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CONTENTS.

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In 1725, the Lord Lieutenant and Council directed "Captain" Thomas Burgh, His Majesty's Surveyor General, and Captain John Perry to assist those appointed by the Ballast Board to examine and make maps and soundings of the harbour of Dublin.

Now as to the buildings which he designed, the first of importance was the Royal Barracks, Dublin, built in 1704. This building is described in *A Pocket Companion for Freemasons*, by William Smith, a rare book published in 1735,* as "the most magnificent, largest, and most comodious of the kind in Europe." The Barracks however then only consisted of the main square, and it is improbable that much of the original building remains.

His next work of importance was the old Custom House, now removed, which was erected in 1707, near the eastern side of Essex Bridge, on the south bank of the Liffey. The principal entrances were in Temple Bar and Essex Street, exactly opposite Crampton Court, there being also a side entrance down a flight of steps by the bridge.

The following description of this building is taken from Gilbert's *History of the City of Dublin*, Vol. II., p. 138:—

"The Custom House Quay was limited in length to the extent of the front of the Custom House, the two upper storeys of which, built of brick, contained each in breadth fifteen windows. The lower storey, on a level with the quay, was an arcade of cut stone, pierced with fifteen narrow arched entrances. A clock was placed in a triangular entablature, protected by projecting cornices, in the centre of the top of the northern front, on a level with which, on each side, there stood on the roof five elevated dormers surmounting the windows beneath them."

This building being too far up the river, was superseded by the present Custom House, which was built between 1781 and 1791 lower down the river on the opposite bank.

His greatest work, however, was the Library of Trinity College, Dublin, which is said to be the largest single room of its kind in cubic content in Europe.

In 1601 it was resolved by the Royal army under Lord Deputy Mountjoy to commemorate the successful termination of their siege of the combined Spanish and Rebel forces in Kinsale by establishing a Library in the College, which had been founded some nine years earlier by Queen Elizabeth; and they subscribed a sum variously given by different authorities as £700 and £1,800.

The "C.R.E." of this army was Capt. Josias Bodley, who was "mentioned in despatches" frequently for his services during the Siege.† He was subsequently knighted, and in 1612 was appointed

* *Caementaria Hibernica*, Fasc. II., by W. J. Chetwode Crawley, LL.D.
† *Hibernia Pacata*, by Thomas Stafford, 1633.

by Patent "Director General and Overseer of the Fortifications and Buildings in Ireland" for life, he "holding it by ye establishment before"; * for which he was to receive a fee of 20s. a day.

This Capt. Bodley was a brother of the Sir Thomas Bodley who founded the Bodleian Library at Oxford, and it seems more than probable that the Trinity College Library owed its suggestion to Capt. Bodley, influenced by his brother's example.

Thus not merely the building but the books themselves in all probability owed their beginnings to the "Engineers of Ireland."

In 1709, the old buildings being in a very bad condition, it became necessary to erect a new Library; and on June 1st of that year the Irish House of Commons, in recognition of the loyalty of the University, resolved "that this House . . . do address his Excellency the Lord Lieutenant that he will lay before her Majesty the humble desire of this House that £5,000 be bestowed by her Majesty on the Provost, Fellows, and Scholars of Trinity College, Dublin, for erecting a public library in the said College."†

This sum was granted, and on July 20th, 1710, a draft was delivered to Thomas Burgh, Engineer and Surveyor General, who accordingly prepared a design and estimate amounting to £7,140, "the wainscotting and the cases for the books" not being provided for. The original estimate was among the Southwell MSS.; ‡ but its whereabouts is not at present known, it being in neither the College Library nor the British Museum.

The foundation stone was laid on May 12th, 1712, and in 1717 the Irish House of Commons voted a further sum of £5,000, and again a like amount in 1721, towards finishing the building, which however was not completed till 1732. Dr. Madden states that the total cost, including fittings, was only £17,000, which seems very moderate for a building of this kind.

The building is composed principally of the "Long Room," which occupies the whole of the first and top floors of the main part of the structure; it is 209 feet 3 inches long and 23 feet 7 inches wide between the stalls, which are 8 feet 4 inches wide on each side, giving a total interior width of 40 feet 3 inches. The ceiling was originally flat and level with the impost of the present arched roof, giving a height of about 35 feet. The present fine wooden roof was erected in 1860 and gives a height in centre of about 48 feet.

At the eastern end of the first floor is the Fagel Library, running the full width of the end block, with a length of 28 feet 3 inches, while above and below it are storerooms for books.

* Privy Seal Royston, December 3rd, 1612. 10. 11. f. R. 28. Patent, January 29th, 1612/13. 11. James I. 1a. pars. d. r. 14.

† Stubbs' *History of the University of Dublin.*

‡ *Bibliotheca Southwelliana*, by Thomas Thorpe, Part IV., London, 1834, p. 252, no. 433.

LIEUT.-COLONEL THOMAS BURGH,

Chief Engineer of Ireland, 1700—1730.

From a portrait in the possession of Colonel de Burgh of Oldtown, Naas.

Lieut Colonel Thomas Burgh

LIEUTENANT-COLONEL THOMAS BURGH,

CHIEF ENGINEER OF IRELAND, 1700—1730.

By LIEUT. W. P. PAKENHAM-WALSH, R.E., R.S.A.I.

PREFACE.

THE first regularly appointed Military Engineer in Ireland was Thomas Burel, who was "Keeper of the King's Works of the Castle of Dublin" 1279—1285; and from him, with the exception of a break from 1441—1508, a period for which the State Papers of Ireland have not yet been edited, there is an almost unbroken succession down to Charles Vallancey, the Chief Engineer of the Irish Establishment at its absorption in 1801.

The Irish Establishment was definitely fixed on a permanent basis at 3 officers in 1669, the English Establishment having been fixed in 1660.

These officers performed both artillery and engineer duties till the separation of the Corps in 1716, when, following the English example, the Royal Regiment of Artillery of Ireland came into being, only to share the fate of being absorbed into the English Establishment at the Union in 1801. The third Engineer is however subsequently shown as "for duty with the Artillery."

In 1757 the Engineers in England, who had mostly held commissions in other regiments, as was also the case in Ireland, were given military rank as officers of the Corps; and Ireland followed suit in 1760.

The Irish Engineers became "Royal" in 1789, two years after the same honour had been conferred on the English Corps; and on the 1st April, 1801, the "Corps of Royal Engineers of Ireland" ended its separate existence by being absorbed into the English Establishment.

Other Corps of Engineers formed from time to time in the British Service were:—"King William III.'s Company," formed January 1st, 1696, and disbanded March 25th, 1700; the "Officers of the Corps of French Emigrant Engineers," 1794—1802; and the "Engineer Officers of the King's German Legion," 1804—1815.

Thomas Burgh came of a family which has always played a leading part in Irish History.

He was descended from Sir William de Burgh, surnamed Athankip, second son of Richard de Burgh, the "Great Lord of Connaught" and Viceroy of Ireland in 1227, who was the ancestor of the famous Irish family of de Burgh and Burke, Earls of Ulster, Clanricarde, and Mayo, and himself a descendant in the direct male line through Godfrey de Bouillon from Charles, Duke of Ingeheim, fifth son of the Emperor Charlemagne.

He was the third son of the Right Rev. Ulysses Burgh, of Dromkeen, Co. Limerick, Lord Bishop of Ardagh, and Mary, daughter of William Kingsmill, of Ballyowen, Co. Tipperary; and was born in 1670.

His father strongly supported the Orange cause in Ireland, entertaining William III. for three nights at Dromkeen, on his way to the Siege of Limerick; and Thomas Burgh himself saw his first service in the same wars in Ireland in 1689–91. In return for his own and his father's services, he was appointed to the Irish Engineers on February 27th, 1691, and he served as an Engineer in the Wars in Flanders, 1692–95. Later, on October 1st, 1696, he was posted as Engineer in King William's Company, and in 1698 he was Third Engineer on the Irish Establishment.

On the death of William Molineux and the resignation of William Robinson, who had jointly held the Office, he was appointed by Patent* "Chief Engineer and Surveyor General of His Majesty's Fortifications in Ireland" for life, an office he held till his death, December 18th, 1730.

He was an engineer and architect of no mean ability, and it is the object of this paper to describe some of his principal works.

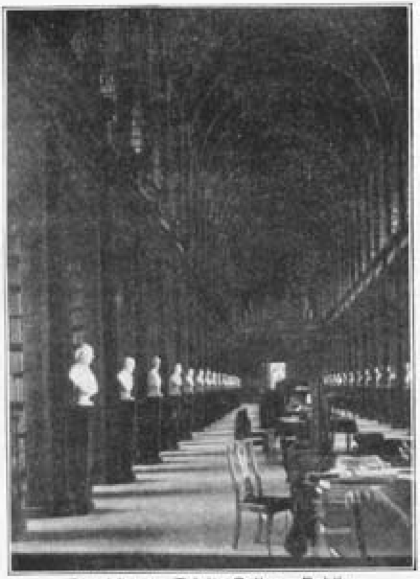
He purchased an estate for himself at Old Town, Naas, Co. Kildare, where he designed and commenced a magnificent mansion for his own use. The house was not completed to the original design; but the plans are still in the possession of his descendant, Colonel de Burgh, of Old Town, to whom I am indebted for the excellent portrait of the Chief Engineer.

He sat as Member for Old Town in the Irish House of Commons from 1715 to 1730.

He married Mary, daughter of the Rt. Rev. William Smyth, Lord Bishop of Kilmore; and was granted the rank of Lieutenant-Colonel, 11th April, 1706.

He published in 1724 "A Method to Determine the Areas of Right lined figures universally: Very useful for ascertaining the Contents of any survey."

* Privy Seal, Kensington, April 19, 1700, d. R. 18. Patent, Dublin, 10th July, 1700. 12. Wm. III., 2a. pars. f. R. 29.



The Library, Trinity College, Dublin.
Interior of Long Room.

The Library, Trinity College, Dublin.
Exterior, from the South-West.
Photo specially taken by G. Holmes, Esq.

Library at Dublin

The whole of the ground floor under the "Long Room" was originally an open colonnade, which was enclosed in 1891, the western third being made a reading room for students, and the remainder used for additional storage for books.

The western end is chiefly occupied by the Entrance Hall and Staircase on the ground and first floors, with a length of 29 feet 6 inches, the remainder being used as storage rooms for MSS., while the top floor of this end is taken up by the Librarian's Office. The total interior length exclusive of partition walls is 267 feet, while the exterior height is about 65 feet. The only part of the original buildings used in Burgh's Library are the curious oak staircases leading from the Long Room to the Galleries.

Under the Copyright Act of 1801 this Library has, with the British Museum, the Bodleian Library at Oxford, the Cambridge University Library, and the Advocates' Library at Edinburgh, the right to a copy of every printed book published in the United Kingdom. It contains many invaluable treasures, notably the famous illuminated MSS. called The Book of Kells, The Book of Armagh, etc.

Burgh's connection with the building of the Irish Houses of Parliament must be left for a future article on that edifice.

The following curious extract from "The New Book of Constitutions of the Most Ancient and Honourable Fraternity of Free and Accepted Masons," by Edward Spratt, 1751,* a very rare book, thus sums up Burgh's performances in architecture :—

"But when King *William* III., of ever Glorious and Happy Memory, (to this Kingdom) aſcended the Throne, vanqſuih'd its Enemies, and ſettled Peace among us, Maſonry began again to flouriſh, and the Arts and Sciences were well cultivated ; as may be ſeen in this and the ſucceeding Reign, by an excellent Cuſtom-Houſe ; a ſpacious and convenient Barrack for the Garriſon, the largeſt in all *Europe ;* a moſt magnificent and beautiful Library in the Univerſity ; with many other publick and private Buildings ; All under the Direction of *Thomas Burgh* Eſq ; Engineer and Surveyor General of all his Majeſty's Forts and Fortifications &c in *Ireland*, and a true and faithful Brother."

My thanks are due to Alfred de Burgh, Esq., Assistant Librarian of Trinity College and a descendant of the Chief Engineer, to Sir Thomas Drew, and to W. J. Chetwode Crawley, Esq., LL.D., for kind assistance and valuable information.

* *Caementaria Hibernica*, by W. J. Chetwode Crawley, LL.D.

DESIGN FOR AN AERIAL ROPEWAY.

By Capt. W. J. W. Noble, R.E.

This article is intended to show a method of designing an Aerial Ropeway up a hill 500 ft. high, for transporting men, water, and ammunition. Most of the information was obtained from Messrs. Bullivant & Co. (72, Mark Lane, E.C.), who have kindly lent the photo blocks illustrating ropeways constructed by them. I have also consulted descriptions of the ropeways at Gibraltar.

VARIOUS SYSTEMS.

The different systems for Aerial Ropeways may be divided into two classes:—

(1) Fixed Rope,
(2) Endless Running Rope.

(1). In the former class the carriers hang from a fixed wire rope, which acts as a rail, and are pulled up by another rope.

This system is suitable for very long spans, up to and sometimes over 1 mile, for steep inclines, and for heavy loads up to 15 tons. It would not be used for comparatively light continuous loads, so will not be considered further.

(2). In the running rope system the carriers hang from the rope and move with it, either (i.) by being rigidly fixed in position on the rope or (ii.) through frictional contact.

In both cases a driving gear at one end of the line is fitted with a 6-ft. or 8-ft. driving drum round which the rope passes. At the other end the rope passes round a similar terminal wheel, which is held back by a tension weight so as to keep a constant strain on the line. At points between the terminals the rope passes over pulleys fixed on trestles.

(i.). Rigidly fixed carriers are suitable for continuous light loads, say $1\frac{1}{2}$ cwt., very steep inclines, and sudden changes of level. The carriers are clipped to the rope by a steel band. Depressing pulleys can therefore be placed at any trestle without obstructing the passage of the carriers. But since the band has to be short to enable it to pass over the bearing pulleys, only light loads can be taken; otherwise the rope would get kinked. Also the carriers have to be loaded and unloaded on the move.

(ii.). In the other endless rope system the Λ-shaped friction grips, which rest on the rope and from which the carriers are suspended, are automatically disengaged on reaching the end of the line; and two small wheels, attached to the frame of the grip, then run on a rail along the platform where the carriers are unloaded (*Photo* 1).

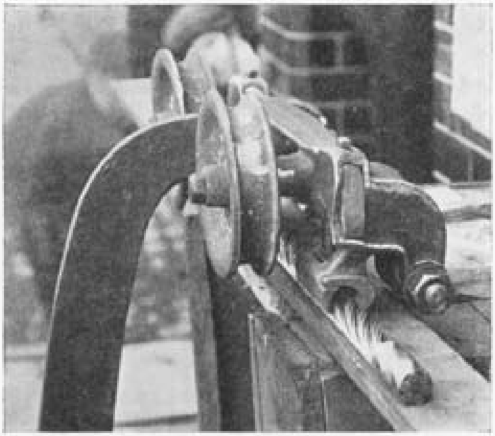


PHOTO 1.—*Friction Grip.*

This system is suitable where the quantity to be carried does not exceed 100 tons an hour in separate loads not exceeding 10 cwt., and where the gradient of the rope when loaded will not exceed 45°. Formerly this system could not be used for gradients exceeding 1 in 3, but Messrs. Bullivant have recently brought out an improved friction grip which will hold on much steeper gradients.

LAYING OUT THE LINE.

Let us assume that the maximum output required is to be 20 tons an hour, in loads not exceeding 3 cwt., excluding carriers (1 cwt.). This is equivalent to a load about every ½ min.; and either two men, or 33 gallons of water, or one 9·2" shell could be taken as a load.

The running-rope system would therefore be suitable as far as loads are concerned. The question is whether the gradient of the rope will exceed 45°; this will depend on the section of the hill.

If the hill is not too steep, it will be possible to make the line more or less conform to the section of the ground, supporting it on low trestles at moderate spans, say 100 to 200 yds.

FRICTION GRIP

If, however, the hill is very concave, the gradient of the rope can only be kept slight either by very high trestles or by *an extra long span over the concave part;* the latter will usually be the best plan.

Of course a long span produces greater sag in the rope, and if this makes the gradient excessive the sag must be taken up by increased tension. But the amount of tension is limited, for any addition means larger rope and larger terminal pulleys, thereby increasing the gauge of whole line and requiring heavier trestles throughout. Also more bearing pulleys are required on each trestle. All this raises the cost of the line. If the tension gets too great it will be better to use the fixed rope system.

The amount of *Tension* which must be put on a uniformly loaded rope between two trestles at any given span, so as to produce a gradient of 45° in the rope, can be calculated as follows.

