces for the pile-piers, and brackets for holding the crosspieces and trestles steady		1 "	10 "
Totals	3 Off.,	12 N.C.O.s,	98 men.

The shore-end at the near side consisted of a bay of 14′, with a 3-legged pile-pier at the end and a 4-legged trestle as a centre support. By taking up the stone pitching the shore transoms were sunk low enough to be level with the bank. The trestle was also somewhat sunk into the slope of the bank in the same way, and strongly fixed by stakes. The pile-pier was partly dug in, and partly driven. A cross-strutting of planks gave this bay additional security.

The further shore-end consisted of a bay of 16′ 5″, with the end and centre support each of a 3-legged pile-pier. Otherwise the construction was the same as on the near side.

For the design of the pile-piers and the trestles of the shore-ends the officers received the accompanying sketches (*Figs.* 2 and 3).

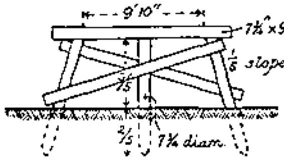


FIG. 2.

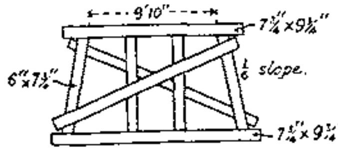


FIG. 3.

The party for driving the double pile-piers got to work almost at the same time, having prepared and brought up the legs, which the officers had chosen of suitable length.

The length of pile driven into the river bed was about the same as that which projected above it, as this was considered sufficient for the object in view; especially as at the end of the driving the piles shook imperceptibly. The piles had to be driven in so deep that, reckoning the thickness of the cap-sills at 9¾″ and of the crosspieces at 6″, the height over all would be 4′ 3″ to bring the head of the pile 2′ 11″ above water level.

The officer received a sketch of *Fig.* 4 as a guide.

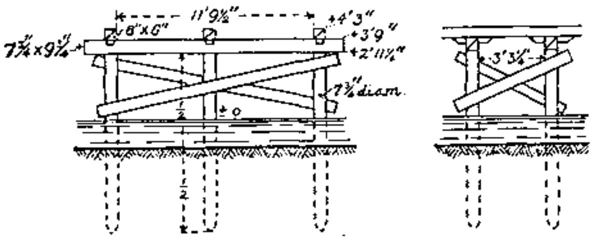


FIG. 4.

Three parties were each furnished with a four-man hand pile-driver; three others each with a section of the Pontoon pile-driver; the seventh party with two light two-man hand pile-drivers.

After the piles were driven, the cap-sills were at once brought up, and each pair was clamped together by the cross-pieces.

At the same time the 7 trestles were got ready, the N.C.O. having received a sketch of *Fig.* 5.

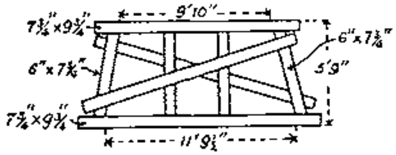


FIG. 5.

The completed trestle was then carried out, by each piling party, to the pile-pier prepared for it, commencing from the further side.

This part of the work took 3¾ hours (10.15 p.m. to 2 a.m.).

3. ERECTING THE TRESTLES AND SUPERSTRUCTURE.

For this work the Company was told off as follows:—

Erecting the trestles	1 Off.,	2	N.C.O.s,	8 men.
Cross-bracing trestles		2	„	16 „
Laying and fixing the road-bearers and planking	1 „	2	„	10 „
Carrying road-bearers		2	„	20 „
Carrying planking		2	„	20 „
Bringing up sills and piles for the intermediate piers and side struts	1 „	1	„	16 „
Erecting the piles		1	„	8 „
Totals	3 Off.,	12	N.C.O.s,	98 men.

The strongly braced trestles were erected on the middle of the pile-piers, commencing at the near bank, and the ground-sill fastened firmly on to the cross-pieces by brackets.

The cross-bracing party at once braced the trestles together by means of short spars laid lengthways, fixing the spars as longitudinal stringers between the pile-piers on each side of the bridge. They also gradually dismantled the temporary trestle bridge.

The five road-bearers were laid and fixed with 9′ 10″ interval between the outside baulks. The planking was formed of a double layer of 1½″ boards, as there were no planks thick enough available.

Stout boat-nails and lashings were used to secure the cross-bracing.

This work took 1½ hours (2 to 3.30 a.m.).

4. COMPLETING THE SUPERSTRUCTURE WITH RACK-LASHINGS AND RAILS. INSERTING THE INTERMEDIATE PIERS AND SIDE-STRUTS.

Working parties:—

2 parties to drive and complete the 7 2-legged intermediate pile-piers	1 Off.,	2	N.C.O.s,	20 men.
2 parties to drive the side-struts for the 7 trestles	1 „	2	„	16 „
2 parties to brace the intermediate piers to the main pile-piers ...		2	„	16 „
For rails and rack-lashings, including carrying materials	1 „	2	„	20 „
		4	„	26 „
Totals	3 Off.,	12	N.C.O.s,	98 men.

The two piles of each intermediate pier were driven from the deck, each of the two piling parties using one heavy hand pile-driver and one section of the Pontoon pile-driver. The prepared cap-sills were immediately inserted and secured.

Simultaneously with this work, two other parties drove piles on each side of the trestles, for side support; one party used a heavy hand pile-driver, the other used one of the sections of the Pontoon pile-driver. The fixing of the pile-struts to the trestles by means of dogs and lashings followed.

The parties told off for cross-bracing braced the intermediate piers, on both sides of the pile-piers, lengthways of the bridge.

For bringing up the rack-lashings and rails all available men were used, besides the parties allotted to the work.

Racking down followed. The ribands were bound to the corresponding road-bearers by means of wedged-up wire lashings, about 4 lashings for each bay on either side.

The rails were made from round stuff. The uprights were driven in to the river bed, and lashed to the spars nearest them; the rails were secured with wire at about the height of the hips.

This work took $1\frac{1}{2}$ hours (3.30 to 5 a.m.).

V. CONCLUDING REMARKS.

The whole time taken over the work was $7\frac{1}{2}$ hours. There was fairly bright moonlight after 10.30 p.m., so that arrangements for artificial lighting were not required.

The result arrived at may be considered as satisfactory, for the last-joined men had not, up to the time of the exercise, been instructed in this technical work and could therefore only be used as assistants.

In any case the result shows that, even with partially trained men, a well-trained staff that is practical and intelligent and a commanding officer with experience and a faculty for good organisation are the essential factors for producing good technical work.

E. G. GODFREY-FAUSSETT.

NOTES ON THE EXECUTION OF WORKS AT PORT ARTHUR.*

THIS article gives many interesting details of the work of putting into a state of defence that portion of the fortified zone which extended from Battery A to Fort No. III. (Erlungshan) inclusive.

The rôle played by Port Arthur during the campaign has once more turned attention towards the effect of fortresses in war. Even with the very poor means of defence with which Port Arthur was provided, the garrison by their unequalled steadfastness succeeded in occupying for eleven months a hostile army of 100,000 men, and thus gave the field army time to concentrate.

But the strength of a fortress lies chiefly in the condition of its works. By their condition at the time of the outbreak of war the possible period of defence can be predicted with a fair amount of accuracy.

The state of the works at Port Arthur on the 9th February, 1904, presented a melancholy picture. The declaration of war found the engineering works still far from completion. From various causes, but chiefly through the insufficient allotment of funds, many of the forts and batteries included in the approved design of the fortress were still unfinished, others were only just begun and on others again the work was not even started. This state of unreadiness necessitated the provision of an enormous quantity of defensive work during the mobilisation period, and it was found necessary by means of field fortification to make up as far as possible for the deficiency of permanent works.

This work was carried out by the fortress engineering staff with the assistance of the Kwangtung Sapper Fortress Company, the Fortress Telegraph Company, and the Port Arthur Mining Company.

The fortress engineering staff was detailed from the establishment of the provincial engineering staff of the Kwangtung Province. This latter staff up to the time of the outbreak of war had carried out all engineering works in the peninsula, but, in accordance with the mobilisation arrangements, it had marched out with all the central staffs of the Province to join the Manchurian field army.

The officers left behind to form the engineering staff of the fortress were as follows:—Chief Engineer, Colonel Gregorenko; Colonels Krestinski, Rashevski and Dukhnovski, and Capts. Lilye, Rodionov, Shwartz, Zedginidze, and Barmin. On these officers fell all the defensive arrangements of the region Kinchow—Port Arthur and also many engineering works which were in no way connected with the defence.

* Extracts from an article by Engineer Capt. Barmin, in the August, 1906, number of *Enzhenernee Zhoornal.*

For carrying out these works the fortress was organised in sections as follows:—

1. Capt. Shwartz was given the Kinchow position; and after its fall in May, 1904, he took charge of Fort Erlungshan and the open caponier (No. 3) lying to the east of it.

2. Capt. Zedginidze was detailed to prepare for demolition the wharves and harbour works at Dalny and the railway from there to Nangalin, and also to assist Capt. Shwartz.

3. Colonel Rashevski was given the sea front lying to the east of the harbour, and also the portion of the land front lying to the south of Battery A. Capt. Zaturski of the Naval construction staff volunteered as his assistant and was detailed accordingly.

4. Capt. Barmin received the section from Battery A to Fort No. III. (Erlungshan) inclusive.

5. Colonel Krestinski received the section from No. 3 (Sungshushan) to Fort No. IV., including the valley of the river Lun Ho.