It will be sufficiently accurate to consider the rope uniformly loaded. The carriers for a line delivering 20 tons an hour will be about 50 yds. apart. Just before a carrier reaches a supporting pulley the gradient at that point will get steeper, for which an allowance must be made; we may therefore assume that the gradient of the rope at the trestle is not to exceed $\frac{1}{2}$.

First suppose two trestles on the same level.

Then $$\tan\theta = \frac{4d}{a},^{*}$$

where d = dip,

a = span,

$\tan\theta$ = gradient of rope at one end.

$$\therefore \ \frac{1}{2} = \frac{4d}{a} \text{ and } d = \frac{a}{8}.$$

Also Tension $$= \frac{wa^2}{8d}$$

where w = wt. per yd. run

$$= \frac{wa^2}{8\frac{a}{8}} = wa \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1).$$

If one trestle is higher than the other the same formula applies; but a is taken as the distance between the higher trestle and the point where a horizontal line through the top of this trestle would cut the parabola formed by the cable, if produced beyond the lower trestle (*Fig.* 1).

e.g. Suppose that in the line under consideration it is necessary in one place to have a span 400 yds. long with difference in level of 150 ft.

* page 189, *Instruction in Military Engineering*, Part III., 1902.

20 tons per hour in 3-cwt. loads = 133 loads per hour. The rope travels 4 miles an hour; therefore the loads are $\frac{1760 \times 4}{133} = 53$ yds. apart.

Then 53 yds. of ropeway weigh 3 cwt. + wt. of rope (say 10 lbs. a fathom) + wt. of carrier (1 cwt.) = 713 lbs., *i.e.* wt. per yard = 13·5 lbs.

The value to be taken for a in a 400-yd. span with 150 ft. rise = 538 yds. (*Fig.* 1).

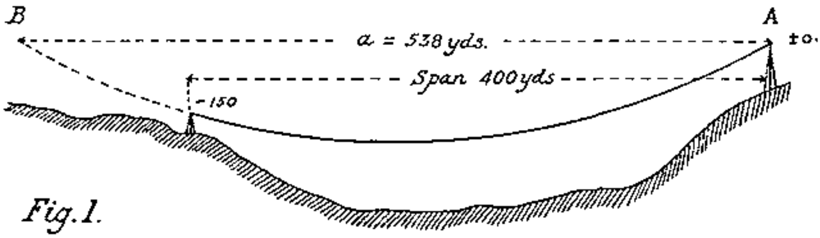


Fig. 1.

Substituting in formula (1),

$$T = wa = 13{\cdot}5 \times 538 = 7{,}263 \text{ lbs.}$$
$$= 3\tfrac{1}{2} \text{ tons say,}$$

which is the tension required at the bottom of the sag in this particular span. This is not excessive, even after adding, as described later, the increase in tension at top of line.

The other important factor which limits the length of span is the pressure on the bearing pulleys at the trestle, as will be shown later.

The line should, when possible, run in a straight line between loading and unloading stations. Angle stations increase the wear in the rope, and also add to the cost of erection and of running since extra hands have to run the carriers on to shunt rails.

The line should cross as few public roads as possible, as the County Councils generally require bridges with 16 ft. clear headway and strong enough to catch any loaded carrier. This necessitates high trestles to carry the line over the bridge.

The direction of the ropeway having been decided on, the centre line should be accurately pegged out with a theodolite and an accurate section of the ground plotted on a large scale.

The position and heights of the terminal stations have to be decided, these being kept as low as possible. The whole strain of the cable comes on to them, so that they have to be strongly built, and if high they become expensive.

The power should, if possible, be applied to the *loaded* rope, *i.e.* to the ascending rope in this case, and should therefore be at the top or unloading terminal; but this is not absolutely necessary.

The positions of the trestles should be fixed as described above, with long or short spans, according to the section of the ground.

Their *heights* should be fixed so that

(1) Their tops rise above the line representing the catenary of the rope when unloaded and with the full tension weight on. This is to prevent the rope having a tendency to jump off the pulleys.

(2) When the line is fully loaded there is sufficient headway under the carriers to clear obstacles.

TENSION GEAR.

The *Tension Gear* is for keeping the cable taut under variations of load and for taking up the stretch in the cable. It usually consists (*Fig. 2*) of a suspended weight attached to the lower terminal pulley A, the cable passing over the vertical drums BB. The tension weight W rises and falls between guide bars.

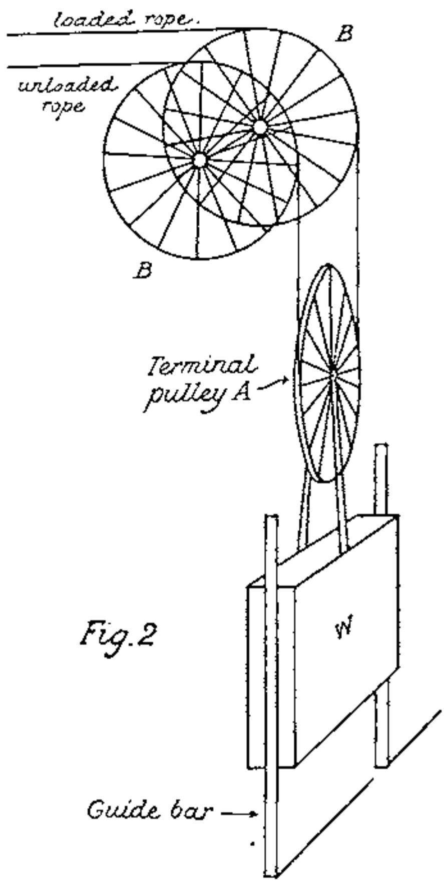


Fig. 2

When possible the tension weight should be at the bottom of the hill. It can then be much smaller to produce a given maximum tension in the rope than if it were at the top.

This is because the strain increases from the bottom of the line upwards. At the *bottom* the strain on the loaded rope equals that on the unloaded one and is $\frac{1}{2}$ the tension weight. At any point up the line the strain on the loaded side is increased by the weight of a length of loaded line equal to the height of that point above the bottom. Similarly the strain on the unloaded side is increased by the same length of unloaded line.

For example, we have found wt. per yd. of loaded rope = 13·5 lbs. and our line has to go up 500 ft. Then difference in tension between top and bottom of loaded rope $= \frac{500 \times 13 \cdot 5}{3}$ lbs. = 1 ton approx.

We have also found that the tension required at the bottom of the sag of the long span = $3\frac{1}{2}$ tons. Assume this point is half-way up the line. Then the tension at *bottom* of line must be 3 tons and at top 4 tons, and there must be a 6-ton tension weight at bottom. A 3-in. rope would be used, having a breaking strain of 20 tons per sq. inch, and an 8-ft. terminal pulley (up to $2\frac{1}{4}$-in. rope a 6-ft. pulley is used).

Another arrangement of tension weight is shown in *Fig.* 3.

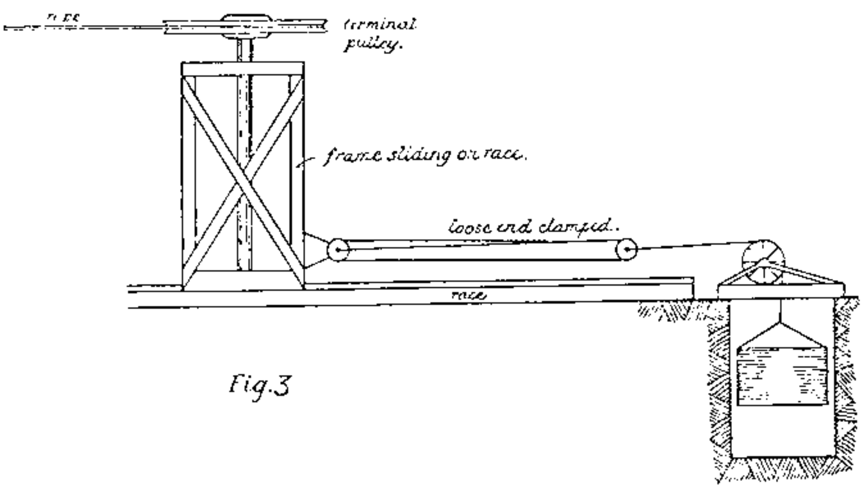


Fig. 3

This is only suitable when the tension is very small, say 1 or 2 tons, and is chiefly used with the fixed carrier system. It does not allow such free movement in the terminal drum for variations of load as does the arrangement in *Fig.* 1. But it has the advantage that, when the rope stretches after use and the weight gets near the bottom of the pit, the tackle can be hauled up and the terminal frame moved back along the race to any distance; thus only a shallow pit is required.

Photo 2 shows a similar arrangement. But here the near block of the tackle (not shown in photo) was fixed instead of being attached to a live weight. Live weights are almost always used now as they allow more give and take for variations of loads on the line; also the tension throughout the rope is exactly known.

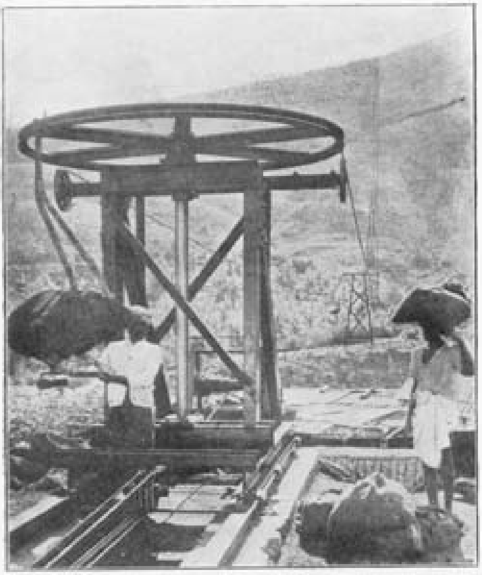


PHOTO 2.—*Ropeway in Ceylon, 3 miles long.*

The rope stretches about ½ per cent., *i.e.* 18 ft. in a 1,200-yd. line. In the first method (*Fig.* 1) the rope has to be cut from time to time and respliced after taking up the slack; or else a very deep pit must be made.

If the tension weight is at the same end as the drive the latter can be geared to the pulleys BB in *Fig.* 2.

ROPEWAY IN CEYLON

COUNTERBALANCING BEARING PULLEYS.

The bearing of the rope on each trestle is taken by one, two, or four *Bearing Pulleys* fixed in compensating brackets (*Fig.* 4). The pulleys set themselves round a curve, ease the sharp angle, and reduce the bearing pressure on the rope.

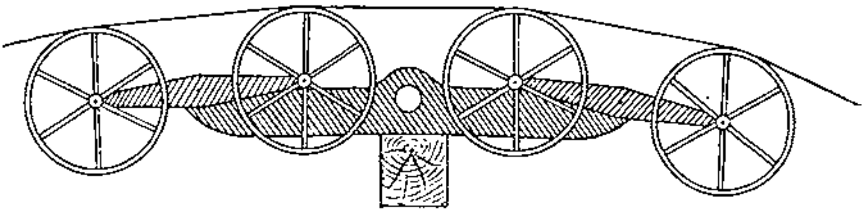


Fig. 4

To find the number of pulleys required at any particular trestle *e.g.* at B, *Fig.* 5.

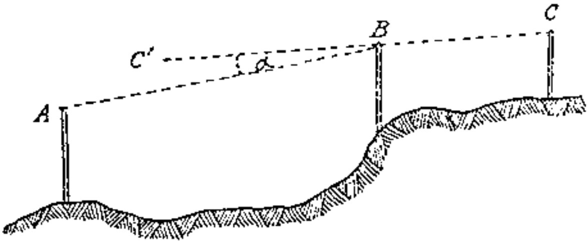


Fig. 5

The pressure by the loaded rope on trestle B
=T tan ABC′ (the angle which CB produced makes with AB)
+½ weight of span AB of loaded rope
+½ weight of span BC ,,

The bearing pulleys are made 18 in., 21 in., and 24 in. in diameter, taking 500, 750, and 1,000 lbs., respectively. So that the maximum pressure which one set of pulleys will take is 4,000 lbs.

Suppose the trestle B is at the top of a 400 yds. span AB. Assume the next span BC=100 yds.

Then the pressure of the loaded rope at B

$$=\frac{1}{2}(400+100)\times 13\frac{1}{2} \text{ lbs. per yard} + T \tan ABC'$$
$$=3,375 \text{ lbs.} + 8960 \tan ABC',$$

where T is tension on cable at B, say 4 tons or 8,960 lbs.

But the pressure on one set of bearing pulleys must not exceed 4,000 lbs.,

that is, 8960 tan ABC′ must not exceed 4000−3375=625

$$\text{or } \tan ABC' \text{ must not be greater than } \frac{625}{8960}=\frac{1}{14}$$

that is, the angle α must not exceed $\tan^{-1}\frac{1}{14}$.

Thus, assuming only one set of 4 bearing pulleys at B, then (with the assumed lengths of the spans AB, BC) B must not rise so far above AC as to make the angle ABC′ more than about 4°. It can, however, be considerably *below* the line AC, provided it is not below the catenary of the rope unloaded.

If the section of the ground requires the angle ABC′ to be greater than 4°, then the spans AB or BC must be reduced. If this is impossible, another separate set of 2 bearing pulleys can be added, so that the rope passes over 6 pulleys at trestle B (which should be kept low in such a case on account of the extra pressure coming onto it).

If the pressure is so great as to require two sets of four pulleys, it would be preferable to have two trestles close together with one set of four pulleys on each.

TRESTLES.

Trestles are made either of timber or angle iron. At home the latter is generally used (*Photo* 3). They are made by the firm, and sent to the site complete and ready to put together. Abroad timber will probably be cheapest.

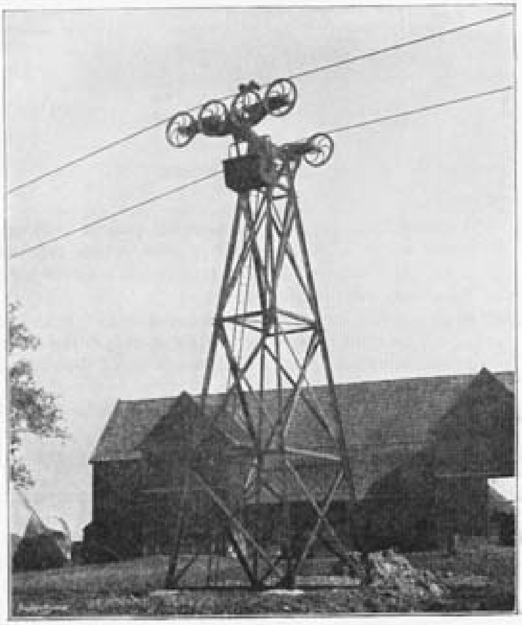


PHOTO 3.—*Type of Iron Trestle and Bearing Pulleys.*

IRON TRESTLE

It is very important to get the trestles all exactly in line. If the bearing pulleys are a few inches out, a cross strain will come on them, and there will be a constant wear of the rope at that point.

The best method of erecting iron trestles is as follows (*Fig.* 6) :— Make a wooden template, with holes corresponding exactly with the holes in the feet of the trestle. Support the template exactly over the centre line already pegged out, and at the height at which the feet of the trestle are to come. Suspend the holding-down bolts from the holes in the template and fill in the concrete foundation, but *leaving a few inches space round the holding-down bolts.* The trestle can then be put up, and the play in the bolts will allow a final adjustment of its position.

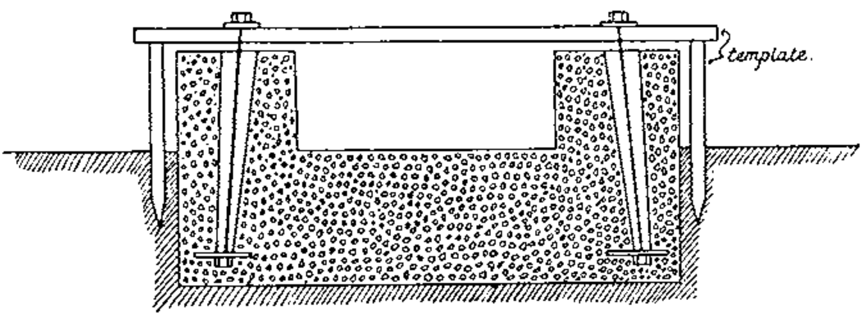


Fig. 6

TERMINAL STATIONS.

These consist of—

(1). A strong frame to take the terminal pulleys with driving gear and the vertical pulleys over which the tension weight is suspended. The framework must be securely anchored back by tie rods.

(2). A pit, with guides, for the tension weight. It should be sufficiently deep to allow, say, $\frac{1}{4}$ % stretch in the cable ; as cable stretches $\frac{1}{2}$ % in its lifetime, it would then only have to be cut and respliced once.

(3). Horizontal transverse beams, fixed above the cable, from which shunt rails can be suspended.

(4). A gallery round the shunt rail for men loading and unloading.

The rope is led horizontally on to the terminal pulley by ordinary bearing pulleys.

Shunt Rails are used at each end of the line and at any intermediate unloading stations or angle stations. They are usually of about $\frac{5}{8}$ in. × $3\frac{1}{2}$ in. flat iron (with rounded edge), suspended by hangers from horizontal beams (*Fig.* 7).

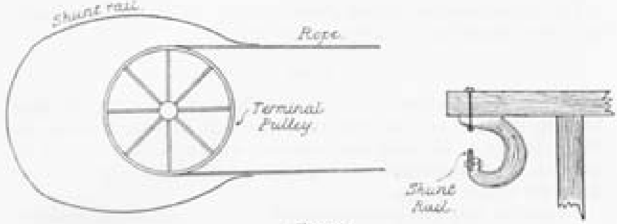


Fig.7

The friction grip, from which the carriers are suspended, hangs over the rope and is held fast to it by two claws. Immediately the grip is lifted off the rope the claws automatically disengage. This is effected, as soon as the carrier reaches the shunt rail, by the two small wheels (attached to the side of the frame of the grip) running up the rail at a slight incline from the level of the rope, thereby disengaging the jaws of the grip (*Photos* 1 and 4).

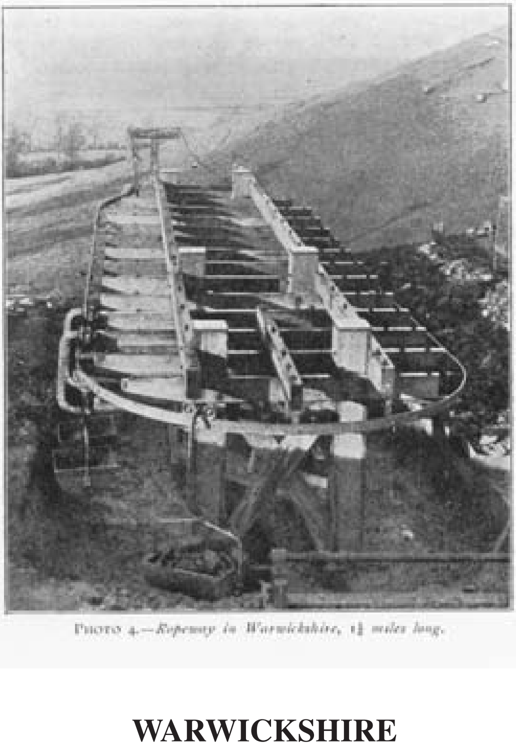


PHOTO 4.—*Ropeway in Warwickshire,* $1\frac{1}{2}$ *miles long.*

WARWICKSHIRE

The carriers are now hauled round the shunt rail by hand, unloaded, and rolled on to the rope again on the other side.

ROPE.

For the rope Bullivant's "Improved Patent Crucible" steel, with breaking strain of 90—100 tons to square inch, is recommended. A higher quality of less mild steel does not wear so well, but would be used where great strength was required and it was necessary to keep down the weight of rope.

To get the rope into position the end is taken over all the pulleys; the tension weight is then fixed on, and the two ends of the rope hauled together by tackles, taking special care to avoid kinks and twists. The ends are joined by an 80-ft. or 90-ft. splice; to make this satisfactorily an expert is required.

A cable, if well cared for, should last four or five years, running continuously almost every day. It should be greased once a week and tarred about every 6 months.

CARRIERS.

The best plan when different types are required is for the vertical arms, which are fixed to the grip, to have hooks, so that one pattern of carrier can be taken off the arms and changed for another.

POWER.

The weight of rope and unloaded carriers going downhill balance the rope and carriers coming up; so that the engine has only to lift the material itself, 20 tons an hour, up a height of 500 ft.

But an extra allowance has to be made for friction, which varies as the length of the line. A good rule is to add $\frac{1}{40}$ of length of line to the height, *i.e.* $\frac{1200}{40}$ yds.$=$90 ft.

$$\text{HP required} = \frac{20 \times 2240}{60} \text{ lbs. a minute} \times \frac{590}{33000}$$
$$= 13\tfrac{1}{3}, \text{ say } 14.$$

Steam is almost always used as the loads may vary and the line often stopped.

The terminal driving drum is connected by bevel gear and counter-shaft to the belt pulley.

COST.

The cost might be put down as follows:—

Rope 46s. a cwt.

Pulleys, about £5 each, including bearing frames.

Driving gear, terminal drums, and shunt rails, about £200.

Carriers £8, including grips.

Iron trestles £18 a ton not including erection (a 30-ft. trestle weighs about 30 cwt.).

The total cost, including engine and erection, usually comes to about £1,000 a mile. Minor maintenance amounts to about £30 a year.

The personnel required for working would be, say, 2 engine drivers, 3 men at each end for loading and unloading, and 1 man to look after the rope and oil the bearing pulleys, etc.

USE OF ROPEWAYS ON ACTIVE SERVICE.

The endless running rope system might, I think, be sometimes of great use on service, *e.g.* for supply of ammunition, especially in siege warfare for batteries on a hill which is too steep for a railway.

Messrs. Bullivant made out the following outline specification for a portable ropeway :—

Carriers to be permanently fixed to rope, so that shunt rails or big terminal stations would not be required.

Driving gear to consist of a 6-ft. pulley fixed on a vertical shaft with bevel gear, etc., which could be driven manually or by horses. The weight of the whole of the driving gear to be not more than 25 to 30 cwt., and might be much less by using special wrought-iron pulleys. The 6-ft. wheel would be the heaviest single part, and if necessary it could be made in four sections so as to keep the weight of every separate part under 300 lbs.

The tension for the other end of the line would also consist of a 6-ft. wheel on a light tension truck, sliding on guides with a screw and spring tension (the spring to keep a constant pull on the rope and the screw to take up the stretch in the wire).

The terminal frames could be constructed entirely of angle iron, except a couple of channels in each case to take the pull of the rope through the 6-ft. wheels. Wherever possible the frame would be riveted, so as to reduce the time required for erection, and the riveted parts would be connected together by bolts. The uprights of the frames could be driven into the ground, which could be plugged hard ; this would be quite sufficient on any ordinary surface.

The trestles would consist of 4 steel tubes, coupled together at the top by a casting and braced with round tension bars. Maximum height to the rope about 15 ft. and distance apart about 60 yds.

The rope would be carried on special reels. It would have to be made in sections, so that the length could be made to suit whatever distance the materials had to be conveyed over.

A special connection would be designed wherever the rope was joined, preferably at the point where a carrier would be fixed.

FIELD ENGINEERS FOR OUR NEXT WAR.

By Capt. E. E. B. Wilson, D.S.O., R.E.

As there is an almost complete dearth of printed information on the present-day duties of our Field Engineers in co-operation with other arms in War, it is thought that an outline sketch, forming as it were a skeleton framework of principles into which the details prescribed in the various text-books can be fitted and revised by the light of experience, may be of use at the present time. The following notes do not include the duties of the Electrical, Railway, Aeronautical, or Survey branches of military engineering, except in so far as they bear upon the peculiar duties of the Field Engineers who march and work with the troops of the fighting line. Much that is here written has been repeatedly urged by the abler pens of my brother officers in articles contributed to this and other technical Journals.

It was a current saying among Field Engineers towards the close of the late war in South Africa, that some of the leaders of our troops, who before the war had not known what on earth to do with Field Engineers on peace manœuvres, were now to be numbered amongst those who did not know what on earth to do without them.

It is true that before those days the opportunities for leaders to train their Field Engineers at their war duties with other arms had been extremely limited. In many cases such training had been confined to a little water-supply work in connection with camping grounds, carefully selected and prepared in advance, for manœuvres.

However, with the best intentions the employment of engineers in peace operations is bound to be full of restrictions. Like artillery, they require expensive toys to play with. They are not allowed to rip out kitchen boilers and nail them on the front doors of houses. They may not even blow up a small County bridge. Moreover, the British artizan in his turn hates shams, and detests any rehearsal of his handicraft which does not bear immediate fruit in meeting visible necessities and earning solid wages; and it is traditionally as difficult in peace as it is easy in war to extract from the military engineer the best work of which he is capable.

In the following remarks on Field Engineers it is to be assumed that reference is made to the Field Troops and Companies whose establishment and equipment are as laid down in current "War Establishments" and "Mobilization Store Tables." These figures are nominally based upon our requirements for our coming great struggle against armies of great numerical strength. Provision is made at present of 2 Field Companies, each composed of 4 self-contained Sections of about 40 working strength, to each of the new 12-battalion Divisions of the Field Army. This proportion, though a slight increase on previous establishments, falls far short of that in other armies, and will require to be greatly augmented by some costly process of improvisation before we can turn the balance against our opponents in the field.

It must not be overlooked that for operations differing in nature from the above the Field Engineers must be provided and equipped, as in the past, to meet the special conditions of the theatre of war as regards local labour, material resources, and topographical features.

The conditions obtaining in South Africa were in many respects abnormal as regards Field Engineers, especially during the closing year of the war. The groups of combatants were scattered over an enormous area, and the "vital point" was shifted with such rapidity that it was as impossible as it was unnecessary to concentrate such a relatively immobile unit as a Field Company, with its lumbering park of heavy wagons, at the point of immediate importance. Nor was the fighting as a rule of such a nature as to cause the rifleman to call for help from the Field Engineer.

The difficulty of making the Boers put up a fight to a finish was emphasized by the absence of skilled engineers with their forces. The result of this deficiency was that in both attack and defence their fighting powers became restricted to the use of pony and rifle alone, with such slight artifices, clever though many of them were, as the individual had the surplus energy to execute on his own initiative. Consequently there was but little demand for Field Engineers to be called on to the battlefield to overcome difficulties, and they therefore relapsed into their secondary rôle of garrison and line-of-communication constructors.

There was no systematic co-ordination of the engineering resources of the civilized world, as adapted to military uses, or bringing of them to bear upon the exigencies of the moment.

How different was the case in Manchuria. It is no exaggeration to say that, whereas in South Africa the relative fighting efficiency of shovel to rifle throughout the campaign could scarcely be computed at a higher ratio than 10 per cent., until in the blockhouse era perhaps it rose to 40 per cent., during the decisive phases of the war in Manchuria the ratio never fell below equal value as between these weapons.

In the light of recent experience we have indeed cause to be thankful that the Boers had not a trained engineer staff in the vicinity of Kimberley, Mafeking, or Ladysmith.

One of the most difficult questions that can be put to a Field Engineer is, "What do Field Engineers do in war time?"

It is no answer to say that the things to be done are illustrated by the examples given in the Manuals of Military Engineering. For there are a very large number of important duties which fall to the lot of the Field Engineer that have not yet been collected and classified in any such way as to distinguish them in relative importance. It is impossible in the scope of this paper to attempt an exhaustive summary of these duties; but it is hoped that sufficient headings have been given to enable any duty of the first importance to be classified in its proper perspective.

The duties fall naturally under four headings.

I. Duties on the Line of March with an army.
II. Duties in Co-operation with Other Arms during the periodical attempts to destroy or reduce the personnel of the enemy.
III. Duties in Co-operation with Other Units of Engineers.
IV. Duties in Camps, Bivouacs, Billets, Garrisons, and on the Lines of Communication down to high-water mark on the seashore.

I. DUTIES ON THE LINE OF MARCH.

Before considering them let us assume the following statement to be an axiom.

"The *raison d'être* of Military Engineers in war time is to ensure, as far as it is possible to control the physical and material forces of nature, that every constituent item of the army they serve may be despatched, located, and retained, without prejudice to its subsequent working efficiency, in whatever location or position the commander of the forces may desire.

Conversely, to render it, as far as possible, a physical and material impossibility for the enemy to locate and maintain any item of his army in positions which the said commander does not desire."

Therefore the principal function of the Field Engineers on the line of march is to make it possible for the least mobile items of the force, say the heavy artillery and second line transport, to get from one position to another. Their secondary function is to make it possible for the first line transport and personnel to do the same. The latter is secondary because in this case the personnel are better able to help themselves and their first line transport, and should learn not to rely on the engineers; while to move the heavy transport, without which the force will wither and die, often requires the employment of special measures involving the use of appliances exceeding 'one man-power,' such as engines, machines, and explosives, and consequently forms a primary function of the engineer. When the time comes to leave this heavy material stationary for the purpose of joining issue with the enemy, then the function of the Field Engineer moves forward to the assistance of the field artillery, the machine guns, and the personnel, until finally the engineer can say to his comrade of the line, 'There is your enemy, put your bayonet through him.'

The principal duties on the march are therefore connected with the tracks or roads to be followed by the least mobile of the transport. This work may include anything from clearing a track, or constructing a new road with all necessary bridges where none exists, to merely strengthening the weak culverts on a main road, or cutting back the briars in a country lane which would tear the covers of the field ambulances. As a rule maintenance of new tracks should only be provided for as long as the moving force can arrange for it without leaving its engineers behind; beyond this it devolves upon the line of communication engineers with their gangs of hired civil labourers.

Although it is often possible for the engineers of a moving force to prepare the way right up to the outpost line during a halt, it is as a rule inadvisable to work beyond for fear of drawing attention to the direction of the next move of the heavy transport. It may even be necessary to postpone obviously desirable preparations until darkness or artificially constructed screens will prevent this betrayal of intention. A skilful leader can often use his engineers as a deliberate blind over his intentions by thrusting them out to work on roads or bridges for which he has no use. It is as well, however, to let the engineers into the secret, if he wishes to reserve their energies for a genuine effort later on.

Once out into the country there is little time to make new tracks. So the work is chiefly confined to removing the more salient obstacles, floating the transport over soft ground on brushwood and undergrowth, improving drifts on the pull-out shore where the chief deterioration occurs from the dripping animals, or, in the absence of fords, repairing existing and as a last resort constructing new bridges.

It is highly probable that in traversing a well-watered tract of closely-cultivated country, as is frequently to be found in Europe, the whole of the few available Field Engineers with a division would be absorbed in bridging operations, cutting gaps in fences and banks, filling in gun-widths of ditches, etc., before the division had marched one mile from its outpost line. Not one single Field Engineer would be available again that day until the force had halted sufficiently long to enable them to rejoin. This is one of the strongest reasons in favour of enhanced mobility for the Field Companies, whether this be effected by Irish cars, bicycles, or aeroplanes.

Just as the principal duties of the Field Engineers in an advance are to open up the required communications, so in a retirement it is their double duty to clear away obstacles from the path of their own army and to close every avenue of communication to the enemy on the rear and flanks. In commencing a retirement it is justifiable to push out the engineers to a far greater distance along the main routes than in an advance.

The commonest forms taken by these duties in retreat are described in *Combined Training*, § 67. They include the preparation for destruction (and the eventual demolition) of bridges; also the closing of fords by cumbering them with damaged vehicles, ploughs and harrows, felled trees, and cases of high explosive set to detonate on interference, and by clearing false approaches leading to dangerous water, with misleading signposts and warnings placed to add to the moral deterrence from use of true fords.

It must not be forgotten, however, that to gain time is the essence of a successful retirement. With this in view—and the fact that material obstacles, other than impassable water, take more time to prepare than would often be available for them to be made sufficiently formidable to delay a victorious foe—the engineers would frequently be better employed in the rapid entrenchment of a few key-points from which the fire of a few unruffled marksmen would most effectively cool the insistence of a pursuing enemy.

Other general duties of engineers on the line of march include taking charge of all temporary water supplies *en route*, and either maintaining and repairing existing pumps, tanks, etc., or providing temporary substitutes from their own equipment (which now includes one lift and force pump and one 600-gallon sheet trough per section of a field company). Taking charge of the water *en route* involves greater responsibilities than mere control of the distribution and marshalling the water traffic. It includes fencing off the sources from contamination by stray animals, both four and two-footed, or at least rendering such material assistance to the water piquets as is possible.

Occasions also arise when the commander wishes for additional directions to be lettered on signboards and buildings to guide those following. A can of white paint should be slung somewhere on each engineer tool-cart for this purpose and for other 'gypsy language' signs to which reference will be made later.

It is also conceivable that during a retirement in their own country the engineers could perform a service by the judicious orientation of existing signposts at cross roads.

We come now to the distribution of 2 companies of engineers with a division on the march. The secret of getting full value out of Field Engineers is to push every available sapper as far to the front as the military situation will justify. There is some chance then of finding communications open when they are required.

A normal distribution of 2 Field Companies at the start of a day's march is suggested to be as follows:—

1 Section follows the infantry of the vanguard. If mounted sappers are available they should be further ahead still, but dismounted

men cannot well precede the infantry without interfering with their scouting connections.