6. Capt. Rodionov was given the section from Fort No. IV. to Fort No. V. inclusive.

7. The remaining portion of the land front and the coast defence of the Tiger's Tail were allotted to Capt. Lilye.

8. Colonel Dukhnovski up to March carried out the duties of assistant to the Chief Engineer and administered the engineer park, furnishing the necessary materials from the town to the various positions. But after this date he was obliged through illness to return to Russia and died there in the summer of 1904.

The central enceinte was divided between Colonels Krestinski and Rashevski and Capt. Lilye.

The preparation of detailed plans of the defence works had been begun in December, 1903, by the fortress staff, but at the time of the outbreak of the war they were far from complete. Consequently each of the Engineers had to prepare these detailed plans for his own section on the lines of the approved design of the fortress, and subsequently carry them out. The Chief Engineer's duty was to bring the various plans into conformity: in this he was assisted by Colonel Kanavalov, who was attached for a month to the fortress by the Viceroy of the Far East and who left it in the last train which succeeded in breaking through to the north.

Simultaneously with the defensive works the engineer officers were employed on other tasks not connected with the defences. For instance Capt. Barmin had to superintend the installation of a hot water apparatus in the general hospital and complete a new wing two storeys high, and also to commence the construction of bakers' ovens in the region occupied by the 10th East Siberian Rifle Regiment.

The construction of huts for the accommodation of the garrisons on the positions also gave a lot of trouble, as none existed, and the troops had to be sent there in January, *i.e.* at the coldest season of the year. At this time no splinter proofs had been made; but even later it was decided for hygienic reasons that the troops should not be quartered in splinter proofs until the arrival of the enemy. It consequently became necessary to make temporary barracks of the most simple type for men and officers. In this way there grew up at various points on the positions little wooden towns which were of great service in preserving the health of the men. After the close investment of the fortress, when the men were moved into the splinter proofs, these little towns were demolished and furnished a great quantity of useful material for splinter proofs, revetments, etc. In places, when left standing, they caused trouble by being set on fire by the enemy's shells; *e.g.* in Erlungshan and the Panlungshan redoubts during the bombardments in August.

Before long the civil engineering work in the town was handed over to volunteers from the Naval Construction Staff, and later on some of these officers took an active part in the defence.

At an early period the deficiency of skilled assistants made itself felt. In Capt. Barmin's section it was obviously a physical impossibility for one man to immediately superintend the works, which were being carried out in a great number of different places and were spread over a distance of 4 versts. The one Fortress Sapper Company was insufficient for such a large area and at the most important time, *i.e.* when commencing the works, Capt. Barmin had not a single assistant from the officers of the Company. Some of the foremen and supervisors who had been engaged on the works in peace time were posted by General Stoessel to the fortress engineer staff as assistants, and some volunteered, and did good work. Of these Capt. Barmin secured 8, of whom one was employed in procuring stores from the town and keeping diaries of the work, and three were so ignorant that they could only be used as gangers in charge of daily labourers. The remaining four had at first but little experience of field fortification.

It was decided to carry out the work by hired Chinese labour, sparing the troops as far as possible. The latter had heavy guard duties and were fully occupied with their training, their strengths having been made up with a large number of reservists who had forgotten many of their military duties and many of whom had never seen a magazine rifle. But it was particularly necessary to maintain the strength of the troops in anticipation of the fatigues of the siege, when it would be no longer possible to reckon on the services of the Chinese.

Throughout the whole time the work was audited by the Section Control, who verified the accuracy of the lists of labourers shown in the rolls, the measurements of the works, and the quantities of materials expended.

The natural characteristics of the Chinese frequently impeded the progress of the work. After the first sea fights in the neighbourhood of the fortress they were so nervous that even those working on the land front and at some distance from the sea ran away at the appearance of the Japanese fleet; and at first such interruptions were very frequent, for the enemy was constantly cruising within sight of the fortress. The cold and windy days of winter and the rainy days of summer also delayed the work, as on such days the Chinese could not by any means be induced to work.

Their chief incentive to work was good and punctual payment. Well understanding the weakness of the fortress, and constantly expecting the landing of the Japanese, who they thought would at once take possession, the Chinese required payment daily. This much delayed the work, but it was not possible to put a stop to this arrangement until April when the main works were nearly finished.

For entrenching tools the labourers usually brought their own, which was extremely fortunate on account of the hardness of the ground and the scarcity of tools in the fortress. This scarcity became very apparent when the troops had to go on the works.

The girdle of forts and the positions prepared in the intervals between them were on the crests and slopes of the hills and in these places the ground was very unfavourable. It consisted of hard beds of clay or rock covered in places with a 3″ layer of vegetable earth. In most places blasting was necessary, and sometimes in order to save time excavation was abandoned and the works were built up with earth carried from elsewhere. At the same time, although so difficult to excavate, the ground broke up under the action of the weather, forming landslips and making such obstacles as *trous-de-loup* useless.

The parapets of the works were made of the stony soil obtained from the excavations, and for protection against splinters they had to be covered with about a foot of soft earth. This soft earth was generally found in the ravines at some distance from the works, often from 700 to 1,000 yards away. The hill slopes were very steep, in places attaining 35°. As there were no roads, carts and wheelbarrows could not be used and the earth had to be all carried on small donkeys.

Every donkey carried a pack saddle, from which were hung two baskets, each capable of holding about 3 cub. feet of earth. One driver worked with 3 or 4 donkeys, loading up the earth and emptying it at the place ordered. An especially large number of donkeys were required for the construction of the Wolf Howitzer Battery, the Great and Little Eagle's Nests and Forts II. and III. In the latter (Erlungshan) it was necessary to coat with earth the whole interior of the Fort, as it was entirely excavated in rock.

The want of timber in Kwangtung and the thinness of the layer of vegetable soil made it impossible to use either brushwood or sods for revetting. The only suitable materials available were sacks and planks sawn from Chinese beams. At the beginning of the work the Chinese had in store a fairly large number of sacks filled with grain. But the supply was not endless, and towards the end of the siege it was exhausted, so that it became necessary to make sand bags of any material which could be purchased locally. At first they were cheap enough but later on they became very expensive. The Chinese sacks measured 3′ by 2′ or 1½′.

In view of a prolonged siege and an enormous expenditure of sacks, it was necessary to use them as economically as possible; and consequently the parapets were generally revetted with drystone walling with a crown of one or two rows of sacks. The sack revetments were sprayed with a solution of clay and water, as otherwise they showed up as a white ribbon.

Use was also made of empty cement casks for revetting, as a large number were available from the cement work in the forts and permanent batteries. The casks were placed like gabions and filled with earth.

These casks were also used to make temporary niches for artillery shells and cartridges. They were placed in rows (4′ or 5′ apart) perpendicular to the parapet, and covered with $2\frac{1}{2}''$ and 3″ planks with earth on the top. These niches, though not proof against the enemies' shells, at any rate protected the stores from the weather, and later on more permanent niches were constructed.

Both the sacks and the casks formed excellent revetting materials. But they required constant renewal, as the former rotted and the latter were frequently broken up by careless use.

The Chinese beams used for making splinter proofs measured about $8\frac{1}{2}'$ long and $10'' \times 13''$ in section. The length of the beams decided the breadth of the splinter proofs, and, allowing 9″ on each side for resting on the walls, gave a width of 7′. The splinter proofs were made with flat and sloping roofs, the latter being conveniently applied to the great Chinese Wall.

The thickness of earth on the level roofs was 3′. This was estimated as proof against 12 and 15-c.m. shells; but subsequent experience showed that it was not always sufficient, and that its efficiency depended on the kind of earth used. It was found that clayey earth gave the worst results; and that in such conditions it was advisable to place a layer of stones 1′ thick on the top of the earth, or else to cover it with 1″ or $\frac{1}{2}''$ iron sheets. This arrangement caused the Japanese shells to burst on the surface of the splinter proof instead of penetrating to some distance before bursting.

The insufficiency of transport soon became a serious consideration, especially of carts for carrying beams from the town to the positions. The distance averaged from $4\frac{1}{2}$ to $5\frac{1}{2}$ miles, on fortress roads which in places had fairly steep gradients. A one-horse cart usually carried 2 beams, and made 3 and occasionally 4 journeys in the 24 hours. When it is understood that the splinter proofs required one beam for each foot of length, some idea may be formed of the enormous number of carts required to bring up the materials for the roofs of splinter proofs and magazines and for the platforms for the naval guns. Little help was obtainable by hiring from the inhabitants, as they possessed very few carts.

Owing to the relative smallness of the garrison when compared with the size of the fortified area, it was determined that the character of the forthcoming defence must be simply passive and of long duration. This required a large provision of obstacles and of safe shelter for the garrison from the enemy's fire.

The fortress was encircled with obstacles from sea to sea. These were generally in one row, in places in two rows. The only suitable material available was wire. For economy the obstacle was made only about 10′ wide, on three rows of stakes. Even with this limit the whole stock of wire in Port Arthur was expended, and it became necessary to improvise by unwinding wire ropes, etc.

It had long been intended to make trial of an electric fence; and with this object a dynamo, giving a 3-phase current up to 3,000 volts, had been sent in to Port Arthur from Dalny. The idea was ingenious, but with the means available it proved to be of little or no use.

The details of its construction were as follows:—In front of the wire entanglement surrounding the infantry positions were stretched 3 rows of copper wire on porcelain insulators fastened to wooden stakes. The front row was 1′ 6″ from the ground, the second 2′ 6″, and the third 3′ 6″. The rows were connected in places by cross wires. The total breadth of the obstacle was about 14′. In each row there were occasional gaps of about 2′ 6″ in length; and to these the current was carried in insulated wires from distributing stations in splinter proofs behind the Chinese Wall, the stations in their turn being supplied by an armoured cable laid from the central station. Both the cable and the insulated wires were buried to protect them from splinters.