The special duties of this section are to act as engineer scouts who will render early and accurate reports on the more technical engineering subjects of those enumerated in *C.T.*, § 100. From the information furnished by this section the O.C. Advanced Guard should be fully aware of the time and labour required to deal with impediments to his further advance; also of the position and nature of the water supplies along the road. This Section should not undertake more than the barest necessary works on the road, and these only until relieved by the engineers who follow, but should push on and organize the water supply at the next halting place, whether for a momentary or a night halt.

3 Sections precede the artillery of the advanced guard. With these march the whole of the locally hired pick-and-shovel labourers; that is, provided the latter are not too gun shy (if they get mixed up in a shooting bout they can be safely trusted to turn up in time for rations in the evening). If bridging is known to be required the gear should be with these 3 sections, who form the heavy working party for the day.

Of the second Field Company, 3 Sections should march at the head of the infantry of the main body, ready for 'Brigade excursions' if the expression may be coined. They will rapidly swell in numbers as they pick up the parties dropped by the advanced guard.

The remaining 1 Section follows in special engineer charge of the second line transport. This is the vanguard section of the previous day. It will have been in charge of the water supply duties at the halting ground just quitted, and its final duty there was to collect the last of the pumps and gear kept back for watering the transport column. It acts as engineer rear-guard and reserve for the day; and usually swells to the strength of the two companies, less vanguard and flank excursion parties, before it arrives into camp with the transport safely over the last drift.

When the day's work is such that it can be planned from definite information before starting, these dispositions can be plotted in advance so as to provide suitable reliefs for the engineer work on the route quite independently of the movements of the rest of the column.

The test of good staff work in disposing of Field Engineers for the day's march is the absence of the necessity for the order, given on the march, 'Send on the Sappers.' The bitter sound of these words addressed to footsore tramping men, who need all their remaining strength to march step for step with the infantry alongside them, after being out perhaps all night with pick and shovel, would lose its sting if it was really possible to send on a few sappers up the moving column when required.

The print-trained wiseacre may say at once, 'Why not shove them on their tool-cart and trot them up?' Such a suggestion would not deceive the soldier who knows the amount of 'trot' there is to be obtained from a team of underfed draught animals straining at war-laden vehicles over an axle deep trackless country.*

II. DUTIES IN CO-OPERATION WITH OTHER ARMS IN ACTIVE OPERATIONS.

CO-OPERATION IN GENERAL.

The time has come to definitely abandon the arbitrary labels of attack and defence. All successful operations must be positive and offensive in character.

The word Defence conveys a false meaning. The correct word in fighting language is 'Parry'; and to plan the simplest measures of 'defence' successfully it is necessary to consider them purely as certain parrying operations forming part of an offensive programme. Hence to organize solely for 'defence' large mobs of men, who are incapable of delivering an attack, is to ensure certain defeat.

In planning an attack the situation is viewed from a different but equally offensive standpoint.

Here we may have to overcome an active enemy who parries intelligently and stubbornly. In this case the fire by the holding lines of the attack must be scientifically and sufficiently applied at the right times and places to reduce the parrying powers of certain portions of the enemy's force. Meanwhile the attack is gathering depth and weight where the parrying is growing weak or wild. Then follows the skilful and relentless application of the bayonet by the accumulated masses of the attackers at the points selected for assault.

The duty of the field engineers is to strip these selected points of all that may impede the proper application of the bayonet. So many of our successful campaigns in recent times have been conducted against troops unwilling to meet steel with steel that we have grown almost to imagine that successful manœuvring and heavy firing, followed by a flourish of the bayonet from afar, is the equivalent to victory. This game of bluff has its uses, but the day will come when the adversary will ask to 'see our hand.'

Now for the spade. Its function is to allow a forward but to prevent a backward movement.

* It may be as well to remind the general reader that all the working engineers (156) of a Field Company are dismounted.

In a Field Troop, of which 4 are allotted per Cavalry Division of 4 Brigades, there are 40 working engineers, of whom about half are mounted and the remainder carried in light spring wagons.

Ever since the death of several of our messmates from 'red-coatitis,' in the early days of our last big war, there has been a gradual disappearance in troops of the line of the idea that digging on the battlefield is a 'fatigue' and that it is a glorious British tradition to display yourself as a review-order target to the enemy's marksmen. This was the last campaign in which our infantry will wish to throw away the spades provided by an intelligent administration.

One of our great present-day leaders says, "It has been noted in Japan, as characteristic of a good and bad soldier, that the former thinks it an honour to dig a gun-pit, the latter stoops to calculate that if he had been a civilian he would have received so much pay for the job." Moreover, the Japanese had no scruple in ordering troops who had marched and fought all day to entrench at night and so hold fast to every foot of ground won.

Another writer has recently recorded that, "It is now an accepted axiom that infantry and artillery must entrench themselves, not merely as working parties under engineer supervision, but as tactical units selecting and preparing their own lines of defence."

The planning and laying out of entrenchments requires chiefly tactical and in very minor degree technical knowledge. The Boer with his shikari instinct exemplified this over and over again. The instincts of the chase are not implanted in all, but any officer who understands modern fire tactics should be able to plan fire trenches and to construct them with the very men who are to hold them at the risk of their lives and honour. This may sound commonplace to the modern field engineer; but it is not many years ago that defences were drawn on paper with the ruler and set out in the field with long white tapes. The modern system of selecting and fortifying the few essential firing points first, and connecting these subsequently as required, has appeared but little in print.

Any officer too can also plan and execute the score of other field engineering operations now annually practised by all arms. Where do the engineers come in?

These operations cannot be undertaken intelligently and efficiently in the field on the go-as-you-please principle. Central co-ordinating authority is required here as in all other operations of war. Just as the non-commissioned officer of infantry is the co-ordinating authority over the rifles of his section or squad, so is the Field Engineer the co-ordinating authority over the spades of his division, brigade, battalion, or chance working party of troops of the line.

To maintain that, because there is nothing intrinsically beyond the scope of the line officer or soldier in any task of field engineering considered singly, no Field Engineers are necessary, is similar in reasoning to a statement that, because any soldier can be taught to weigh out meat and biscuits with reasonable accuracy, therefore the special supply services of an army are superfluous.

Among the principal factors which should be introduced by trained Field Engineers, when present in sufficient numbers (at least *5 %) with the troops of the line are the following :—

Economy of effort. Co-operation and cumulative benefit from all labour undertaken. Dissemination of information and instruction on the types of work which have proved to be the most efficient under the war stress of the moment. Economy of material, by acting as distributing agents of all field-work materials, such as bags and wire, etc., of which the supply is often very limited and liable to be cornered by units on the first-come-first-served principle if drawn direct from army stores. Supply of skilled labour of the usual constructional trades as required for special portions of the works in hand.

But Field Engineers have also a special tactical function, in addition to their general duty of clearing away obstacles and obstructions under every situation. This special tactical mission, which requires the very highest type of spade-rifle instinct, is the consolidation of the successful infantry assault.

Here the special rôle of the Field Engineer is to introduce that element of stability into the newly occupied position that is only too often momentarily lacking in the confusion of success. While the victorious infantry are still swaying over the captured ground the Field Engineers, without awaiting orders which no human staff officer could improvise on the moment, must make for and occupy or reinforce with their own rifles, and subsequently strengthen artificially, such key or pivot points as a calm review of the tactical situation shows it to be vital to retain at all hazards. This must be done regardless of the momentary dispositions of the scattered infantry. The instinctive power of recognition of these pivots or *points d'appui* is not a common gift, and some men never acquire it. It is often represented merely by the natural inclination to occupy every prominent knob on the terrain.

It is thus a primary duty of every Field Engineer to become a tactical master of marksmen, and to have under his command engineers of the standard of marksmanship that the shooting records of this country have shown to be so intimately associated with our Royal Engineers. The knowledge of alternative types of field works is of relatively little account compared with the tactical distribution of marksmen instinct with the use of the spade.

The formation of these strong supporting points by the engineers extends in detail to the preparation of villages and other pivot points (with which every reader of our Training Manuals is well acquainted).

* 800 per Division of 16,000 combatants or 5 Field Companies at war strength of 160. At present we have only about 2%. Compare Japan with 770 per Division of 14,000, which has been condemned as inadequate and is to be raised to 1,000 Field Engineers, exclusive of Telegraphists, etc., etc.

Their duties also embrace the planning, and the responsibility for the efficiency of, the multifarious accessories to a position, such as economical communications, efficient overhead cover, properly set-out lines of obstacles, and the rest of the items comprised in the list of recognised field works.

Although it is not intended that these notes should form a treatise on modern field works it will be as well, before dismissing the question of obstacles, to draw attention to their tactical abuse in the past.

The modern soldier has never quite been able to shake off the idea that a fight to the last gasp can only be made from inside a continuously enclosed position, such as the enceintes of the 18th century. This notion has been kept alive by the necessity for forming zaribas in our Egyptian campaigns and in other operations of mediæval tactics.

Unlike the fence of common life, of which the sole function is to deny or impede access to the area fenced, an artificial obstacle placed on the battlefield is only one more of the offensive weapons of the side employing it. When properly utilized it should, insensibly to the attacker, delay, restrict, and deflect his approach to the position in such a way as to direct his riflemen into a series of *culs-de-sac* with blind ends formed by strong obstacles under the close fire of machine guns and selected rifle points. In shooting parlance, the true function of these obstacles is to make the birds come over the guns, not to scare them away.

Of all the movements of man those made by the individual who is trying to carry his life intact as far as the point where he suspects his foe to be lurking may be said to most surely follow the lines of least apparent resistance, and so are peculiarly susceptible to deflection in this manner.

When an important outpost line is being taken up an officer of Field Engineers should, if possible, always accompany the commander of the outposts on his first few rounds of inspection. The special duties of this officer are to note the natural defensive capabilities of the lines selected by the commander, and to take stock of the probable engineer requirements and local resources in case it should subsequently become necessary to carry out the further strengthening of the position referred to in *C.T.*, § 80(4). He should also note any portions of the line where the hasty defences being undertaken by the infantry are, from the difficulty of the soil, lack of men or tools, or peculiar tactical importance, in need of immediate assistance from the engineers. He should also acquire sufficient information on all points likely to affect the work of the telegraph and telephone engineers.

C.T., § 140 (3), lays down that a party of engineers should accompany the reserve which, at a distance of some 400 yards, supports each attacking column in night operations, and that these engineers should carry entrenching implements. As plenty of entrenching implements will be the rule rather than the exception in future, it would be more rational for the engineers to carry such tools and explosives, other than or in addition to entrenching implements, as the circumstances require. The Japanese, in their night assaults, appear to have distributed a small party of engineers to the very first line, and the bulk to the third line or reserve. If no engineers are detailed to the first line of a night attack, it is difficult to see how their special powers can be brought to bear until, by the process of arrest undergone by the first line, the reserves arrive at the front.

The chief articles required by engineers for a night attack are the following:—Powerful wire cutters (not such toys as were available in South Africa). A fairly heavy fireman's hand-axe of perfect balance (not the prehistoric article now issued). A long charge of high explosive, in the form of a flexible tube, rope, or sausage, which can be flung extended across a wire obstacle and detonated from one end, or of which a piece may be cut off like a plug of tobacco and wrapped round a post or refractory portion of the obstacle. For firing these charges self-lighting fuse and spring clip detonators, or small delay-action self-contained detonators,* are required. (The fact that, in the absence of wire leads and heavy electrical exploders, we still rely upon striking a light before carrying out a detonation of explosive is an anachronism unworthy of our progress in other directions). Some empty sandbags (in addition to the one used as tool bag), clasp-knives, binding wire or spunyarn, a few hand grenades, and magnesium light and incendiary balls complete the essentials.

We can now summarize briefly some of the principal functions of Field Engineers acting alone, or in co-operation with infantry, on the march and during active operations.

To get heavy transport from point to point.

To collect and provide all engineer materials, tools, and skilled or artizan labour required to supplement the normal equipment and personnel of the army. This includes the reception and custody of all captured tools and materials.

To obtain and supervise the distribution of all materials which are not found *in situ*, such as water tanks, taps and pumps, loophole plates, wire, bags and sacks, materials for overhead cover in shelters and splinterproofs, timber, nails, bolts, fastenings, and constructional materials generally.

To lay out and arrange for the construction of all field works requiring the use of tools other than the infantry equipment, providing superintendence wherever required.

To doctor sick defences and improve those already constructed, seeing that proper steps are taken in time to save the top soil,

* To burn, like an artillery fuze, upon removing a safety device.

grass, etc., and that undergrowth is collected or cleared as required for purposes of concealment of fire trenches.

To commence revetments and drainage arrangements, disposing of surplus earth.

To site shelters, communication trenches, and other accessory works.

To supervise and co-ordinate the concealment and landscape gardening of adjacent sections of the fire positions.

To construct all forms of overhead cover, if desired.

To provide, fix, and maintain all forms of mechanical signals, alarm guns, field illuminations (other than electrical), flares, land mines, and obstacles generally.

To carry out the blasting and removal of all ground too hard for the infantry to deal with.

To construct brushwood and other improvised shelters for the sick and wounded.

To arrange for the burial of all unclaimed dead, and keep all necessary records of the same.

In the absence of Survey detachments, to carry out surveys of portions of positions on a larger scale than is provided by the map of the country.

To act without further notice as Field Fire Brigade for extinguishing burning billets, bush fires, etc., with the aid of inlying piquets.

In attack:—To open up communications and lay bare the approaches to points selected for the application of the bayonet, by the use of explosives or other appliances as required.

To consolidate the hold of our troops upon ground gained, by strengthening those points which most control the tactical situation of the moment.

The keynote to the treatment of terrain by the Field Engineer is to render it suitable for the tactical offensive. A great deal is heard and written of the placing of villages and buildings on the battlefield in a 'state of defence.' This state is more often attained by defending or controlling a village, building, or convoy *from without*, and not by standing behind the walls or wagons.

Although two very important phases of field engineering, namely bridge building and the conduct of siege works, have not received any special analysis in these notes, the duties incumbent on the engineers in connection with them fall within the outlines of these already sketched, and are sufficiently well recognized as fundamentally pertaining to the Field Engineers to require no further emphasis. There are, however, certain duties which follow the successful conclusion of siege works, or the capture of a town or position, which require passing notice.

The case of a captured position only demands the extension of the principles applicable to isolated captured field works, namely that it should be immediately converted to the tactical requirements of the moment. The steps to be taken will seldom include the occupation of the actual works recently vacated by the enemy, except as a temporary haven pending the construction of fire trenches and gun positions more suited to the prosecution of the offensive than those which have so recently failed in their mission.

In the case of captured towns the primary duty of the Field Engineers is to take over and cause to continue the municipal engineering functions which have until then been discharged by the town or borough engineer department. The taking over should, when possible, include the borough engineer and his staff in person. The duties include the town conservancy system, the collection and disposal of refuse, and the municipal lighting and water services. These may, with the additional staff furnished by the Field Engineers, be extended to serve the camping or billeting areas occupied by the troops.

All stocks of engineer supplies, tools, and materials of every description should be inventoried from the merchants' stock ledgers where these have not been destroyed, and the materials themselves should as soon as possible be taken over and brought to account by the Field Engineer Park.

The importance of gaining the good-will and services not only of the chief town officials but also of their working staffs cannot be overestimated in relation to the health and comfort of the troops. An officer of engineers should be specially detailed to muster all civil engineers and mechanics still in residence.

There is seldom sufficient watering accommodation in towns for animals in the numbers present with an army, and this provision should be made on the first day of occupation.

DUTIES IN CO-OPERATION WITH ARTILLERY.

It was reported that in the Manchurian campaign "the engineers were very good friends to the Japanese artillery."

Although in the British service such a statement would never find need for expression in view of the intimate mutual understanding which has always existed between the sister Corps, still there are a few points in connection with their relative duties in the field which appear to be worth notice.

The main body of the Divisional Engineers are usually somewhere near the guns both on the march and in action, since experience has shown that the guns must ever have the first claim to special assistance when horse power fails to move them over unprepared ground. The Japanese appear to have decided that, except when specially required in the front line, the Field Engineers form the normal escort to the Divisional Artillery, both on the march and in the opening phases of a general action, and that no further escort need be normally detailed.

This principle appears to be sound and economical, but it must be remembered that a very small number of Field Engineers are allotted to our divisions.* With our small numbers it would require few calls for bridging or other work to remove the Field Engineers altogether from their place in the divisional order of battle.

As regards entrenchments, the Japanese rule appears to have been that the gunners, if available, dug their own gunpits, while the engineers laid out and constructed the approaches and communications. If enough gunners were not available, the engineers supplied the deficiencies and the whole party worked under the supervision of the senior artillery officer—a rational and economical arrangement. It would appear desirable to extend this co-operation between engineers and artillery to the training of all Field Engineers to assist in the performance of certain of the less technical duties of artillery, such as the service of ammunition in action.