In Capt. Barmin's section there were only two distributing stations. The paucity of stations, necessitating considerable lengths of fence being supplied by one insulated wire, was due to the great scarcity of wire in the fortress and to much of the available supply having to be kept for use in land mines.

The results showed that, if one insulated wire was cut or the fence broken, a very great length was put out of action, and this happened in the very first bombardment. By the night of the 20th—21st August both stations in Capt. Barmin's section had ceased to work, and it was impossible to find the breaks and repair them.

Besides disappointing the great hopes that had been put in it, this obstacle had proved itself to be actually harmful. When the men understood the fatal effect of touching the wires, they were so afraid of them that no outpost would venture beyond them; consequently the enemy was able to approach unperceived, and to commence his attacks from much nearer than would otherwise have been possible. Indeed it was fortunate for the defenders that the fence was cut as soon as it was; and the earliest possible information of this was published to all the regiments, with a notice that they need no longer fear it and could in future push their outposts to a more useful distance to the front.

F. E. G. SKEY.

THE GRIFFITH WATER STERILISER.

By LIEUT.-COLONEL R. H. FIRTH, R.A.M.C.

(Transcribed by kind permission of the Editor of the *Journal of the R.A.M.C.*).

THE dominant rôle which water plays in the dissemination of disease on field service renders any means which secures purity of this alimentary essential a matter of the first importance to the soldier. Foremost among methods which claim to render water safe is boiling, or some subjection to heat. The sterilisation of water by ordinary boiling—that is, in open vessels—presents three main objections. These are:—(1) it is extravagant in fuel; (2) the water is rendered flat and tasteless owing to loss of dissolved gases; (3) the treated water is hot, and some time must elapse before it is sufficiently cool to drink, except as tea or coffee. These difficulties have suggested to workers in this field of preventive medicine the need of subjecting the water to treatment by heat in something other than an open vessel, whereby there might result not only an economy in heat applied, but the obtaining of a water at once sterile, cool, and containing a sufficiency of dissolved gases. The pioneers in attempts to solve this question practically were the French, who, some ten years ago, submitted the Maiche and Vaillard-Desmaroux apparatus, which we tested at Netley, only to find them unsuited, for reasons which one need not here discuss, to our wants. Following these machines came some designed by English makers and the well-known Forbes-Waterhouse apparatus, invented by the Americans, and used by their troops in the Philippine campaign, and to some extent also by ourselves in the late war in South Africa and in Somaliland.

All these machines were designed on the principle of heat exchange, which, as applied to the purification of water, depends on the fact that, with a sufficient area of metallic surface of good conducting capacity and sufficient time, a given quantity of liquid will yield nearly all its heat to an equal amount of the same liquid. Thus a volume of water at 100° C. will give practically all its heat to an equal volume of water at 15° C., the hot water being cooled down to about 17° C., and the cold water heated to 97° C., less the loss by radiation. The recognition of this principle was, of course, a great advance towards the practical sterilisation of water under service conditions, the essential features for the success of an apparatus being (1) lightness and portability; (2) rapidity and facility of operation; (3) ability to deliver a considerable volume of water; (4) ability to deliver a sterile but cool water. The earlier makes of machine failed chiefly in respect of (1), while some of the later types revealed the difficulty of reconciling (1) with (3) and (4). In fact, this is the real problem, how to get a machine at once portable and capable of yielding a considerable volume of cold water. Given portability, then, considerable volume of water is incompatible with cold water, and *vice* *versâ*, or the delivery of much and cold water means a weighty and cumbrous apparatus. Curiously enough, feature (2) has never been a difficulty, most machines being capable of quick and ready working.

Matters were in a very unsatisfactory state up to 1904, when it seemed as if we had reached finality, as represented by the Forbes-Waterhouse and Lawrence apparatus. In the autumn of that year Dr. Griffith called on us in the Hygiene Laboratory of the College and discussed the lethal temperature for various disease-producing micro-organisms common in water. It so happened that we had been making some observations in respect of this matter just previously, and our results were in accord with Dr. Griffith's own results, which clearly showed that a very short contact at a temperature definitely short of boiling point was sufficient to kill all the ordinary pathogenic bacteria associated with water-born disease. Our discussion led to that of practical means for the sterilisation of water by heat, especially for soldiers on field service, when Dr. Griffith told us that he had ideas for the making of a suitable apparatus, wherein the water was sterilised without submitting it to actual ebullition. We urged him to persevere and let the War Office have the opportunity of putting the steriliser to a practical test. In 1905 Dr. Griffith submitted his apparatus to us, and it was tested in the Hygiene Laboratory of the Royal Army Medical College with sufficiently satisfactory results to justify its being recommended for practical use by the War Office. The subsequent history is sufficiently simple, for, as the outcome of the inception of a School of Army Sanitation at Aldershot, where men of our own Corps are receiving instruction in the practical use of various apparatus and re-agents for the purification of water, we have been able to establish an experimental installation of four of the Griffith sterilisers at Whitehill, near Bordon, by which 250 gallons of sterilised water can be delivered hourly for the use of the garrison of that camp. The installation is in the charge of and worked entirely by a corporal and eight men of our own Corps, who not only sterilise the water, but pump it from the surface wells to the tanks. As this constitutes an absolutely new departure in our campaign against preventable disease in the field, and may serve as a type or example how newer methods may be applied to the purification of water in a fixed camp on lines of communication, a short description of the steriliser itself and its compound installation cannot fail to be of interest to both officers and men.

The essential novelty in the Griffith water steriliser is the recognition of the fact that an exposure of 15 seconds to a temperature of 72° C., or a momentary exposure of water to a temperature of 80° C., is sufficient to destroy all disease-producing micro-organisms that are conveyed commonly by water. The general appearance of the apparatus when fitted up is shown in *Fig.* 1, from which it will be seen to consist of two main parts, namely, a boiler or heater on the right coupled to a recuperator or cooler constructed on the heat exchange principle placed to the left. Above the cooler is a small supply reservoir, to which the water can be conveyed by hand or from a suitable tank or water-cart by means of the hosing, the flow of water through this duct being controlled by a screw tap and a ball valve. The heat is obtained from an oil lamp working on the pressure principle, placed beneath the heater within the door shown in the diagram; the various other parts are drawn in the same figure, and their general object will be understood from the following directions for the use of the apparatus. Place the heater and the cooler on a level piece of ground, about six inches apart, with the heater to the right. Connect the supply tank of cooler by means of the armoured tubing with the water-cart or tank. Connect the heater with the cooler by adjusting the rubber union H to the openings A and B, then turn on the water to the supply tank. When the heater is seen to be nearly full of water by inspection through the opening C, adjust the bent pipe G to the opening C and screw the gland home; place the lamp in position under the heater and light, or it may be lighted beforehand and then put in position, but it must never be put under the heater lighted unless the heater is full of water. Connect the expanded union I at E, taking care to have the expanded end around the aperture D in the heater; now connect the outlet pipe K with the opening F at the bottom of the cooler. As the water in the heater rises in temperature it will slowly pass through D, down the expanded union I to the cooler, but no delivery of water will take place from the outlet pipe K until the inner vessel of the cooler has filled with sterilised or safe water.

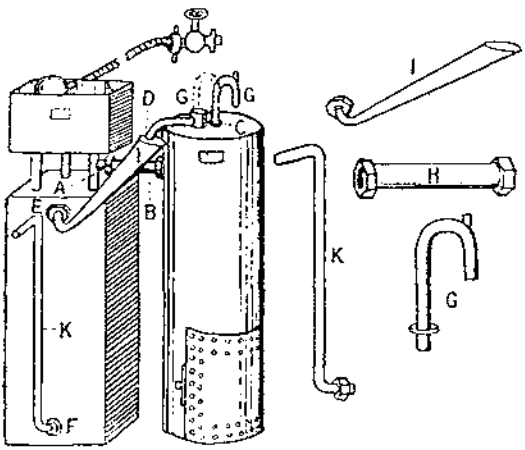


FIG. 1.

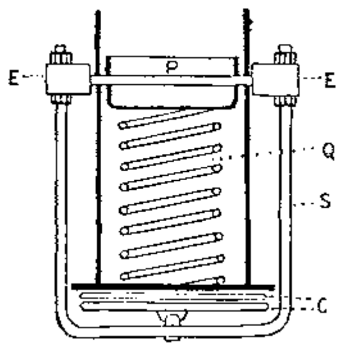


FIG. 2.

The vital part of the apparatus is the valve which controls the passage of water from the heater to the cooler, and which cannot be seen in *Fig.* 1, as it lies concealed within the heater. This valve is distinctly ingenious, and is so made that it expands or opens only when the water attains a temperature of 80° C., closing automatically when this temperature is not maintained. The general plan of this valve can be seen in *Fig.* 2, in which C are certain capsules made of copper containing a mixture of alcohol and ether. When immersed in water having a temperature of 80° C., these capsules expand or swell, and, being retained firmly by the stirrup S, against the bottom of the spring Q, force up the plug P, which again lifts or opens a valve, not drawn in this diagram. This arrangement of expanding capsules is conveniently controlled or adjusted by manipulations of the screw nuts over and under the ends of the crossbar E, and once accurately adjusted require practically no further attention, beyond occasional inspection to see that the capsules are sound and in position. If the capsules or the spring require renewal they can be readily replaced from the spare parts supplied with the machine.

Continuous trial of this steriliser at the School of Army Sanitation, when worked by non-commissioned officers and men of our Corps undergoing instruction in practical sanitary duties, has demonstrated its efficiency and facility of application. The whole apparatus packs conveniently into two boxes, one containing the heater and lamp (full of oil) and weighing 80 lbs., the other containing the cooler and weighing 84 lbs. These can be unpacked, the steriliser put together, coupled up with a supply tank, lamp lighted, and sterile water obtained, flowing from the outlet pipe, in fifteen minutes. This has been done over and over again by the men under instruction. The flow of water is wonderfully regular, the minimum delivery being never less than 60 gallons an hour; frequently it is at a rate of 68 gallons an hour; the rate of flow is dependent obviously on the amount of heat used and whether the lamp is burning well. This it generally does, even in a fresh breeze, but if oil needs renewing such an interruption for a few minutes reduces naturally the delivery in a given period of time. The temperature of the water at D, that is, when it leaves the heater, varies from 82° C. to 85° C. The temperature of the finished water at the outlet pipe is usually 9° C. higher than that of the original ingoing water when the delivery is kept at 60 gallons an hour; if the delivery is pushed, say, to 68 gallons an hour, the difference in the temperatures between the ingoing and outgoing waters may be as much as 15° C., but in all cases the water is sufficiently cool to be drunk at once. The capacity of the lamp for oil is 3½ pints if filled absolutely full; this is undesirable, as we find the optimum amount to be 3 pints. With care and an intelligent man in charge, this amount of oil will run the machine for two hours, but for practical or every-day working once filling of the lamp should be reckoned to run the steriliser for an hour and a-half, or, say, deliver 100 gallons of water. If oil is not available, the apparatus can be worked with wood as fuel placed in the position the lamp occupies in the heater. This is more troublesome to work than oil in the lamp, as frequent stoking is required. When ordinary wood is used as fuel, a delivery of 40 gallons an hour is obtained, but if the wood be sprinkled with kerosene, 75 gallons have been delivered in the same time. Our experience has been that men learn readily how to work the steriliser and to manage the lamp; the only drawback to a general use of this class of apparatus is the necessity of not using a muddy water; if a muddy water is the sole source of supply, it should be strained before being passed into this steriliser. In future makes of this machine it is expected that this difficulty will be overcome and a means provided for clarifying a water before passage into the supply tank.

As illustrative of the practical application of this steriliser to the needs of a fixed camp, such as on lines of communication, where the water supply needs purification before issue, the installation of four of these Griffith apparatus at Whitehill, near Bordon, is instructive. This camp, having only a small garrison of some 600 men, served as a convenient experimental station. The outside daily need of safe water of this camp was put at 800 gallons. With four machines at work, 250 gallons of safe water can be supplied readily per hour, or, roughly, three hours' daily working of all four sterilisers is sufficient to supply the daily water requirements of the garrison. *Fig.* 3 gives an idea of the general

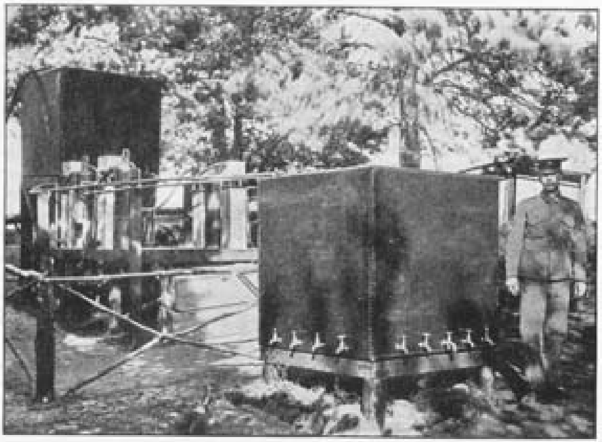


FIG. 3.

arrangement made; it is not ideal, but local material only was employed, and no attempt made to supplement the installation by drawing upon outside resources. Two 400-gallon tanks in local use were fitted on to wooden supports or stands by the Royal Engineers. One tank was placed five feet and the other one foot from the ground. To the upper tank were fitted the four stop-cocks belonging to the four sterilisers, each of the taps being coupled up, by means of its armoured tubing, to a steriliser. The other, or lower, 400-gallon tank was fitted with thirteen ordinary taps, arranged around three of its sides, to serve as points from which safe water could be drawn after passage through the sterilisers. These machines were placed on a rough wooden platform immediately between the upper supply and the lower delivery tank, their respective outlet pipes being connected by ordinary piping to this lower or delivery tank. The whole installation is in charge of a corporal with eight men. These nine men belong to our own Corps, have been instructed in the

Griffiths Water Sterilisers

working of these sterilisers in the School of Army Sanitation at Aldershot, and constitute a water squad for the provision of a safe and sterilised water to Whitehill Camp. In addition to having to work the actual sterilisers, this water squad pumps all water from the source of supply into the upper or supply tank; a corporal and eight men were allocated originally to this post, as it was felt desirable to run no risks of failure on account of too small a *personnel*, but experience shows that a corporal and four men would have sufficed. The following daily routine was laid down. Each evening the lower or delivery tank is filled with safe water from the sterilisers; this can be done in about an hour and three-quarters or a trifle less, while at the same time the upper or supply tank is filled by means of a lift and force pump. The two tanks are thus left full of water during the night, providing an ample supply for the early morning needs of the camp. As the lower or delivery tank is emptied, it is refilled from the sterilisers working for about a couple of hours during the forenoon, and the supply tank replenished by pumping up from the source. By this means the two large tanks are filled twice each day. Of course on some days there is less demand for safe water than on others; if so, the sterilisers need working for a proportionately shorter time.

The average consumption of fuel at Whitehill works out at about $2\frac{1}{2}$ pints of oil for each 100 gallons of water passed over. This is better than was anticipated. The success of the installation at Bordon has justified its transfer to Welford Camp, near Lambourne, where it will be used in connection with the Cavalry Brigade training. Two other sterilisers are being tried singly, each being used in connection with an ordinary tank water-cart at Oxney Camp.

So far this experimental installation has worked well. Of course, there have been minor difficulties, but these have been overcome by the good sense, zeal, and initiative of the corporal and men of our water squad in charge, and to them is due full credit for having made the installation a success. Further, not the least important lesson to be drawn from this experiment is that it shows how the problem of providing a safe and treated water for soldiers in camp is capable of solution by employing for this duty men specially trained in the use of the necessary technical apparatus; and that these men can be supplied from the Royal Army Medical Corps, whose function is clearly as much to prevent disease as it is to tend the sick. The due appreciation of this fact, and the proper and loyal co-operation of all ranks in furthering the evolution of the functions and aims of our Corps on these lines, is the pressing need of the hour. The intelligence and keenness for the work shown by the men who have gone through the school of instruction shows that we have good material at our command for these duties. The solution of the problem how to supply a safe water to troops on the field, using for this purpose not only sterilisers of this type, but all and every apparatus or re-agent which science indicates to be suitable for our needs, is now merely a question of time, organisation, and the provision of adequate equipment.

REVIEW.

THE WORK OF A RUNNING DEPARTMENT.

By H. SIMPSON.—(Pamphlet No. 71 of the *Transactions of the Swindon Engineering Society*, 1906-7. Price 1s. 6d.).

FEW people outside the staff immediately concerned, realise the immense amount of organisation required on a large railway system to ensure a fully equipped engine being ready to run whenever and wherever the traffic authorities require. Much has been written about the design of locomotives but little or nothing about their maintenance and the arrangements for the supply of coal, water, oil, etc.

This pamphlet therefore fills a distinct gap in the literature of the subject, for in it the author, who evidently has a large practical experience of the matter, has given the full details of the organisation of the Running Branch of the Locomotive Department of the Great Western Railway.

The pamphlet commences with an account of the organisation of the Personnel on the G.W.R. system, as shown in a sort of genealogical tree. This may be considered as typical, though the arrangement varies slightly on different Lines.

The author then proceeds to enumerate the various operations which take place from the time an engine comes off a train, and is left by the driver and fireman, till it goes out from the running shed again on another trip. These operations are given as:—

1. Examination by Engine Men.
2. Coaling (and Watering if necessary).
3. Cleaning Smoke Box.
4. Fire Dropping.
5. Tube Rinsing.
6. Cleaning.
7. Bar Laying.
8. Lighting Up.

Apropos of Coaling the remarks on the qualities of coal are instructive. In locomotives the draught is intermittent, and the punching effect of the blast produces the same results as poking an anthracite fire. With a bituminous coal this punching has the effect of keeping the fire open, and so utilising its binding qualities to the best advantage. The quality of the coal must be adjusted to the work the different engines have to perform, those with light work getting a hard coal, and those with heavier work requiring the coal to be mixed with a slower burning variety. This is not however always easy to effect, unless a large Coal Stage exists for mixing. The desiderata (p. 8) for such a stage are worth study by anyone called on to design one. Put shortly, they amount to this, that things must be so arranged that the coal can be tipped from wagon to tip truck or stage, and thence into the tenders, with as little handling as possible.

As regards Fire Dropping the author recommends that, where time permits, as much of the clinker as possible be shovelled out through the fire-door before knocking out any fire-bars. This is the more expensive method; but it prevents a sudden change of temperature in the firebox, and so saves the cost of making good the leakages of tubes, foundation ring, etc., which frequently occur when the usual method of dropping fires is adopted.