The rapid development of the technical details connected with the service of field ordnance has in recent years rendered it no longer practicable for the engineers to doctor artillery material in the field, and has compelled the artillery to rely more and more upon carrying spare parts or on sending to artillery depôts for complete exchange of ordnance and mountings. At the same time there have been many instances in recent campaigns of good improvisation of artillery material, and it is very essential that Field Engineers should be able to apply their resources in this direction. The gradual loss of touch with the details of artillery material, which is the rule rather than the exception with the present training of our officers of Field Engineers after completing their cadet instruction in artillery subjects, is a point which appears to require close attention.

It is a great many years now since any money was spent upon a peace rehearsal of combined artillery and engineer operations on the scale that would be required for the systematic reduction of a fortified position. The attendance of individuals at casual artillery field practices is not a satisfactory training for these arms in this respect.

DUTIES IN CO-OPERATION WITH MOUNTED TROOPS.

The duties of Mounted Field Engineers,† attached normally to brigades of Cavalry, differ in no material respects from those of other Field Engineers. But to enable them to co-operate efficiently with

* About 320 sapper rank and file, in 2 companies. A Japanese divisional engineer battalion has about 770 sapper rank and file, in 3 companies. On the experiences of the war it is proposed to increase these to 4 companies, totalling about 900 sapper privates per infantry division, or over 1,000 purely field engineers of all ranks, exclusive of the special engineer services with telegraphs, etc.

† 4 Troops of 40 rank and file; working strength per Cavalry Division of 8,000 = 2 %.

mounted troops it is necessary for them to become thoroughly imbued with the methods by which such troops achieve their tactical mission. It is therefore not rational to attempt to improvise Mounted Engineers in war time from men whose ideas of time and space are derived from their experiences with the foot soldier.

As the Mounted Engineers have to devote a large proportion of their time to their horses, it has not been usual to expect the same quantity of heavy work from them in the field in purely engineering matters as from their comrades on foot. This however is more properly attributable to the shorter time spent in one spot by the mounted troops to which they are allotted.

Their primary duties are, as before defined, to open up practicable communications for the force they accompany, more especially for the wheeled transport, including the construction of small and light bridges over which field pieces can be passed by hand.

When the mounted force is preceding a column containing dismounted engineers, it is usual for the Mounted Engineers to continue any works in hand only until relieved by the leading section of engineers on foot, when they hand over and rejoin their column. In the same manner the divisional engineers hand on their temporary efforts for consolidation by the engineers and civil labour gangs of the lines of communication.

Other of their principal duties are to carry out the more important demolition works with explosives, usually in connection with raids; to distribute water for their force; and to provide supervision and instruction for their working parties in all the duties previously enumerated.

In reconnaissance and information work the Mounted Engineers should preferably be employed in furnishing reports on the following matters :—Bridges, buildings, defences, fords, ferries, forts, obstacles, railways, rivers, roads, towns and villages, telegraphs, water supply, and wells. But information upon other subjects of more tactical import would doubtless be equally well obtained at the same time.

In the preliminary investment of a force or position one of the special functions of the Mounted Engineers is to sever all the arteries along which flow the necessaries of life to the invested force, such as telegraph and telephone lines above and below ground, railways, and water and electric light or gas mains; this includes the seizure and temporary administration of the headquarter stations of these services when attainable. It will probably be necessary in the future for Mounted Engineers to carry means specially devised for picking up the tune of and intercepting or killing wireless messages.

These duties require exceptional skill and judgment. For instance, upon whether a waterworks pumping station, or an electric power station, is skilfully and scientifically disabled in a manner absolutely irreparable by the enemy but so as to be easily refitted if subsequently required by our troops, may depend not only the comfort but the health and welfare of our forces.

There is great scope for further development of co-operation and communication between the Field Troops and Field Companies of engineers.

The former by means of code messages (of the sort usually attributed to gypsies and tramps), consisting of signs and hieroglyphic symbols, not necessarily written but formed with sticks and stones, etc., could convey valuable information to their friends following in rear. The following occur as typical illustrations:—'Do not stop to mend this bad place, there is a far worse one a mile further on.' 'There is no necessity to leave the road where you see these tracks striking off; we were fighting here and had to divert our transport.' 'This water gave our horses colic.' 'This is the last place you can collect firewood before reaching X——.' 'This house is not to be requisitioned upon; they have done us good service already.' The principle requires to be codified for universal use.

It may be added in conclusion that Mounted Engineers require to be very specially selected and trained, for so much may depend upon their technical judgment in the steps they initiate. The rank and file should be exclusively recruited by selection from marksmen, qualified signallers, 'very superior' tradesmen, holders of 'first-class' education certificates, and men of three years' service in the Field Companies.

DUTIES IN CO-OPERATION WITH MEDICAL AND SANITARY SERVICES.

Thorough and intelligent co-operation between the sanitary-medical and sanitary-engineering services of the army has not always been a conspicuous feature in our military annals. But the object lessons furnished in recent campaigns appear to have been very fully assimilated by both armies in Manchuria, and are very much under review at the present time.

There is only one method by which our Field Engineers can efficiently discharge their share of these services, which to-day are universally appreciated as of greater importance than all other engineering operations in the field. This method consists of a very thorough grounding in the principles of sanitation and hygiene that form the very foundation of modern medical science, followed by continuous instruction and current experience in the engineering details of the highest grade of sanitary engineering practice of the time.

As to the groundwork, it is only necessary to remind the reader that British military engineers, whatever their special rôle in other directions, have ever been the pioneers by a decade in sanitary engineering as practised in domestic life, and that the instruction in these matters is thoroughly abreast of the times in our School of Military Engineering. As regards current experience, a most necessary complement to knowledge of principles, now that the maintenance of our military hospitals has once more been transferred to the military engineer, there should be no difficulty in obtaining the best and latest to be had.

Here, as in all field engineering, a knowledge of the ideal and experience of the best attainable, are essential before improvisation can proceed upon efficient and practical lines.

In these days of enlightenment and progress in sanitary matters, it must form an unpleasant reminiscence to many, who to-day would march to the guard room a delinquent detected in the act of failing to close the lid of a refuse bin, to think how very few years ago the mention of such subjects as drains or sanitation was invariably accompanied by ironical pleasantry at the expense of those who showed a disposition to take such matters seriously.

III. DUTIES IN CO-OPERATION WITH OTHER ENGINEER UNITS.

The duty of the Field Engineer in co-operation with the specialized branches of military engineering is a simple one to define. It is like the relationship between the plumber and his mate, or perhaps that between engine driver and stoker. The expert has a job of his own which must be efficiently executed; the mate or understudy has acquired a fair knowledge from observation of the requirements and methods of the superior craftsman, but possibly has not his technical experience or ability. To qualify this simile it should be added that very often the Field Engineer has other attainments which have been acquired by experience inaccessible to the one-line specialist.

It is impossible to do more than briefly illustrate the division of duties.

The *Railway Engineer* can fairly call upon the Field Engineer to remove the shattered débris of a bridge; to rebuild masonry or timber piers and abutments; to assist in simple platelaying; and to undertake earthwork generally. He could not, however, expect to find amongst the Field Engineers men capable of setting out, making, connecting, and adjusting a set of point and signal connections for a new yard.

On the other hand the Railway Engineer would not invariably be competent to devise efficiently disposed and tactically correct defences for his railway.

For the *Telegraph and Telephone Engineers* the Field Engineers would render such assistance as digging or jumping post holes; improvising additional posts; equipping, erecting, and staying the same; and similar work. They would not as a rule undertake wiring or any description of office connections.

For *Electrical and Mechanical Engineers* they would provide concrete foundations, holding-down bolts, buildings and shelters, and similar auxiliary services. They would not as a rule set out or erect plant or machinery.

Co-operation between Field and *Aeronautical* or *Survey Engineers* is principally of a tactical nature, and is usually connected with the detection and penetration of the weak joints in the enemy's harness.

It is necessary for all Field Engineers to realize that, although there are specialist engineer units, trained and equipped to perform certain highly technical services, circumstances constantly arise in war where it is not possible to obtain their assistance or even the use of their appliances. Just as one of the fundamental principles in the training of troops of the line to-day is to teach them to rely more on themselves and less on the Field Engineers for field works in war time, so in his turn the Field Engineer must strive to attain comparative independence of his specialist brethren, while at the same time qualifying himself to afford them the fullest measure of intelligent co-operation.

The system of military engineering in the field which divides the engineer services into water-tight compartments, as found in other armies, is not an economical one. It does not possess the elasticity necessary to produce efficient discharge of the engineer services as a whole. Nor does it recognize the momentarily changing requirements of a field force.

On the other hand it is a grave mistake to attempt to officer a Field Engineer service throughout with a 'general service' brand of engineer without a special technical line of his own. The happy mean should be arrived at by constantly endeavouring to raise the standard of proficiency which is common to all military engineers alike, whilst making each of them an expert in one special subject.

In appointing officers to companies of Field Engineers allotted in peace time to the Field Army, this point requires due consideration. Amongst the staff of each Field Company there should be at least one officer capable of acting as instructor, adviser, and interpreter on each of the more specialized and technical operations which are normally performed by special units of engineers but very often partially devolve upon the Field Engineers.

It is suggested that the six officers of each Field Company should include expert representatives of the following special lines.

One *Sanitary Engineer*. Expert in hospital and barrack construction; experienced in business methods, contracts, labour, and accounts; corresponding in ability with a modern municipal or borough engineer in civil life; accustomed to utilize expert advice.

One general *Electrician* of the old Submarine-Mining stamp. Expert in searchlights, telegraph and telephone duties, land mines, repairs to electrical appliances; willing to run a captured electrical power station. Might act as naval adviser for embarkation and landing duties.

One *Machinery Officer* and mechanical engineer, for pumps, motors, boilers, power tackle, workshops, and similar duties.

One *Astronomer, Survey,* and *Photography* expert, for reconnaissance and guide duties. To act as instructor and master of the engineer scouts, and for engineer intelligence duties.

One *Railway Construction* expert, for light railways, siege traffic, and chief road and heavy bridge duties.

The remaining officer should be expert in *Transport, Veterinary,* and *Supply* duties. To act as organizer and agent for engineer requirements in the distribution of engineer stores and for mustering civil labour and working parties on a large scale; also general quartermaster and for field park duties.

The first of these experts should preferably be the commanding officer, the last the second in command.

In addition to the above qualifications it is urged that no officer should be appointed for service in a Field Company in war time with less than five years commissioned service. The severe strain of work which falls upon the engineers, as the cutting edge of a field force, demands well-tempered material.

Before turning from those duties of Field Engineers which require a special organization for mobility to duties of a less mobile nature it will be as well to consider the effects of the Manchurian campaign upon the future duties of such engineers in our own army. The chief points which have been demonstrated beyond question are as follows.

There is more need of the skilled Field Engineer for work in the front fighting lines than has ever been fully appreciated in this country.

Much of the fighting which came to a profitless deadlock while prosecuted with firearms and weapons was rapidly decided in favour of the army which made the most intelligent use of the spade.

The army which can place the largest number of skilled Field Engineers into the fighting line will carry all before it in a contest with troops equally trained in the use of their weapons and equal in numbers and discipline.

The policy which has relegated all bridging duties to the Field Engineers of the fighting divisions is a correct one, but only so far as it is followed by throwing the bridging engineers into the ranks of the fighting engineers to swell their numbers.

Our present proportion of Field Engineers to other arms, namely about 2 per cent., is quite inadequate for the tactics of the immediate future, and is endorsed by no considerations derived from actual requirements in modern war.

A study of the actual types of field works and fire trenches employed by either side at the close of the war in Manchuria is disappointing to those who looked to find some new secret, some magic prescription for killing without being killed, some hitherto unsuspected significance in the manner of tracing or siting or concealing fire trenches. It would be strange indeed if such could be found so soon after our own experiences in South Africa. To expect this was to forget that the soldiers in Manchuria, as in South Africa, learnt their lessons from the same instructor—from that "whistling, nickel-necked beggar" of Mr. Kipling's verses, who "has the knack of making men feel small" and who lectures to the quick with the dead and dying for illustration.

Neither side in Manchuria appeared to have grasped, before the commencement of the campaign, the full inwardness of the lessons we learnt in South Africa; possibly each preferred to test the futility of the field-work manuals of ten years ago *in corpore vili* before arriving at the inevitable conclusions. It may have been that the dearth of record of our spade work discoveries in South Africa was accountable for their out-of-date operations in the early days of the war.

At least the fact remains that to-day the field engineers of Russia, Japan, and Great Britain are alone in equal possession of certain spade secrets, which cannot be clearly described on paper or demonstrated apart from the flight of the venomous bullet, but which are concerned with vital facts that can only be fully appreciated after bitter and costly experience.

One principle at least has once again been brought into its true perspective; namely, that the army which delivers blows with the spade and the bayonet, and parries them with the rifle, will defeat any army which parries with spade and bayonet and attacks with the bullet fired from afar off.

IV. DUTIES ON LINES OF COMMUNICATION.

INCLUDING DUTIES IN CAMPS, BIVOUACS, BILLETS, AND GARRISON.

Many of the duties already outlined form part of the daily routine of the Field Engineer with stationary troops.

Certain other duties, which approximate more closely to the engineering works of peace, will now be briefly enumerated. As a general rule they only fall within the province of the Field Engineer in their initial stages, or until handed over to units of Fortress Engineers or to special Line-of-Communication troops. It will be evident from a perusal of these duties that many of them could be, and in fact in past campaigns have been, carried out in part by civil engineers hired for the occasion.

There is a certain school of thought which asserts that it is a mistake to maintain a small regular force of skilled artizans as the universal Field Engineers of an army; and that it would be better to maintain a larger force of relatively unskilled and worse paid pioneers for the mobile field work, and to hire, at whatever cost, the best civil talent available for stationary or Line-of-Communication work.

The mistake of maintaining a small force of skilled artizans for the mobile work is freely admitted. With resources such as are at the disposal of a world empire the force should be a correspondingly large one; but it should nevertheless be of the highest grade of technical skill which the empire can produce. Nothing less than the best of its kind can produce or maintain a world supremacy. Skilled labour of the highest grade is more and more required to accompany the front ranks of an army in the field. As each year passes the technical standard of the work to be dealt with in an enemy's country, or upon entering captured towns, is becoming higher and higher. The appliances to be converted to use are more intricate, and those to be circumvented require greater artifice to overcome.

Because we allow weaklings and failures in the daily struggle for bread to enter the ranks of our troops of the line is no argument for failing to place in the field that high grade of artizan and engineer with which the empire abounds, and in sufficient numbers to combat successfully the operations of any possible hostile engineers. Again, the military engineer fully trained in the methods of war is amenable to discipline and conversant with the economics of the army administration of the moment, and consequently, in the stress of war, is more likely to appear when and where he is wanted. Moreover, as has been discovered in more than one crisis on our national battlefields, he can also hold a straight rifle and a steady one.

All experience of campaigns in the past condemns unreservedly the attempt to work undisciplined artificers at war pressure within sound of gun fire. It is only after they have undergone a considerable preliminary measure of disciplinary training and instruction in military matters, either in the course of their civil vocations or since enlistment, that their services can be expected to rank with those so brilliantly performed by such a corps as the Railway Pioneer Regiment in South Africa.

The general question of what type of Field Engineer we require on the Lines of Communication wears a different aspect when considered in the light of our requirements on a national mobilization under the present order of things. Although our tiny army of regular soldiers is becoming year by year more intelligent in the use of the spade, and many of our battalions are undoubtedly prepared to fly alone as regards the simpler field works, it must not be forgotten that in our next great national call to arms there will be a vast horde of partly untrained men, in numbers far beyond the possibility of educating to the high standard of tactical spade head-work necessary to defeat a civilized army in the field. These must not look in vain to the Field Engineers for help.

So urgent will be the need for trained and disciplined Field Engineers with the front line that it would be safe to predict that every single available trained officer and man of the Royal Engineers, irrespective of his special technical line, will be required to serve with the Field Engineers for the value of the military engineering that is in him. Under such circumstances the more civil or technical branches of military engineering would perforce be transferred *en masse* to the Volunteers, Militia, or National Engineers, who, with their enormous resources of the highest grade labour and materials, should require but little military supervision to direct their efforts, in the second lines of the campaign, into the proper channels.

For home defence also we should require an extremely large Corps of Pioneers of the artizan labourer class to deal with the engineer services required; and it would be essential to release from this Corps all men trained for the first line of field engineering, involving a use of the rifle. This fact has been so long appreciated that it would appear to be desirable that special regulations on the subject should be in the hands of all Commanding Officers of Royal Engineers serving in the United Kingdom.