The author prefers the system of Cleaning in which each cleaner follows his own engine. No tallow should be used—merely oil and water, tallow being said to affect the varnish detrimentally. A useful table of stores required to clean engines of different sizes is given.

In his remarks on "The Ideal Shed" Mr. Simpson correctly states the fundamental principle for the design of a Running Shed and Yard, viz.:—"All shed operations can be done in proper sequence, and without necessitating a single back shunt." But the design he gives can hardly be regarded as more than the ideal shed fitted to the exigencies of a cramped site, which is what generally happens in practice. A "round" shed certainly economises space. But its successful working is entirely dependent on the turn-table; and certainly in India and the Colonies, where native staffs are employed, there is considerable risk of the turn-table, disabled through carelessness or accident, paralysing the working of the whole shed. Under these conditions a "run through" shed is to be preferred.

It will be noticed that Washing-Out of boilers was not included in the regular routine work carried out between trips. The reason for this appears to be that the water supply on the G.W.R. is so pure that it only becomes necessary to wash out after 5 or 6 trips; but this would not do everywhere—*e.g.* where canal water is used in India.

The author's remarks on Boiler and Engine Failures are well worth study, as the relation of the cause and effect of all the minor locomotive ailments is carefully gone into. Space forbids more than a passing notice of this matter and of the equally important ones of the preparation of engine links from time-table (on the G.W.R. this is now the work of experts, who do nothing else) and of accidents. The section on the latter includes a complete list of all the locomotive tools and plant which should be found in a Break-Down Van.

The records and accounts necessary for the proper control of Expenditure on Running Engines are very thoroughly dealt with. An appendix contains specimens, with explanations, of most of the forms in use on the G.W.R. for this purpose. This, together with the discussion on the paper by the members of the Swindon Engineering Society before whom it was read, is full of excellent and detailed information.

The pamphlet is well worth careful study by all R.E. officers who have charge of locomotives. It will also be found of considerable interest to that larger number who deal with the other branches—traffic, engineering, etc.—of railway work both at home and abroad.

E. P. ANDERSON.

NOTICES OF MAGAZINES.

Engineering News.

August 1st, 1907.

Waterproofing Coast Defence Structures.—Some methods which have been used in the U.S.A. The difficulties mainly experienced seem to be of the nature of percolation through the concrete; and to have been remedied usually by coating the top surface with some impermeable compound, such as "hydrolene," "Staso" liquid cement, linseed oil, commonly covered with tarred paper over which hollow tile is laid.

A leaking traverse was in one instance treated, after filling the cracks with cement, with a mixture, consisting of one part of white paraffin and two parts kerosene, laid on by brush at a temperature of 212° F., and smoothed with a hot iron. 2,400 ft. of surface absorbed 88 lb. of paraffin.

In another instance a leaky ceiling was treated with a mixture of 3 parts by volume of litharge, 1 part glycerine, 48 parts Portland cement, 48 parts sand. This makes a strongly adherent and dense plaster. The concrete was cleaned with a wire brush to form a key.

As regards condensation, linings are placed in order of efficiency thus:—

Hollow porous tile,
Porous brick,
Porous mortar ($\frac{1}{2}''$ coat),
Rough-finished concrete,
Smooth-finished concrete.

August 15th, 1907.

A Horizontally Curved Girder Bridge.—The line of the Metropolitan Railway, Paris, connecting the Place d'Italie and the Place de la Republique, crosses the Seine on a steel arch bridge. On the right bank the approach is curved and, in order to clear the quays, a bridge is necessary. This bridge has accordingly been constructed curved in plan, turning through nearly a right angle, with one intermediate pier and two spans (measured along the curved centre line) of 106 ft. and 124 ft. respectively. The radius of the curve is 246 ft. Instead of making the girders straight and spacing them sufficiently far apart to accommodate the curve of the roads, as has hitherto been the practice in such cases, they have been constructed curved in plan.

At the land end roller bearings are employed, at the two other supports there are pin bearings, the girders being continuous. It will be seen at once that, as the straight line connecting the points of support falls outside the centre of the curved span, considerable torsional stress must be set up: the design of the inside girder of the curve is consequently materially different from that of the outer one, and the cross frame plays a material part in stiffening the structure. The type of girder employed has Pratt trussing and is nearly 10 ft. deep, and the cross frame is of U plate form carried up to the top of the side members.

Although the general theory of the design of such a structure is discussed in an appendix to the article, to the extent of showing in general terms how the various stresses should be calculated, the details of the design are not very clear. One would like to know what nature of anchorage is adopted at the piers and abutments, as without anchorage the structure itself would apparently be barely stable. The sideway stress set up by a train moving round the curve at any speed has to be considered.

Altogether, the "technical difficulties and æsthetic considerations," which appear to have mainly influenced the designers in adopting this type of structure, do not seem to afford very strong grounds for such a big experiment.

A BATTER PILE-DRIVER.—This is an account of a pile-driver pivoted at the head, so as to allow of the guides being swung for driving inclined piles, as in trestle work. The machine is intended to be moved along the top of the trestle work, and to put in the whole set of piles for a trestle without being shifted. It has recently been in use on the C.P.R., putting in a bridge 3,600 ft. long. The piles were driven butt down.

CENTRE-BOUND TRACK.—This article opposes the practice of beating up ballast hard under the centre of sleepers. The author points out that, especially in frosty weather, this conduces to loosening of the outer ends of the sleepers, so that eventually the rails may loosen their fastenings and spread. But English practice is surely to beat up under the rails, and not under the middles of the sleepers!

August 29th, 1907.

LIGHT FERRO-CONCRETE BRIDGES AT VENICE, CALIFORNIA.—The use of ferro-concrete for three light bridges over a lagoon at this place has permitted the erection of lighter and more graceful constructions than would, in all probability, have been possible in other material. The largest span is 96 ft., and the type of construction is of arched parabolic ribs with panel filling and reinforced slab roadway.

The main ribs vary in depth from 26″ (including roadway) at the centre to 36″ at the piers. Vertical cross walls are carried up at the piers and at 13′ and 27′ from the piers. The roadway is in slabs of about 8′ by 15′.

The piers are in mass concrete resting on piles inclined so as to take the resultant thrust of the arches, and the abutments are similarly in mass concrete carried up to the waterline and thence continued by walls reinforced on the face side. Cofferdam construction was used in making the abutments and piers.

September 5th, 1907.

THE FAILURE OF THE QUEBEC BRIDGE.—This number contains a descriptive article and an editorial regarding this disaster. Pending a full enquiry it is of course not practicable to arrive at any final conclusion as to the cause. The view is expressed that, generally speaking, the fault lay neither in design nor workmanship.

The editorial opinion is, however, that "the initial cause of the wreck appears to be the failure of some compression member in the anchor arm of the cantilever." It seems to be clear that the failure did not primarily occur in a tension member,—the eye-bars of the upper chords are intact, unbroken, and still joined in a continuous chain. Suspicion is in fact narrowed down to a particular bottom chord, the ninth of the left truss, which was found lying apart from the remainder of the débris and distorted into an **S** shape. The calculated load for unit stress was taken as 24,000 lb. per sq. inch, and this particular member seems to have been intended to bear a working stress of 15,000 lb. per sq. in. Enquiry shows that the strut suffered several slight injuries in manufacture at the works and in transit to the site.

Again, it seems pretty clear from the time occupied—10 or 15 seconds—in the collapse of the bridge that failure was not due to a breakage. The cross bracing was complete for the length erected.

It must be borne in mind that the article was written only four days after the disaster, and that further facts may yet be elucidated. The lessons to be drawn from the failure have yet to be formulated, but the fear is expressed that much discredit will be cast on the professional and business reputation of the engineering profession in the U.S.A.

September 12th, 1907.

THE FAILURE OF THE QUEBEC BRIDGE.—Assuming that the initial failure occurred in the chord A9L (one of the bottom struts of the shore bay of the cantilever)—and nothing has come to light to contest the accuracy of the deduction—the next step is to consider "Why did the member fail?"

Although the bridge was only partially loaded and a considerable amount of superstructure was not in place, it is of course conceivable that stresses such as would not occur when the bridge was complete would be set up during erection; but it is shown that the calculated stresses were much below the calculated strength of the member.

Admitting that this particular strut was the initial point of failure—and we know that it had suffered one or two misfortunes in manufacture and transit—what caused it firstly to buckle out of line so much as to be detected by a watchful inspector, and secondly to give way entirely?

There are two possible answers:—1st that this particular strut was so defective as to fail and thus throw an unequal stress on its fellows; or 2nd that this member was typical of its class, and that, while it was the first to fail, all members of the class were also loaded to the point of serious danger. All the facts and circumstances, in the opinion of the *Engineering News*, point to the second of these being the correct answer.

It is almost pathetic that the editorial article should be headed "Our deficient knowledge of the strength of Long Columns." We have at least two compression members failing at a stress of some 8 tons per sq. in. though designed to bear a stress of about 12 tons per sq. in. It seems as if there must be some fault in the way the structures were built up.

Consider the construction of the compression chord members of the bridge. They each consist substantially of four massive plate girders, nearly 4′ 6″ deep, each built up of four rolled plates riveted together and finished with an angle at top and bottom; "and these four long thin (57′) girders are supposed to be stiffened and bound together by latticing on the top and bottom made of 4″ x 3″ 8½-lb. angles, so as to act as one girder."

"What does the Engineering profession know about stresses in column latticing?" "There is no doubt that the stiffening latticing *or web* that binds the parts of a strut together ought to be in proportion to the parts which it holds."

The latticing was in every case torn off the edges of this set of chords. In fact the conclusion is that the latticing was insufficient to resist the buckling tendency of the plates. Their sectional area may have been amply sufficient to resist the thrust, but their tendency to resist deformation under the load was insufficiently restrained by the bracing applied to their edges only. A correspondent urges that the failure points to the necessity of cellular construction in long struts.

The *Engineering News* holds that our ignorance of the stresses in columns of these vast dimensions demands experiment on a large scale, so that engineers may for the future have something more than theory to guide them in making their designs, and expresses the hope that such experiments will now be made.

It may not be out of place, in this connection, to draw attention to the comments on the failure made in *Engineering* of 20th September, 1907, which remarks that any further investigation of the behaviour of such long columns should include enquiry into their behaviour under eccentrically applied thrusts. It is easy to understand that a small irregularity, such as might be negligible in a small structure, may on a larger scale bring entirely uncalculated stresses into play. The pin and link type of construction so largely adopted in American practice as eliminating indeterminate stresses does not in fact obtain this advantage, for if the pins actually did rotate in their links at each change of load wear must be set up. To all intents and purposes, bearing in mind the frictional resistances involved, pin and link connected structures are just as rigidly connected as if riveted.

C. E. VICKERS.

MEMORIAL DE INGENIEROS.

April, 1907.

MESSING OF THE MEN OF THE 1ST MIXED REGIMENT OF ENGINEERS.—By Lieut.-Colonel Don José Madrid.—The article has been written in order to draw the attention of officers to the important subject of the food of the men in peace time.

Colonel Madrid goes exhaustively into the question of food values and the amount of nourishment required by a man performing hard work. The men of his regiment are on an average 22 years old, 5′ 6½″ in height, 34″·65 chest measurement, and 141 lbs. in weight. Such men lose daily 20·5 grammes (0·88 oz.) of nitrogen and 310 grammes (11·935 oz.) of carbon, to replace which it is necessary to digest 130 grammes (4·586 oz.) of proteids, 70 (2·47 oz.) of fats, and 550 (19·4 oz.) of hydrocarbons in the cold season; in hot weather the amount of fats should be reduced to 50 grammes (1·76 oz.) and of hydrocarbons increased to 640 grammes (22·575 oz.).

The idiosyncracies of the race determine to a large extent the nature of their food. In Spain the best results are obtained when at least one-third of the proteids are of animal origin and the fats half animal and half vegetable. Owing to the expense it is impossible to maintain this proportion in the rations of the men, and the amount of animal food has to be reduced.

In addition to the above each man requires daily 10 grammes (0·35 oz.) of common salt, and a minimum of 1 litre (1·76 pint) of drinking water.

The volume of the food is a matter of importance. It must not be too concentrated, or the stomach will not digest it properly. On an average the solids should amount to 1·750 cubic decimètres (106·8 cubic inches) daily, and the liquids to an equal amount.

The animal proteids should be derived from butcher's meat, either beef or mutton, in the proportion by weight of 50% meat (muscle), 25% fat, and 25% bone; the vegetable proteids from dry vegetables, chick peas and beans being the most usual.

The animal fats most easily assimilated are those of beef and pork, whilst olive oil is the best vegetable fat.

The hydrocarbons are provided by bread, rice, potatoes, and dry vegetables.

Besides these a part of the mineral elements and organic acids, which are necessary to perfect digestion, are supplied by green vegetables and fruits. These, although of very low alimentary value, play an important part in the assimilation of the other elements and in the expulsion of the useless residue; and they should therefore always be provided.

The following Table shows the composition of various alimentary substances:—

1,000 Parts by Weight.	Proteids.	Fats.	Hydrocarbons.
Beef with 25 °/₀ bone	150	100	—
Mutton	160	50	—
Pork with bone	170	250	—
Pig's head	110	150	—
Bacon	20	890	—
Sausage	90	720	—
Cod	260	10	170
Chick peas	120	20	740
Beans	290	20	550
Rice	70	7	770
Potatoes	20	2	210
Greens (average)	11	1	70
Troop bread	110	5	560
Olive oil	—	990	—
Sugar	—	—	960
Coffee (infusion)	75	5	150

From this Table—remembering that meat loses about half its weight when cooked and when the bone has been taken out; dry vegetables such as beans double their weight; potatoes lose about 25%; greens lose 40%; and rice quadruples its weight—it will be possible to calculate the amount of each kind of food that is required to provide the necessary nourishment. There are of course many practical difficulties, expense being not the least.

Most authorities agree that there should be three meals a day—two light, on rising and after sunset, and the principal one in the middle of the day. The following distribution is suggested:—

	Proteids.	Fats.	Hydrocarbons.	Calorics.
Breakfast	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{2}{10}$	20%
Dinner	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{4}{10}$	46%
Supper	$\frac{5}{10}$	$\frac{4}{10}$	$\frac{4}{10}$	34%

The following are a few bills of fare:—

1. *Breakfast for* 100 *Men—Potatoes and Pig's Head.*

(lbs.	oz.)	Kilo-grammes.	Articles.	Cost. pes'a. cent'o.	Proteids.	Fats.	Hydro-carbons.
110	3½	50	Potatoes @ 0·10 ... (42 nett)	5·00	840	84	8820
6	9¾	3	Pig's head @ 1·40...	4·20	330	450	—
1	5	0·600	Oil @ 1·02..	0·61	—	594	—
0	14	0·400	Salt @ 0·09	0·04	—	—	—
0	8¾	0·250	Pepper @ 1·00......	0·25	—	—	—
0	7	0·200	Flour @ 0·50	0·10	—	—	—
				10·35	1170	1128	8820
Result a ration of 370 grammes (13 oz.) per man.							
Ration of 370 grammes (13 oz)				0·1035 (about 1d.)	11·7 (180 grains)	11·3 (174 grains)	88·2 (3·14 oz.)

Various other types of breakfast are given, *e.g.*:—

Potatoes and cod providing 390 grammes (13¾ oz.) at a cost of 0·108 peseta per man.

Caparrones (a kind of bean) with pig's head providing 320 grammes (11¼ oz.) at a cost of 0·1115 peseta per man.

Beans and bacon providing 330 grammes (11¾ oz.) at a cost of 0·1145 peseta per man.

2. *Dinner for* 100 *Men—Soup and Boiled Meat and Stew.*

(lbs.	oz.).	Kilo-grammes.	Article.	Cost. p. c.	Proteids.	Fats.	Hydro-carbons.
14	5	6·500	Meat @ 1·30	8·45	975	650	—
5	8	2·500	Bacon @ 1·75......	4·37	50	2,225	—
23	2	10·500	Chick peas @ 0·57	5·98	1,260	210	7,776
52	14½	24	Potatoes @ 0·10...	2·40	400	40	4,200
5	8	2·500	Beans @ 0·70......	1·75	225	7	1,750
6	10	3	Greens @ 0·30 ...	0·90	33	3	210
2	3¼	1	Salt @ 0·09........	0·09	—	—	—
Result 350 cubic centimètres (about ⅝ pint) of soup, 370 grammes (13 oz.) stew, 25 grammes (⅞ oz.) meat, and 17 grammes (½ oz.) bacon per man.							
Ration				0·241 (about 2d.)	29·4 (453·7 grains)	31·3 (483 grains)	139·4 (4·9 oz.)

3. *Supper for* 100 *Men—Rice and Cod.*

(lbs. oz.).	Kilo-grammes.	Article.	Cost. p. c.	Proteids.	Fats.	Hydro-carbons.
16 8½	7·500	Rice @ 0·50	3·75	525	52	5775
44 1½	20	Potatoes @ 0·10...	2·00	340	34	3570
12 2	5·500	Cod @ 1·00	5·50	1,430	55	935
2·64 pts.	1·500l.	Oil @ 1·02	1·53	—	1485	—
(lbs. oz.). 0 10½	0·300	Salt @ 0·09........	0·03	—	—	—
0 10½	0·300	Pepper @ 1·00 ...	0·30	—	—	—
Result a ration of 500 grammes (17¾ oz.).						
Ration of 500 grammes (17¾ oz.)			0·132 (about 1¼d.)	22·9 (353 grains)	16·3 (251·5 grains)	102·8 (3·6 oz.)

Other suppers suggested are:—

Meat and potatoes providing a ration of 320 grammes (11¼ oz.) at a cost of 0·131 per man.

Rice and sausage providing a ration of 450 grammes (15¾ oz.) at a cost of 0·1345 per man.

Rice and loin of pork providing a ration of 470 grammes (16½ oz.) at a cost of 0·1365 per man.

The average cost of the three meals works out at 0·4845 (say 4¼d.) per man per day; and as fifty centimos (about 4½d.) are allowed for messing, there remains the sum of 0·0155 over. This is saved, and permits of a specially good dinner being served once a week, and in addition an extra special dinner once a fortnight. The suggested menus are:—

Special Weekly Dinner for 100 *Men.*—Soup, stew, and sausages. Similar to dinner 2, but with 11 grammes (½ oz.) sausage per man. The cost is 0·301 per man (about 2¾d.).

Special Fortnightly Dinner for 100 *Men.*—Rice soup, with sausage and estofado.