The question then resolves itself into this proposition—That, in order to hold our own with our present little 'army of samples,' it is necessary that all our regular units of the line should be trained in field engineering up to the standard of the pioneer battalions of other armies, while the Corps of Royal Engineers should aim at a standard which is far beyond the military engineering ideals of other countries.

Commanders are sometimes heard to say that, if they are only to be provided with a small handful of trained Field Engineers to carry out all the bridging and technical work for their force, they do not propose to fling them away against the wire entanglements of the enemy. This is a false application of the specialized training of Field Engineers in peace for their duties in war. The Field Engineers should not be drawn into the abysmal folly which results from the attempt to destroy the enemy in a half-hearted manner without receiving loss or injury. It is not only the victory of the hour, but also the prestige and spirit of the Empire, which shines more brightly from the whole-heartedness with which an attack is carried through after the word to advance has gone forth. To trifle with bloodshed is to seal the fate of an Empire.

If, after years of disciplined training, and animated by the traditions of past glories, the Field Engineer is to succeed in some dangerous task, surely such a moment would be one in which to use up your best material. We have nothing in our past history to compare with the losses of a certain battalion of Imperial Japanese Engineers, which, after clearing the way for the vanguard of a victorious army for nine months, was reduced from 600 to 60 effectives.

The duties of Field Engineers with stationary forces in war require the fullest training in peace, and for their efficient execution all the engineering resources of the day should be adapted and prepared in advance.

WATER SUPPLY.

This subhead includes :—Improving, protecting, and administering existing sources of supply. Well sinking; also soak-wells and filter galleries near existing, but contaminated, streams and ponds. Developing and opening up springs. Constructing ground tanks and reservoirs. Building dams.

Boring for water; lining boreholes with tubing; fixing borehole pumps, with top gear and motive power; raising water with compressed air plant. Constructing and providing troughs and watering places for animals. Erecting overhead tank towers and tanks for filling water carts. Subsequent extension to a pipe service. Pipe laying, with the use of all connections and valves.

Draining, paving, and improving ground near open watering places. Fencing and protecting supplies. Repairs and maintenance, especially of pumps. Riveting, soldering, and upkeep of iron and wooden tanks and troughs. Arrangements for providing and distributing sterilized boiled water on a large scale. The sanitary handling of water in bulk. Protection of gathering grounds. Construction of settling tanks and filters. Administration of temporary fire service.

FORTIFICATIONS.

Under this subhead are comprised :—Strengthening and elaborating chosen firing points and temporary shelters by the use of other than entrenching tools.

Deliberately constructed emplacements for all classes of ordnance, with all the accessory services, excepting railway and telegraph or telephone connections, and machinery. Accessories to fire positions, such as steel loophole plates; rifle rests and clamps; automatic alarm signals with their connecting systems; illuminations and flares; additional local signalling appliances.

Repair and maintenance of semi-permanent defence works. Obstacles and mine-fields.

Providing staff and artificers for work in engineer workshops.

COMMUNICATIONS.

Taking up all communications from the points reached by the Railway Engineer, or, in the absence of railways, from the coast. Providing additional entraining facilities. Constructing or improving roads in order of urgency. (In the absence of a field tramway the first and smoothest roads are required from the railway to the field hospitals).

Assisting other arms in opening up message routes by erecting signalling and look-out platforms, semaphore masts, and pigeon cotes.

BUILDINGS.

The construction, alteration, or adaptation of buildings for military use forms by far the largest of the various classes of work falling to the Field Engineers of a stationary force. They may be classified approximately in the chronological order in which they are usually called for.

(1). *Covered Sheds and Storehouses* for perishable articles of supply held by the Supply and Ordnance Departments ; and field workshops and accommodation for the workmen engaged in their erection.

These store sheds are of many kinds, and require to be modelled upon the accommodation provided for the same class of supply in peace time. A small accounting office and weighbridge should always be included in the design. The absence of these causes the greatest inconvenience and delay to the departments concerned in dealing with invoices and requisitions and in accounting generally.

These sheds often take the form of extensions to existing railway goods sheds ; but it is preferable that they should be quite separate from the railway depôt and have their own sidings, platforms, approach roads, and freight-handling tackle.

(2). *Hospitals,* either as a separate establishment or by the conversion or extension of existing buildings. The construction or adaptation of these buildings calls for the highest degree of technical skill from the Field Engineer.

The literature bearing upon the design and construction of Field Hospitals is extremely meagre ; and in spite of the many hundreds of such buildings erected in our recent campaigns there is no working manual with detailed instructions and illustrations at present in the hands of our military engineers.

In any case nothing but an exhaustive study of the principles of current permanent hospital construction can equip the Field Engineer for the provision or rapid improvisation of just that accommodation which shall include essentials. A summary of the principal buildings required for a Field Hospital will be found in the *R.E. Journal* for February, 1906.

In addition to the buildings and many accessories to be provided for Field Hospitals, special disinfecting depôts for quarantine purposes are often required at the principal bases ; and these also demand the most careful planning to enable them to be utilized with economy and despatch.

(3). *Veterinary Hospitals.*—Remount Depôts and field stabling generally, including accommodation for handling animals on a break of journey for rest, grazing, and watering. Among the accessories are included shelters, mangers, water troughs, exercising tracks, alleyways and crushes for catching stock, shoeing frames and slings, forage stores, forges and farriers' shops, pharmacies and offices.

Enclosures with gates, mangers, and water troughs are also required on a large scale, both at bases of supply and up country, for store cattle and for dairy stock for the field hospitals.

(4). *Field Prisons.*—Early provision must be made of prison camps for prisoners of war. These differ from ordinary camps chiefly in being completely surrounded by an impassable obstacle and in the provision of elaborate artificial lighting at night.

It is essential that the boundary should be formed of a succession of straight faces flanked by observation caponiers, raised above ground, and that a considerable area outside the enclosure should be kept clear of any form of cover. The camp limits should be defined by a light fence, several yards within the enceinte, beyond which the inmates carry their lives in their hands.

In deliberately preparing prisoners' camps the boundary fence should be continued below ground with steel sheet piling as a precaution against tunnelling. It is sometimes also feasible to trench deeply round the camp and keep the cut flooded from a stream.

For military prisoners of our own forces such elaboration is not required, and the fence would usually be a matter of light steel palisading or jagged-top corrugated iron sheeting.

(5). *Buildings Generally.*—The remainder of the general constructional, sanitary, lighting, and heating work required of the engineers may include the provision of the counterpart to any or all of the buildings and constructional services which are comprised in the barrack accommodation of peace time and also the adaptation of existing civil buildings to military requirements.

Among the earliest requirements in this direction are cooking ranges; insect-proof food stores; cold storage for meat; slaughter houses; and paved latrines and ablution arrangements with proper surface drainage and plenty of water for cleaning. There are also certain types of accommodation, not often constructed by military engineers in peace time, such as post and telegraph offices with their special fittings.

An urgent call for an office will also be received from every commanding officer and head of department who has grown weary of chasing papers and documents across the camping grounds.

Rifle ranges also are soon demanded when standing camps have settled into routine life.

A large quantity of coarse concrete work is called for, and a knowledge of the principles of economical reinforcements and use of centering is essential.

CEMETERIES.

These should be laid out (with all due respect to the medical profession) wherever field hospitals are established. Care should be taken to introduce plan and system from the commencement. Areas should be allotted to such religious denominations as make representations through their chaplains for separate ground. It should be borne in mind that the Church of England consecrates ground in advance of burial, while Roman Catholics consecrate the single grave in the ceremony of burial.

The cemeteries should be carefully selected with a view to their future convenience and beauty from the point of view of neighbouring settlements and the landscape generally. They should be out of sight of the field hospitals and camping grounds. Tree planting, paths (7 ft. wide), approach roads, fencing, and entrance gates should be dealt with from the start.

It is the duty of the Field Engineers to allot sites for graves, keep accurate registers of the same, supply numbered metal labels corresponding with the register, and, when so requested, provide materials and execute lettering for plain crosses and monuments.

The unit concerned, or the camp commandant, provides the labour for digging the graves.

GENERAL SERVICES.

Amongst other engineer items constantly recurring in war time, with which every Field Engineer should be prepared to deal on sight, may be mentioned the following. Selection, and opening up of, stone quarries. Employment of stone crushers. Brick making and lime burning. Economical rock blasting, and routine work with explosives, as distinct from the occasional use of large charges. The scientific demolition of structures for the rapid extraction and salvage of useful engineer materials and fittings, as apart from ruthless and sweeping destruction entailing heavy labour in clearing before the required materials can be taken out.

Then we come to the wider question of purchase of materials; making contracts; hire and control of skilled labour; storekeeping and accounting; and the business side of engineering generally. Officers who have been employed in peace as garrison engineers or on public works will bring a trained mind to bear upon these problems; but the novice will find that the solution of them bears but a very small resemblance to the 'deduction for sawdust' and 'extra for screws supplied only' methods of peace.

To the school of engineers who say "the pioneer with his rough-and-ready methods is all that is required for a Field Engineer, and away with the figures after the decimal point," a reply would be that the man who has twenty good uses for a steel rail is more likely to be of service to his country than the one whose ambition is limited by the desire to obtain another rail in order that his row of camp kettles may be adequately raised above the fire. Much has been heard of the rough-and-ready pioneer who constructed a footbridge while the engineer was verifying the strength of the materials from his notebook; but history omits to record the bridge for the guns, which was subsequently made by the engineer by stealthy abstraction of the material wasted by the pioneer in the first bridge.

MAINTENANCE.

In the course of a long campaign the repair and maintenance of field works, whether fortifications or buildings, take up an appreciable amount of the available engineer labour.

It is scarcely realized by troops, who in peace practice are accustomed to dig earthworks and see them levelled a few days afterwards, that fire trenches, rifle pits, and communications require a great deal of skilled attention to maintain them in full fighting condition after a few storms of rain.

Similarly with the rest of the engineer services in the field. The troops never cease to hanker after the flesh-pots of Egypt. The longer the campaign lasts the higher rises the standard of comfort and accommodation which is expected of, and provided by, the Field Engineers.

V. SOME FIELD ENGINEER PROBLEMS.

In conclusion we may consider a few of the problems or Field Engineering, concerning things as they are, to which a satisfactory solution must be found before the next campaign. They include the following subjects, some of which affect the Field Engineer alone, while others require most careful consideration from the point of view of all arms concerned.

(1). OBSTACLES.

The best and most economical type for the battlefield. An article of store which shall form the nucleus of a rapidly constructed obstacle.

Their tactical uses. How to construct and protect them. How to surmount them rapidly and without undue loss of life. Powerful appliances for destroying wire obstacles from a distance.

A wire cutter which shall form an integral part of every rifle in the service; or, failing this, a prepared edge on the infantry intrenching tool against which a wire may be cut by a blow from a stone. The rifle might be fitted with a small pair of prongs which would seize and hold a wire across the path of the bullet.

(2). NIGHT WORK.

Night work with the spade. Organization of night work generally, especially bridging.

(3). TEMPORARY ILLUMINATIONS.

The best types of flares, magnesium or other lights. Hand grenades, for man killing and for incendiary purposes. Standard alarm and sound signals for field use. Incandescent and oil gas lamps.

(4). NIGHT FIRING.

Standardized methods for controlling and directing rifle fire in the dark upon spots of which the position and range have been definitely discovered during daylight.

(5). GUNS FOR CLOSE DEFENCE.

The introduction of a powerful close defence weapon, portable by infantry, for covering a large area as opposed to long range; required for the close defence of obstacles, for night use, and for repelling assaults *en masse*. To replace or supplement such primitive 'one-shot' devices as land mines and fougasses

Suggested form to be a light, short, smooth-bore, quick-loading or automatic gun of the nature of a punt gun, firing say 15 lbs. of slugs up to 500 yards. Such a weapon would be an invaluable asset to detached posts and small garrisons. It will be remembered that the 32-pounder S.B.B.L. was improvised for a similar purpose, and was located in caponiers and other points in fixed defences. We now require a portable field piece of similar properties. It should be capable of projecting high-explosive bombs for the close attack of obstacles and earthworks.

(6). EXPLOSIVES.

The making up and issue of explosives, for field demolitions, in definite charges of, say, 5, 10, and 50 lbs.; and in a form in which neither electric exploders, insulated wires, fuzes, detonators, matches, fusees, nor any of the cumbersome paraphernalia now required, and often in part deficient or unobtainable, shall be necessary.

Somewhere attached to the box or case, and with due safety arrangement, should be a stout ring, the only action required to fire the charge being a smart pull on the ring by a single piece of string or wire, preferably salmon line carried on a light reel. Auxiliary means of firing by fuzed or electric detonators should be provided for by a tear-off strip which will expose only a detonator hole.

For the limited class of demolition which requires a thin band of explosive in close contact with an irregular surface the 'sausage' type, above referred to, should be provided. By these means the use of the extremely unhandy rectangular slabs of guncotton, or short cylindrical packages of commercial dynamite or other explosive, would be obviated.

(7). SANDBAGS.

Sandbags are destined to play a part second only to the spade in the attack; and it is required to produce a bag which can be filled rapidly by one man.

Experiments by the writer with the present service sandbag provided with a wired hem to the mouth, strong enough to hold it open during filling, have shown that it can be filled between two and three times as rapidly as when not wire-mouthed, since the man can fill the bag about one-third full instantaneously by dragging it into the soil from which the filling is to take place. As is well known at present it takes two men to fill one sandbag.

The best instrument for filling sandbags in bulk against time is a grocer's scoop. The infantry mess tin is also quicker than the full-sized shovel in ordinary soil. The mess tin should be provided with a steel lip and a vertical rib to the rounded wall of the tin, of sufficient strength to enable a man to scoop cover in moderately firm soil.

Some remarkable work was done in S. Africa with the mess tin in the attack. In one instance a soldier scraped up a mound, measuring not less than one yard cube, within 200 yards of the enemy's riflemen, on perfectly flat open ground, in the course of an unsuccessful assault. The mess tin was completely crumpled up, and the soldier fell dead the moment he advanced from behind his mound.

(8). RAPID BRIDGING.

The development of rapid bridging in the absence of pontoons, floating piers, or prepared trestles. In lowland or soft-bedded streams bridging with light driven piles and nailed or bolted fastenings is much more rapid than lashed trestle framework. Nails and wire are more plentiful, lighter, and equally or more efficient than cordage, which is becoming relatively scarce in Europe.

The rapid utilization of light steel and tubes, which are plentiful in all towns, for temporary bridges.

(9). AERIAL ROPEWAYS.

The construction and use of light aerial wire ropeways for transporting supplies and munitions of war over distances unsuited to ground traffic; especially for connection across ravines, or for water supply to hills in the absence of powerful pumps.

(10). WATER SUPPLY EQUIPMENT.

Improved water supply gear; light self-supporting portable steel framed canvas tanks and troughs, not requiring rows of clumsy pickets and elaborately threaded lashings.

Thin stamped metal notices with raised letters, for indicating the uses of the water supplied at the various sources.

A portable oil-fuel combined engine and pump of light construction as an article of engineer store.

An efficient portable sterilizing plant which will not deliver lukewarm water deficient in aeration.

(11). ENGINEER TOOLS AND EQUIPMENT.

A scientific and exhaustive revision of the tools and equipment carried by Field Engineers. Elimination of out-of-date artificers' tools and substitution of the best modern patterns.

Self-contained equipment for each of the four working Sections of a Field Company, especially as regards implements for wheelers, farriers, saddlers, shoemakers, tailors, and butchers.

Further development of the transport of engineer material and tools between the wheeled transport and the working parties. Light tool racks, stretchers, bags, or baskets in which two men can carry intrenching tools for twenty.

Two single tool carts with pairs of animals should be the normal first line transport per Section, instead of the double cart and four animals. This would result in increased mobility, quicker distribution, and gain of stowage space at present occupied by the pole of the rear cart.

Relegation of all bridging equipment for normal custody to the Bridging Trains. The animals thus reduced in field companies to increase the pack transport from one to four animals per Section. It would appear rational for a field unit, or its working Sections, to keep with it bridging material according to the anticipated requirements of the near future, and for all such material to revert to the Bridging Train when no longer required.

To emphasize the importance of constant revision of the equipment to be taken into the field, it is necessary to bear in mind that, in spite of the enormous mechanical resources of the day, the actual appliances which the individual soldier can have at hand in the field in readiness for the moments of conflict are extremely few and must be strong, simple, and efficient. No amount of experiment, thought, and endeavour can be too great to devote to the perfection of every ounce of prepared material which is to form a common necessary in the field. It is a mistake to suppose that the resources of civilization are at the instant beck and call of the soldier in the field. Those who have seen the intense feeling with which the soldier in war will dispute for the possession of a piece of string, an empty matchbox, a button, or a buckle, will fully appreciate the meaning of this apparently superfluous statement.