(lbs. oz.).	Kilo-grammes.	Articles.	Cost. p. c.	Proteids.	Fats.	Hydro-carbons.
26 7	12	Meat @ 1·30	15·60	1,800	1,200	—
2 3¼	1	Bacon @ 1·75......	1·75	20	890	—
3 4¾	1·500	Sausage @ 4·00 ...	6·00	135	880	—
13 3½	6	Rice @ 0·50	3·00	420	42	4620
79 6	36	Potatoes @ 0·10...	3·60	600	60	6300
5·28 pts.	3l.	Oil @ 1·02	3·06	—	2,970	—
1·76 ,,	1l.	White wine @ 1·25	1·87	—	—	195
(lbs. oz.). 2 10¼	1·200	Salt @ 0·09	0·11	—	—	—
		Fresh pepper @ 0·45	0·90	—	—	—
Result a soup ration of 350 grammes (12½ oz.), and another of estofado of 330 grammes (11¾ oz.).						
Ration of 680 grammes (24¼ oz.)			0·3605 (about 3¼d.)	29·7 (458 grains)	60·4 (932 grains)	111·1 (3·91 oz.)

In order to carry out this plan, especially where the dinner consists of two dishes, it is necessary to have a dining-room. The men are divided into messes of ten. The soup is brought in in a 5-litre (1 gallon) can and served out by the senior member of the mess; a similar procedure is observed in the case of the stew; but the meat and bacon are handed to each man individually by the serjeant-cook, so that each may receive his proper share.

On festive occasions special meals are served, and a ration of 250 centilitres (not quite ½ pint) of wine is issued at dinner.

Specimen diets for men engaged in the field, at schools of instruction, etc., are also given. The sum available is larger (about a ½d. per man), so that the meals are somewhat more liberal, and coffee is issued in the early morning or before night operations.

The food to which Spanish soldiers are accustomed differs very much from that eaten by our men, but the above will show what pains are taken by their officers in making the money available go as far as possible, and to provide as varied and as nourishing meals as can be given.

May, 1907.

THE SOLAR CHRONOMETER.—By Lieut. D. Rafael Aparici.—The description of a solar chronometer erected at Valencia, with tables and data for the construction of similar instruments at other places.

ABOUT MILITARY BIBLIOGRAPHY (àpropos of *The Campaign of Prussia*, by Commandante Ibáñez Marín).—Concluded from the March and April numbers.

APPLICATIONS OF WIRE NETTING.—By Capt. D. Rogelio Sol.—Taking as his text an article by M. Jules Duval, which appeared in the *Revue du Génie Militaire* in March, 1906, the author proceeds to describe various methods of employing wire netting in the construction of revetments, gabions, and fascines. Apparently M. Duval considered he was proposing something new, but iron wire has been used for these purposes for some years in Spain, and for many more years in the British Service.

MILITARY REVIEW contains a description of the twelve bridges thrown across the Yalu, its branches and tributaries for the passage of the Japanese troops during the battle.

SCIENTIFIC CHRONICLE.—The German Government has established a radio-telegraphic station at Nauen, near Berlin, which has obtained the following results:—Communication has been established with a vessel 1,500 miles distant, telephone messages have been received which were despatched from St. Petersburg, 850 miles away, Morse and telephone messages received simultaneously across a mountainous country despatched from a station 500 miles distant in Switzerland. The station consists of two stories built on a base covering an area of 100 square yards. In the upper story are installed the high-tension apparatus, and in the lower the dynamo, etc. A 35 horse-power engine placed in an adjoining building drives a mono-phase alternator coupled to an exciter. This generator, at 750 revolutions a minute, supplies 25 kilowatts of electrical energy, in the form of a mono-phase current of 50 cycles the second. There are four transformers and 360 Leyden jars, with a total capacity of 400,000.

The antena is formed of a metal tower 330 feet high, from the top of which, like the ribs of an umbrella, are fixed 54 cables, which trifurcate before reaching the ground, so that there are 162 metal wires, forming a surface of about 60,000 square mètres. The tower is in two parts. The upper part is 308 feet high in the form of a prism, whose section is an equilateral triangle of 13 feet side. The lower part is a tetrahedron 22 feet high, united by its base to that of the prism above described. Its vertex rests on a steel plate carefully insulated. The whole is supported by a concrete base. Thus the tower rests on a single point, and in order to keep it vertical three cables are attached to it at a point about 250 feet from the ground, and are firmly attached to masonry anchorages 650 feet from the base of the tower. These cables, in addition to being insulated in the ordinary way, are kept constantly covered with oil. The earth is formed by 108 buried wires radiating from a centre, which are further subdivided into 324, and cover an area of 126,000 square mètres.

The base of the tower is surrounded by a wall 6 feet 6 inches high, to hide what is the system of insulation adopted.

BIBLIOGRAPHY.—English edition of Moedebeck's *Manual of Aerostation.* Very favourably reviewed and in great detail.

CORPS NEWS.

'M.'

REVISTA DE ENGENHERIA MILITAR.

July, 1907.

THE FIELD WORKS CONSTRUCTED AT THE PRACTICAL SCHOOL OF ENGINEERING, 1906-7.—One of the most important works carried out during the spring course consisted in the defensive organization of the position of Cerrinho in accordance with a definite tactical scheme. It consisted of two lines, the first or main line being intended for the occupation of a battalion of infantry with two machine guns, which were installed on one flank. Fire trenches, approaches, and cover for the reserves were provided, and the front was covered by abatis and wire entanglements. Emplacements for machine guns, field guns, and howitzers, with the necessary shelters, were also constructed. The new German *Feldbefestigungs Vorschrift* and Deguise's *La Fortification Passagère* were taken as the text books in designing the works.

An interesting work was a fort of a type for use in colonial warfare in Portuguese Africa. The sides were formed by stockades, against which was banked up the earth excavated from a ditch 5 feet deep which surrounded it. The work was square in plan, and at two of its corners at opposite ends of a diagonal there were flanking works. One consisted of an octagonal 2-storied tambour and the other of a square blockhouse. Both had walls formed of double rows of timbers, the space in between being filled with earth.

Siege works and mining were also carried out.

NOTE ON THE CALCULATION OF BEAMS LOADED ON THE TOP AND TRANSVERSELY.—By Lieut. Ferreira.—The matter is treated mathematically with the aid of the calculus.

EXTRACTS FROM THE REPORT OF ENGINEER REGO LEINA ON HIS MISSION TO THE MINES OF CASSINGA, 1898 (*cont.*).—A description of the district of Bundambungo, with a map on the scale of $\frac{1}{250000}$, special attention being devoted to the geological features.

NEW TYPES OF ACCESSORY DEFENCES.—A translation from the *Revista Cientifico Militar* of a description of a wire entanglement used by the Russians in the recent war in Manchuria.

CHRONICLE of foreign military events.

'M.'

RECENT PUBLICATIONS.

Napoleon and the Invasion of England: The Story of the Great Terror, by H. F. B. Wheeler and A. M. Broadley. 2 vols. ($8\frac{1}{2} \times 5\frac{1}{2}$. 32s. net. Lane).

Waterloo. Reprint of Chap. V. of "Military History Applied to Modern Warfare," by the late Capt. J. W. E. Donaldson, R.F.A., and Capt. A. F. Becke, late R.F.A. ($8\frac{1}{2} \times 5\frac{1}{2}$. 2s. 6d. Rees).

Wellington's Campaigns, 1808–15; also Moore's Campaign of Corunna. Three Parts complete in one Volume. By Major-General C. W. Robinson, C.B. ($8\frac{1}{2} \times 5\frac{1}{2}$. 8s. 6d. Rees).

Les Grenades à Main et leur Utilisation dans la Guerre de Mandchourie, 1904–05, par Cap. M. C. Curey. (8vo. 1 fr. Berger-Levrault, Paris.)

The American Revolution, Part III. Saratoga and Brandywine Valley Forge—England and France at War. By the Rt. Hon. Sir Geo. Otto Trevelyan, Bart. (Longmans. 12s. 6d. net).

Summary of Tactics. Including Lessons of the South African and Russo-Japanese Wars. Compiled by Major J. Markham Rose, *p.s.c.*, R.M.A. 5th edition. ($7\frac{1}{2} \times 5$. 6s. W. H. Barrell, Portsmouth).

Searchlights: Their Theory, Construction, and Applications, by F. Nern. Translated by C. Rodgers. (7s. 6d. Constable).

Ventilation des Casernes Bétonnées, par Cap. Tricaud. (8vo. $1\frac{1}{2}$ frs. Berger-Levrault, Paris).

In Wildest Africa, by C. G. Schillings. Translated by Frederic Whyte. 2 vols. ($10 \times 6\frac{1}{2}$. 24s. Hutchinson).