An outline has now been given of a few of the questions which have to be dealt with by the Field Engineer of the Line. It has been the endeavour of these notes to suggest that it is not only in the preparation of flying machines and wireless communications, important as these and other highly technical subjects are, that careful and weighty consideration is due from those responsible for the preparation of the engineer arm for war.

(12). PEACE TRAINING.

One point, and that a serious one, remains to be dealt with. Are our Field Engineers being afforded a training in peace time on lines which will place them in the field as military engineers truly representative of our best? In a previous issue of this Journal Colonel Kenyon asked whether any Commanding Engineer was fully conversant with all the communications, natural advantages, and resources of his district. We might add many other questions, such as—

Where are the scheduled lists of the local civil resources in engineer material and labour? Where are the lists of registered contractors, who for home defence are prepared to place their resources at the disposal of the government? Where is the military engineering survey of the engineer resources of our empire?

All this information may have been compiled and be revised annually, but if so the knowledge of them is withheld from the "engineer officer in the street."

That all the above should be done is ordained in the various regulations. But the conditions under which the military engineer has to serve in peace time, in order to fulfil the remainder of the peace engineering code as specified in these same regulations, impose upon him a yearly routine more resembling that of a small suburban jobbing contractor than of a military engineer.

The high roads and bridges of the country might be placed in the hands of the national military engineers, instead of left to numerous local bodies without standard or system. Our younger military engineers might be apprenticed, as they already are for railway and mechanical work, to learn more of the great civil engineering world and its methods.

Turning again to our military requirements—Where can the Field Engineer turn to for *practical working instructions and type drawings*, planned and revised with the accumulated experience of engineering history, for the execution of the numerous military works, buildings, and constructions definitely known by experience to be required in the field *in time of war?*

Our *Manuals* deal almost exclusively with Field Engineering proper. What we want in addition is a Manual for the larger works that come under the head of Line of Communication Engineering. Such a Manual would contain items like the following:—Working drawings of a range of modern ovens to bake bread for 5,000 men (such a need commonly arises in captured towns). Lists of tools and plant, including lists of labour-saving appliances and transport, for dealing with earthwork on a large scale with large labour gangs. A list of the gear necessary to equip an artesian bore-hole with the best pumping appliances, say compressed air plant, and where to obtain it. The steps to be taken to convert a domestic dwelling room into a field operating station, where the lives of hundreds will hang upon the knowledge of the sanitary engineer who has carried out the work. A classified list of the appliances required and steps to be taken for equipping a fishing harbour for the rapid embarkation of all arms.

Such instances might be multiplied indefinitely; and of course the reply can be that it is impossible to provide for every contingency. This is no reason why the training of Field Engineers, and the information at their disposal, should be restricted for want of a sufficiently broad grasp of the essentials of the military engineering requirements of an Empire.

TRANSCRIPT.

NOTES ON MILITARY TELEGRAPHY IN JAPAN.*

By Capt. Augustin Scandella.

Part I.

It is not surprising that the experience of the Russo-Japanese war has once more proved the immense advantages which are conferred in war by the use of the telegraph; but perhaps the services rendered in the last campaign by the Japanese telegraphists, civil, military, and naval, have not received the praise which they merit.

It must be confessed that when I was in Tokio my attention was particularly called to the rapidity with which information from the theatre of war was conveyed to the public. The official despatches relating to the battles of the Ya-lu, Nan Shan, and Te-li-ssu, not to mention others, were read in the capital of the empire a few hours after the Japanese armies had proved victorious. In each of these battles at least three strong Japanese divisions took part, and it must be remembered that, without the intelligent use of the telegraph and telephone, it would not have been possible for the staff of each of these armies to have drawn up the official despatches relating to them within a few hours of their occurrence. Moreover the despatches prepared in telegraphic form had afterwards to pass over many miles of military lines; then through submarine cables or wireless installations, before reaching the Japanese coasts; and thence finally to be despatched to the Headquarter Staff, where they were translated into English, and eventually, often accompanied by a sketch, communicated to the foreign military attachés and to the press.

All this required much energy on the part of all those concerned, and more especially of the personnel of the telegraph service. It must also be considered that, if the storms of our own latitudes are sufficient to easily disarrange the working of the submarine cables and land lines, it may be assumed that the numerous typhoons and earthquakes which characterize the Far East, added to the risks run by every telegraph line during active service, were enough to justify frequent interruptions of communication between the Japanese Government and the armies operating in Manchuria; nevertheless I am not aware of any such interruption having existed under conditions that deserve notice.

Devoting myself to the 2nd Army, commanded by General Oku (who during his invasion of Manchuria marched northwards following the

* Translated by kind permission of the author and editor from articles in the *Memorial de Ingenieros* of January and February, 1907.

railway), I will point out that to the right and left of this line there existed two aerial lines with good posts and insulators, the one with five 4-mm. galvanized iron wires, and the other with three similar wires. The Russians in their flight had almost always omitted to destroy them, and thus facilitated their immediate employment by the Japanese. The whole way between Liu-shu-tun and Liao-yang I did not see a single post on the ground, and only occasionally wires which had been cut and promptly repaired.

When the 2nd Army advanced from the banks of the Sha on Liao-yang we left, at Sha-ho-po, the telegraphists erecting their field lines; and a few hours later, when the bloody battle of Shu-san-po was in progress, other telegraphists had taken care to connect by telephone the little hill, where General Oshima of the 3rd Division had posted himself, with the spot where General Oku was, and also with the former's own brigadiers.

Two days later, when the 2nd and 4th Armies were fighting desperately on the left bank of the Tai-tsu in order to gain the line of fortifications to the south of Liao-yang, which was tenaciously held by the Russians, I had the opportunity of seeing how the General Commanding the Artillery communicated by telephone with the numerous batteries which were under his orders. He had selected as the central station the famous hill of Shu Shan, which dominated the whole field of battle.

No sooner had Liao-yang been occupied by the Japanese than the quarters of Marshal Oyama and General Oku, which were a few hundred yards distant from each other, were united by telephone; and the Marshal was also enabled to communicate by telephone with General Nogi, who was besieging Port Arthur, and with Generals Nodzu and Kuroki.

At Kai-ping, Ta-shih-chiao, Hai-cheng, and at all the posts on the lines of communications, the military telegraphs and telephones worked perfectly; so much so, in fact, that General Oku on several occasions authorized the foreign officers who accompanied him to make use of them for sending to their legations in Tokio despatches written in English. Similar permission was also granted in the other armies, which proves that the capacity of the lines was greater than what was necessary for service purposes.

It is well known that telephones played an important part in the siege of Port Arthur, where an extensive system not merely placed the brigadiers in communication with their respective divisional generals, and the latter with the Headquarters of the 3rd Army, but also permitted the General Commanding the Artillery to send telephonic orders to all the batteries. Even at the sap-heads, only a few yards distant from the enemy's forts, communication was kept up between the working parties and the headquarters of the battalions to which they belonged.

The above is sufficient to show that the Japanese armies employed the telegraph and telephone fully and with judgment. It will, however, be well to recall the following facts:—On the 1st May General Kuroki's army crossed the Ya-lu, and four months later reached the neighbourhood of Liao-yang, having advanced at an average rate of 1·85 kms. a day; the 226 kms. which separate Te-li-ssu from Liao-yang were traversed by

General Oku's army at an average daily rate of 2·75 kms.; and lastly the troops of General Nodzu marched from Ta-ku-shan to Liao-yang at the rate of 1·93 kms. a day. The 1st, 2nd, and 4th Armies took the offensive from the beginning, and considered as their successive objectives the various important towns of Manchuria connected by the railway; these towns were, as a rule, defended by the Russians in a purely passive manner, and in no instance successfully. So that on the one side the slow advance of the Japanese, on the other the knowledge that they had to attack fixed positions previously reconnoitred, and finally the accustomed neglect of the Russians on retiring to destroy their telegraph lines, are circumstances which in my opinion have facilitated the success achieved by the Japanese telegraphists.

I regret that I was unable personally to observe the results which are said to have been attained by the Japanese on the battlefield with the wireless Telefunken stations. In spite, however, of my want of definite information, I think it must be accepted as a principle sanctioned by experience that this means of communication is indispensable to every belligerent, and more especially to those that possess a long extent of coast line.

It is sufficient to examine the official despatches of Admiral Togo to see that he, from his naval base in the Elliot Islands, constantly communicated by means of wireless telegraphy with the vessels that were observing Port Arthur or were blockading the Liao-tung Peninsula. It must not be thought that, because these operations were limited to this zone of the Yellow Sea, communication was only maintained at short distances; for, in reading the official account of the last battle which took place in the Sea of Japan, it appears that scouting was performed many miles away from the *Mikasa* (the Admiral's flagship), which clearly shows that the information received by wireless telegraphy was so precise and opportune that, thanks to it, Togo could deduce with certainty the situation of the hostile fleets and form in consequence a plan of battle the result of which was the complete destruction of Russia's naval power in the Far East.

It is also known that during the war the coastal wireless telegraph stations constantly informed the Japanese squadrons of the courses followed by the Russian ships.

These facts of public notoriety, on which I do not think it necessary to insist, cannot be overlooked merely because the employment of wireless telegraphy has not given the result obtained in recent foreign manœuvres, nor because in this war the Russian forces under the command of General Mistchenko decided to substitute the name "useless telegraphy" for "wireless telegraphy." Its shortcomings may be attributed either to defects in the material employed or to want of practice in the personnel, but not to the system, which, though only in its infancy, gave successful results to the English and German telegraphists in their respective campaigns in Africa; and it may be presumed that its results will be even more favourable in the future.

Two applications of wireless telegraphy, worthy of being recorded from the point of view of International Law, were made during the

Russo-Japanese war. One was the communication which the Russians established between their Consulate at Chi-fu and the fortress of Port Arthur whilst it was being besieged; and the other that between the *S.S. Haimun* and the English colony of Wei-hai-wei. This vessel, chartered by the correspondent of *The Times* and equipped with an installation on the De Forest system, used to send its radiograms in cypher to the station at Wei-hai-wei, whence they were communicated to London by means of a neutral cable. Both installations gave cause for diplomatic protests, the result of which was that neither of them could act freely. It must be stated, however, that there existed a great difference of opinion amongst the belligerents as to the case of the *Haimun*. The Japanese prohibited this vessel from going north of the line joining Chi-fu with Chemulpo, and Russia, in April, 1904, addressed the following diplomatic circular to the Powers:—"In the event of neutral vessels carrying newspaper correspondents, and capable of communicating with the enemy by means of apparatus of modern invention not included in international conventions, being met with in the waters of the Kuan-tung peninsula, or in the zone of operations of the Russian fleets, these correspondents will be considered as spies, and the vessels provided with the said instruments will be confiscated." Thus, whilst the Japanese authorities, perhaps because the matter concerned a paper belonging to its ally, confined themselves to indicating to the *Haimun* a line which it must not pass, the Russian Government adopted the resolution of considering this vessel as a lawful prize in case of capture, and of branding as a spy the correspondent of *The Times* who was on board her. If an international convention has not been framed in future wars regarding the employment of wireless telegraphy these two decisions may serve as precedents in analogous cases.

PART II.

The English army is now passing through a period of active reorganization, and is preparing to put into practice all those lessons drawn from the Russo-Japanese war which are compatible with the characteristic nature of its organism. Amongst other recent reforms, some of them so important as the creation of a General Staff, England has reorganized her system of communications in the field, and orders have been issued in the following form:—

Authorities placed in Communication.	*Method employed.*
General-in-Chief with the H.Q. of the different Army Corps.	Electric telegraph, with or without wires.
Commander-in-Chief of each Army Corps with the Generals Commanding Divisions.	Ordinary electric telegraph.
Commander-in-Chief of an Army Corps with independent brigades and Army Corps troops.	Ordinary telegraph or telephone.
General Commanding a Division with his Brigadiers; Brigadiers with Battalion Commanders.	Telephone.
Battalion Commanders with their outposts.	Visual signalling.

This system, which has been tried at recent manœuvres and apparently with good results, recognizes officially the superiority of the telephone to the telegraph on the battlefield, and limits the action of visual signalling, It is also the procedure followed by the Japanese in the last war. In my humble opinion, it possesses the two following disadvantages:—first, the defect inseparable from all telegraphic methods which do not employ recording instruments; and second, the exaggerated centralization of command caused by the Divisional Generals being constantly in conversation with the battalion commanders, which perhaps prevents both from moving within their respective spheres. More important and more learned persons than the author of this article will have to solve this important problem, and decide what is the system best suited to our army. But I will permit myselt to state here my belief that, if the Japanese preferred to use the telephone in place of the telegraph, it was principally because they were deficient of a sufficient number of skilled military telegraphists, and not because they, on *a priori* grounds, considered communication by telephone more advantageous than that by telegraph. This belief is founded on the fact that we are dealing with a service which cannot be improvised; and as the organization of the Japanese telegraph companies was to a certain extent defective, we may suppose that on the outbreak of hostilities they did not contain the necessary number of skilled telegraphists. In addition to this the general structure of the Japanese language forms in itself a difficulty in turning a soldier in a short space of time into a telegraphist, and consequently the replacement of casualties could not be effected so easily as in the case of other nations.

The Japanese received their first civilization from China, and with it the ideographic writing in which each word is represented by a special sign, originally a drawing of the object; thus, for example, in the sign equivalent to the word "horse" there are certain strokes representing the head, tail, and hoofs of that animal. As may be supposed, these ideographic characters are very numerous, and generally very complicated. In order to simplify them the Japanese invented another system of writing, called the Kana. There are two kinds of Kana, the Katakana which consists in taking a single part or fragment of the primitive ideographic character, and the Hirakana, a cursive form of the exterior shape of the character. There is besides an essential difference between the Kana and the system from which they are derived; for whilst in the latter each sign represents an idea, in the former each sign represents a sound or syllable. It may be mentioned that very few books are written in the Kana, but for the most part in the primitive Chinese characters combined with the latter. Thus the Japanese writing is so complicated that a Jesuit missionary in describing it called it "an invention of a congress of devils for the purpose of troubling believers." Naturally it has been necessary to have recourse to the 47 syllables of the Kana in order to apply the Morse code to the Japanese writing; and consequently the following syllabary has been devised, in which the three last signs serve to soften or partly modify the sound of some of the preceding 47 syllables, forming altogether 50 Morse signs, to which must be added those corresponding to the numerals and to certain conventional signs, so that we have as the result a telegraphic code considerably more complicated than our own.

Morse Alphabet applied to the Katakana Syllabary, officially used in the Japanese Army.

i	· —	*ka*	· — · ·	*o*	· — · · ·	*me*	— · · · —
ro	· — · —	*yo*	— —	*ku*	· · · —	*mi*	· · — · —
ha	— · · ·	*ta*	— ·	*ya*	· — —	*shi*	— — · — ·
ni	— · — ·	*re*	— — — —	*ma*	— · · —	*we*	· — — · ·
ho	— · ·	*so*	— — — ·	*ke*	— · — —	*hi*	— — · · —
he	·	*tsu*	· — — — ·	*fu*	— — · ·	*mo*	— · · — ·
to	· · — · ·	*ne*	— — · —	*ko*	— — — —	*se*	· — — — ·
chi	· · — ·	*na*	· — ·	*ye*	— · — — —	*su*	— — — · —
ri	— — ·	*ra*	· · ·	*te*	· — · — —	*|*	· — · — ·
nu	· · · ·	*ma*	—	*a*	— — · — —	*//*	· ·
ru	— · — — ·	*u*	· · —	*sa*	— · — · —	○	· · — — ·
wo	· — — —	*ur*	· — · · —	*ki*	— · — · ·		
wa	— · —	*no*	· · — —	*yu*	— · · — —		

It must be added that in Japanese writing one reads from top to bottom and from right to left; thus what is to us the last page of a book is the first to a Japanese. As the Morse signs are written on a tape in a single line, and as they are read from left to right, yet another additional difficulty is thrown in the way of the instruction of telegraphists.

ORGANIZATION OF JAPANESE ENGINEERS.

A battalion of Engineers, composed of 3 companies, forms a portion of each division of the first line army. The regimental staff of the battalion consists of a commanding officer, 2 captains, 2 medical officers, and 2 veterinary surgeons. The commanding officer is as a rule a lieutenant-colonel, but occasionally a colonel or major; the second in command is one of the captains of the regimental staff, who is at the same time adjutant of the battalion.

Each company on a peace footing is composed of 1 captain, 3 first or second lieutenants, 1 warrant officer, and 165 non-commissioned officers and men divided into 3 sections. On a war footing the number of officers is unchanged, but the rank and file are increased to 226. The working unit is the company, and each contains a proportion of sappers, miners, pontoniers, and telegraphists.