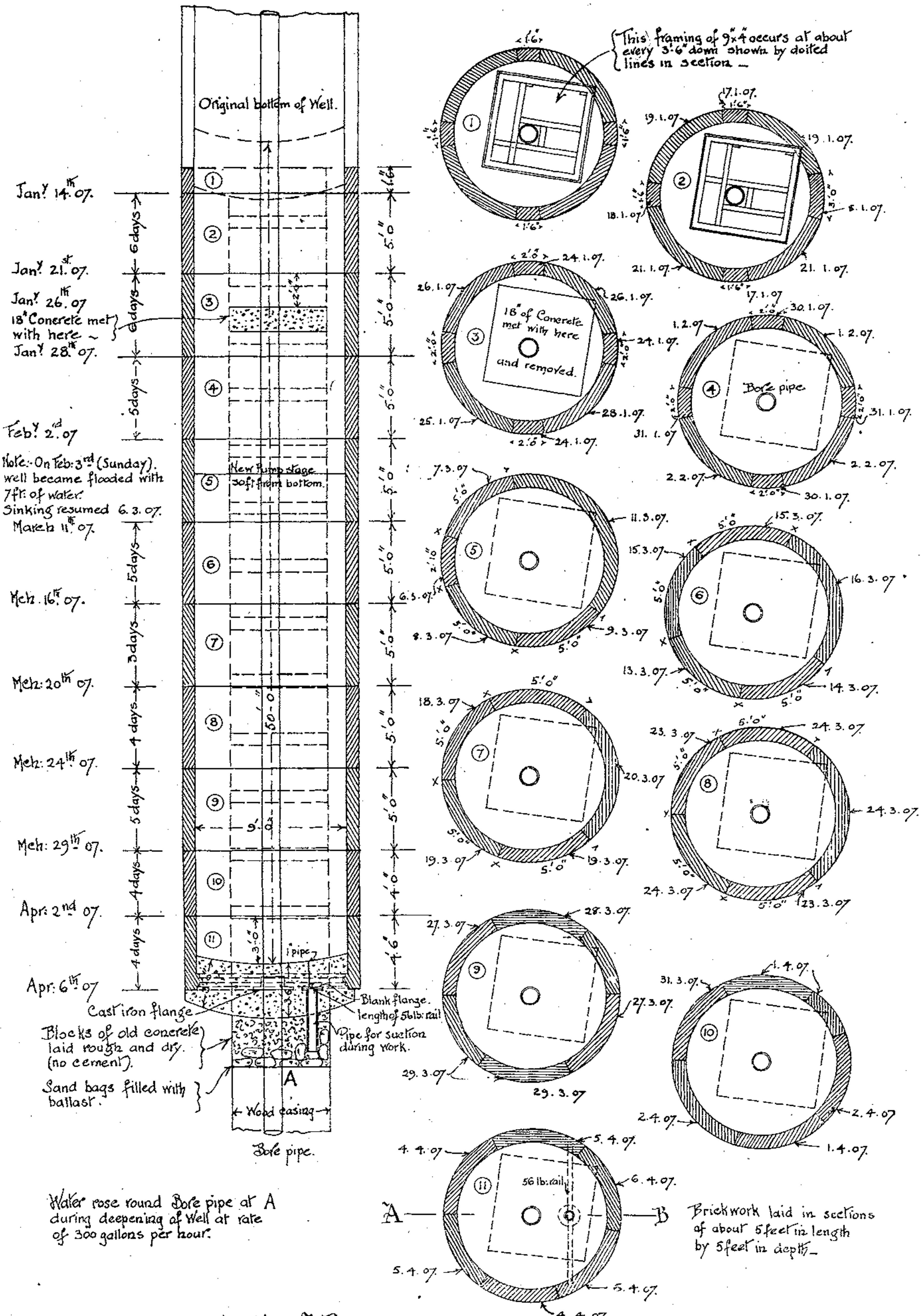
Neolithic Dew-Ponds and Cattle-Ways, by Arthur J. Hubbard and George Hubbard. 2nd edition. (10×7. 4s. 6d. Longmans).

The Letters of Queen Victoria. A Selection from Her Majesty's correspondence, 1837 to 1861. Published by authority of H.M. the King. Edited by A. C. Benson and Viscount Esher, G.C.V.O. (John Murray. 3 vols. £3 3s. net).

William Pitt—Earl of Chatham. Translated from the German by Mr. H. J. Chaytor, M.A. (Heinemann. 30s. net).

WELL AT SHOEBURYNESS.

DIAGRAM. C.



Water rose round Bore pipe at A during deepening of Well at rate of 300 gallons per hour.

Brickwork laid in sections of about 5 feet in length by 5 feet in depth.

Section A.B.

Plans.

SECTIONS.

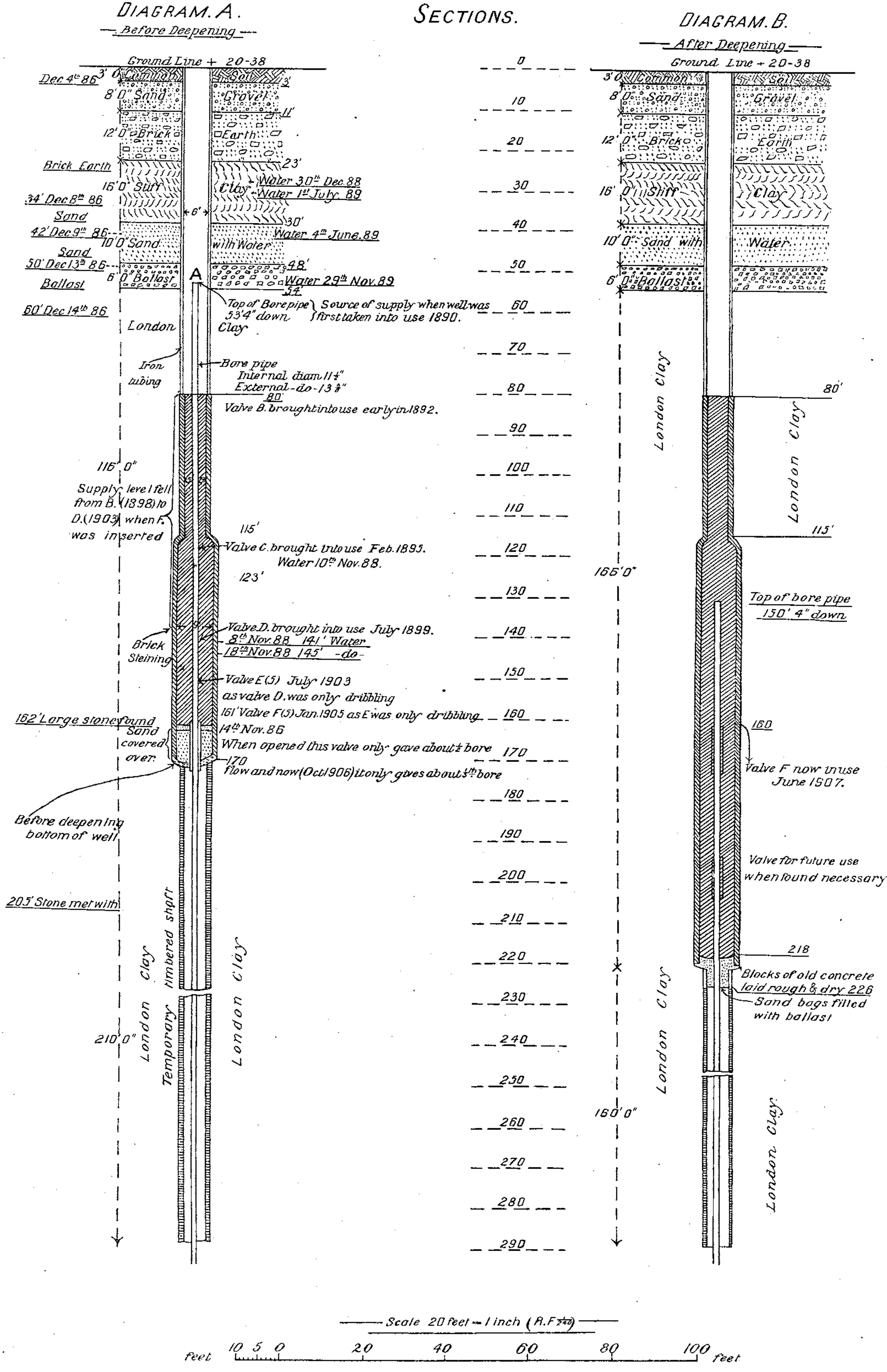


DIAGRAM. A.
Before Deepening
Ground Line + 20-38
Dec 4th 86
3' 0" Common Soil 3'
8' 0" Sand Gravel 11'
12' 0" Brick Earth 23'
Brick Earth
16' 0" Stiff Clay
Water 30th Dec. 88
Water 1st July 89
34' Dec 8th 86
Sand
30'
42' Dec 9th 86
Water 4th June. 89
10' 0" Sand with Water
Sand
50' Dec 13th 86
48'
Ballast
6' 0" Ballast
Water 29th Nov. 89
54'
A
Top of Bore pipe 53' 4" down
Source of supply when well was first taken into use 1890.
60' Dec 14th 86
London Clay
Iron tubing
Bore pipe
Internal diam 11½"
External -do- 13⅜"
80'
Valve B. brought into use early in 1892.
116' 0"
Supply level fell from B. (1898) to D. (1903) when F. was inserted
115'
Valve C. brought into use Feb. 1895.
Water 10th Nov. 88.
123'
Valve D. brought into use July 1899.
8th Nov. 88 141' Water
18th Nov. 88 145' -do-
Brick Steining
Valve E (5) July 1903 as valve D. was only dribbling
161' Valve F (5) Jan. 1905 as E was only dribbling
162' Large stone found
Sand covered over.
14th Nov. 86
When opened this valve only gave about ½ bore flow and now (Oct 1906) it only gives about ⅛th bore
170
Before deepening bottom of well
205' Stone met with
London Clay
Temporary timbered shaft
London Clay
210' 0"
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
DIAGRAM. B.
After Deepening
Ground Line + 20-38
3' 0" Common Soil
8' 0" Sand Gravel
12' 0" Brick Earth
16' 0" Stiff Clay
10' 0" Sand with Water
6' 0" Ballast
London Clay
80'
London Clay
115'
165' 0"
Top of bore pipe 150' 4" down
160
Valve F now in use June 1907.
Valve for future use when found necessary
218
Blocks of old concrete laid rough & dry 226
Sand bags filled with ballast
London Clay
160' 0"
London Clay
Scale 20 feet = 1 inch (R.F 1/240)
feet 10 5 0 20 40 60 80 100 feet

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