Confining my attention now solely to the instruction given to the latter, I will say that each engineer company annually sends 15 men to the Telegraph Battalion at Tokio, which is commanded by a colonel and consists of 4 companies formed from the men sent from the engineer battalions. At the commencement of the war it had a strength of 600 rank and file. This corps is the centre of instruction, in which the men remain for a year. When they have completed their training they return to their respective companies and continue to serve in them as telegraphists.

In case of war each battalion of engineers organizes a telegraph company, which is placed under the immediate orders of the divisional general, and loses all connection with the battalion from which it originally came. It receives the regulation equipment, which will be described further on; and the necessary drivers and transport, drawn from the Train battalion, are incorporated in it.

On the outbreak of hostilities against the Russians the effects of this defective organization made themselves felt. One of them was that there were not enough engineer captains trained in telegraph duties to take over the command of the new companies created in each division. This defect was remedied by promoting to the rank of captain those lieutenants who had satisfactorily passed through the course with the Telegraph Battalion. The instruction in this battalion was also hurried on so that the officers and men might complete their courses earlier. My investigations to discover what was the degree of instruction which they had attained could not proceed very far, and naturally it would be rash to express a definite opinion in the absence of positive knowledge. Nevertheless, as I have had the opportunity of seeing lines badly stretched and laid out, defective joints, posts placed at capricious distances, insulators that did not fulfill their mission, and other similar defects, I am inclined to believe that the Telegraph Companies were far from having been fully instructed; and consequently I am confirmed in the opinion, expressed above, that the preference given by the Japanese to the telephone rather than to the telegraph was due to the want of a personnel sufficiently numerous and sufficiently skilled to work the latter apparatus.

I will conclude this article by making a slight sketch of the approved telegraph equipment of the Japanese army. But before doing so I must repeat that, in spite of the great difficulties I have mentioned, the telegraphists came well through their task, and that the great services rendered by them during the war have not received the praise which they merit.

REGULATION TELEGRAPH EQUIPMENT.

The regulations of September, 1903, classify and divide the telegraph equipment into two classes.

1. Field Equipment.
2. Equipment for the Lines of Communications.

The first is that assigned to each telegraph company operating with its division; the second, as its name indicates, is designed for use on the lines of communications.

The Field Telegraph equipment is carried in 27 pack loads as shown below:—

Number of Load.	Position on Pack.	Contents.	See *Plate* I.
Nos. 1 to 12 ...	Right.	One reel with 833 mètres of covered wire.	*Fig.* 1
	Left.	Ditto.	
	Top.	Ditto.	
Nos. 13 to 15 ...	Right.	Two reels.	,, 2
	Left.	Ditto.	
	Top.	Four handspikes.	
Nos. 16 and 17 ...	Right.	Box No. 1.	,, 3
	Left.	Box No. 2.	
	Top.	Ladder, shovel, pick, and 3 crooked sticks.	
No. 18	Right.	200 mètres of cable.	,, 4
	Left.	Ditto.	
	Top.	Ditto.	
Nos. 19 to 22 ...	Right.	Box No. 3.	
	Left.	Box No. 4.	
Nos. 23 and 24 ...	Right.	Box No. 5.	,, 5
	Left.	Box No. 6.	
	Top.	200 mètres of copper wire.	
No. 25	Right.	Box No. 7.	
	Left.	Box No. 8.	
No. 26	Right.	Box No. 9.	,, 6
	Left.	Box No. 10.	
	Top.	Two reels, each with 600 mètres of copper wire.	
No. 27	Right.	One tent, 15 pickets, 3 stanchions, 1 shovel, 1 pickaxe, 1 borer.	,, 7
	Left.	One tent, 15 pickets, 3 stanchions, 1 shovel, 1 pickaxe, 1 large maul.	

Note.—Sometimes an additional pack animal was supplied for each 12 men, for the purpose of carrying their knapsacks and arms when the telegraphists were occupied in laying out a line.

The Lines of Communication Telegraph equipment is carried in 100 pack loads, distributed as under:—

Number of Load.	Position on Pack	Contents.	See *Plate* II.
Nos. 1 to 36 ...	Right.	Reel with 833 mètres of No. 14 gauge copper wire.	*Fig.* 1
	Left.	Ditto.	
	Top.	Ditto.	
Nos. 37 to 40 ...	Right.	Empty reel.	,, 8
	Left.	Ditto	
	Top.	12 pickets, reel with 600 mètres No. 13 gauge steel wire.	
Nos. 41 to 53 ...	Right.	14 posts.	
	Left.	Ditto.	
Nos. 54 to 60 ...	Right.	6 posts and 3 crooked sticks.	,, 9
	Left.	Ditto.	
Nos. 61 and 62 ...	Right.	One ladder, 1 crooked stick, 1 borer, 1 spoon, 1 rammer.	,, 10
	Left.	Ditto.	
	Top.	One ladder, 1 plank.	

Number of Load.	Position on Pack.	Contents.	*See Plate* II.
Nos. 63 and 64 ...	Right.	4 shovels, 4 pickaxes, 2 spades, 1 maul.	
	Left.	Ditto.	
Nos 65 and 66 ...	Right.	Box No. 1.	*Fig.* 11
	Left.	Box No. 2.	
	Top.	One reel with 800 mètres covered wire, and another with 1,200 mètres fine copper wire No. 21 gauge.	
Nos. 67 to 72 ...	Right.	Box No. 3.	
	Left.	Box No. 4.	
Nos. 73 and 74 ...	Right.	Reel with 200 mètres of cable.	,, 4
	Left.	Ditto.	
	Top.	Ditto.	
Nos. 75 to 80 ...	Right.	Reel with 833 mètres of covered cable.	
	Left.	Ditto.	
	Top.	20 pickets.	
Nos. 81 to 90 ...	Right.	Box No. 5.	
	Left.	Box No. 6.	
No. 91	Right.	Box No. 7.	
	Left.	Box No. 8.	
	Top.	Reel with 100 mètres copper wire, No. 13 gauge.	
No. 92	Right.	Box No. 9.	
	Left.	Box No. 10.	
	Top.	Reel with 100 mètres copper wire, No. 12 gauge.	
Nos. 93 to 98 ...	Right.	Box No. 11.	
	Left.	Box No. 12.	
	Top.	Reel with 100 mètres copper wire, No. 13 gauge.	
Nos. 99 and 100 ...	Right.	Box No. 13.	
	Left.	Box No. 14.	

In January, 1904, a few days before the outbreak of hostilities against Russia, a light two-wheeled cart was approved for use in the Japanese army. The whole of the telegraph equipment is divided and made up in a form capable of being transported in these vehicles; and although, as far as I am aware, pack transport was not entirely done away with, the majority of the telegraph companies preserved their organization as far as personnel was concerned, the only alteration being that caused by the change in the method of transport.

In order not to tire the reader by giving a detailed account of all the loads constituting the field equipment, I will merely point out (*vide Plates* II. and III.) the principal types, which will serve to give a general idea of the nature and approximate dimensions of the different boxes. My information is not sufficiently complete to enable me to enumerate the contents of each of them; but I do not think that this matters, if we start by saying that the material which I was able to examine separately did not present any important novelties, having been made in Japan but copied from American and European models.

Plate II., *Fig.* 12. 2 reels of copper wire; 1 coil of iron wire; and boxes Nos. 1, 2, and 3.

Fig. 13. Boxes 4, 5, and 6; 1 station box; 1 earth plate (on top of box 6); and 2 coils, one of cable, the other of silicious bronze wire.

Fig. 14. Beneath the driver's seat and above the floor of the cart are packed 1 station box, and 1 mallet; then further to the rear tool boxes Nos. 8 and 9; and above them a tent with its pole, etc., and 1 borer.

Fig. 15. 3 reels of well-insulated cable and box No. 7; 2 pickaxes; 1 coil of iron wire; and 1 of rope. This load is completed by 2 axes and 1 handspike for carrying the reels.

Plate III., *Fig.* 16. In the centre of the floor of the cart 4 coils of iron wire and box No. 12; at each end 1 box No. 4 and 1 station box.

Fig. 17. 5 reels of cable, and the arms and equipment of 2 telegraphists.

Fig. 18. Ladders, pickaxes, shovels, rammers, borers, and a small hand-cart. The method of using the latter is shown in *Figs.* 19 and 20.

Fig. 21. 60 posts; arms and equipment of 3 telegraphists.

Fig. 22. Arms and equipment of 8 telegraphists.

Each load is covered by a roped tarpaulin.

The equipment of each company is carried in 35 carts, and suffices for the construction of 42 kilomètres (26 miles) of line. In the recent war most of the companies were given sufficient material to construct another 20 kilomètres (12½ miles) of line. Each unit can provide 6 telegraph and 12 telephone stations.

I will conclude by saying that some of the information which I obtained regarding the engineers of the Japanese army was communicated to me by Capt. S. Shibau, I.J.E., who, in accordance with the orders of the Vice-Minister for War, General Ishimoto, very kindly placed himself at my disposal for several days. General Ishimoto is himself an engineer officer, and has taken a very active part in the study and execution of the defensive works of the Empire.

'M.'

REVIEW.

IRRIGATION: ITS PRINCIPLES AND PRACTICE AS A BRANCH OF ENGINEERING.

By SIR HANBURY BROWN, K.C.M.G., M. INST. C.E., late Royal Engineers. — (Archibald Constable & Co., Ltd., London, 1907).

THE scope of this book is defined by Sir Hanbury Brown in his preface as an attempt 'to set forth the guiding principles that should govern the practice of irrigation, and to furnish illustrations of their application in existing canal systems.' It may at once be said that the attempt has been a great success; and that the book—which fills a distinct gap in the literature of the subject—can be most cordially recommended to anyone who wishes to acquire a knowledge of the principles and practice of irrigation as now understood.

The illustrations have been drawn for the most part from Egyptian practice, and this fact adds to the value of the work since in this direction Sir Hanbury stands on exceptionally firm ground. His long and intimate knowledge of Egypt as an irrigating country, his first-hand knowledge of the facts he relates, and the results of personal observation combine to make him a most trustworthy guide and mentor in this direction. He ceases, of course, to occupy this position of unquestioned authority when—as occasionally happens—he travels outside of Egypt to comment on some Northern India Canal of whose history and working he knows nothing personally, and in such cases the weight of authority must be conceded to the local engineers.

Here and there slips have been made, as for instance on p. 236 where the following astounding sentence occurs:—'*most of the canals of Upper India and those of Egypt serve deltaic tracts, and consequently river banks are an essential feature of their canal systems.*' This will be news to a good many irrigation engineers in India.

Again, throughout the work there appears to be an unfortunate tendency to generalise about India in a manner that it would be often unsafe to attempt even as regards a comparatively small Province of that vast Empire. Such generalisations are regrettable as they tend to detract from the value of the arguments employed. But when all this is said, the fact remains that it is really surprising how few errors have crept into the 266 pages of this treatise, and on this fact the author may be heartily congratulated.

The work commences with a condensed but eminently readable historical sketch of the antiquity of the art or science of irrigation; and then, summing up the results achieved in practically all quarters of the globe, Sir Hanbury lays down certain definite conclusions as to the value of irrigation, conclusions which will certainly be assented to by all those who have any expert knowledge on the subject.

He then treats (Chapter II.) of 'Basin Irrigation,' an essentially Egyptian system, though it is said that its principle is being adopted by the farmers of the North Western Plateau of Cape Colony. This 'basin' system, by the way, must not be confounded with the 'inundation system' of Northern India, with which it has nothing in common. Having traced the evolution of the 'basin' system from its first crude beginnings, the principles to be observed are laid down and full details are supplied as to the latest development of the system, whilst the method of working now adopted in Upper Egypt is explained.

Chapter III. deals with 'Perennial' Irrigation and the 'Duty' of Water. Sir Hanbury remarks that the advantage of a 'Perennial' or continuous supply throughout the year lies in the fact that an average of two crops a year can be grown. If by this it is meant that the same plot of land can be double-cropped year after year, it must be pointed out that—in the absence of heavy manuring, or the practical renovation of the soil by substantial silt deposits of a very fertilising nature,—such treatment would speedily ruin the land. As a matter of fact, and for this very reason, 'double-cropping' is not looked upon with favour in the North of India.

As regards the meaning to be attached to the term 'duty' of water, Sir Hanbury (p. 32) appears to have discovered a difficulty that, so far as is known, has never been felt in India. It would seem quite simple to define the particular 'duty' under discussion by the addition of some such words as 'expected,' 'assumed,' 'estimated,' or 'actual' as the case might be. Moreover, it is further usual to indicate the particular kind of duty of which one is speaking or writing, by prefixing the words 'canal,' 'branch,' 'distributary,' or 'watercourse.'

Great caution is required in handling the subject of 'water-duties,' as *in the absence of local knowledge*, they may prove terribly misleading and thus be worse than useless.

On the other hand, in the hands of the local expert, they afford most valuable information; and they serve much the same purpose as regards the expenditure of water as the auditor's critical examination of the accounts does in the matter of the expenditure of cash.

The *fourth chapter* on the 'Sources of Supply' will be found especially interesting, containing, as it does, most instructive and valuable information on the history of irrigation in Egypt during the last quarter of a century, and on the way in which events have led up to the construction of the Assuan dam and subsequent developments.

The statement (p. 44) that canal water is admitted by the cultivators to be superior to well-water can hardly be accepted as a general proposition without very large reservations, as so many factors have to be taken into consideration. In the particular case quoted, the true explanation probably was that the rise of spring-level, brought about by the canal, had made the wells unusable. If this be so, it would scarcely be correct to say that the cultivators had exhibited any deliberate preference for canal water over well-water; it was more a case of 'Hobson's choice.'

As regards Lake Mœris (p. 47) the suggestion may be hazarded that the depression became gradually silted up until at last it ceased to have any value as a reservoir.

It is stated (p. 58) that Sir Thomas Higham has expressed the opinion that—with the exception of the large canals still possible in Sind and the Punjab—'almost all future extensions of irrigation in India will involve the construction of storage works'; and it is assumed (p. 59) that 'the essential feature of such storage works as those contemplated in India and the United States will be, in most cases, a high dam designed after the type of dams already built for similar purposes.'

Of the United States, the present writer can say nothing; but, as regards India, he is satisfied that, after the completion of the great canals referred to by Sir Thomas Higham, the day of heroic irrigation works in India will have passed. The place of enormously expensive single works will be taken by a multiplicity of small works, the combined effect of which will far transcend anything that has as yet been achieved in the matter of the protection of the country from the effects of drought. Storage works there will undoubtedly be, but not of the kind foreshadowed in the extract given above. They will rather take the form of an infinity of comparatively small and inexpensive works. The total expense will of course be great, but the resulting benefit will far outweigh the cost.

With reference to the problems of 'rainfall' and 'run-off,' which are discussed at pp. 64 *et seq.*, it may be said that they are amongst the most difficult of those that can be presented to the engineer for solution, and call for the exercise of 'good judgment' in an unusual degree.

As to the theories put forward by Mr. Atcherley in 1904, and referred to at some length at page 81 and elsewhere, it may be mentioned that an extended series of experiments, with more suitable materials than those employed by Mr. Atcherley and Professor Karl Pearson, have tended to rehabilitate the older theories and to reassure engineers as to the safety of their works. A paper on this subject by Dr. Brightmore and the writer has been accepted by the Council of the Institution of Civil Engineers and will be read and discussed in the coming session.

It is quite correct to say (p. 86) that it is a mistake to adopt an ogee curve for the downstream face of a fall, and a still worse mistake to make the surface of the ogee smooth. It must be borne in mind, however, that, if the velocity of the water be either partially or wholly checked, or if the water be broken up into spray (as at the Vyrnwy dam) by causing the stream to pass over roughened surfaces, the final result must be the 'wearing away' of the projections, though the action may be very slow.

On the main line of the Bari Doab Canal in the Punjab, the rapids were paved with large boulders (2 ft. to 3 ft. in length) laid on end with a longitudinal slope of 1 in 15; the boulders projected some 6 to 12 inches above the general level of their shoulders, and the face of the structure therefore presented an ideal roughened surface. Notwithstanding their great hardness, these massive boulders were worn down nearly level in the course of some 20 years or so, necessitating their entire replacement with fresh stones.

The destructive action of water moving at a high velocity (especially if it carries with it any hard silt) must be seen to be believed, and in some cases can only be compared to the effect of a sand blast. One such instance appears to be worthy of record. The stone flooring that formed the seating of the 'outlet' gates at Madhopore on the Ravi was found to wear so rapidly into holes that it was decided by the late General Gulliver to replace them by iron sill-plates ⅝ths of an inch thick. At the end of the first season's working it was found that these plates had been nearly worn through in many places. These and similar experiences have led the writer to ponder over the case of the Assuan dam, and to wonder how long the granite below the dam and the surfaces of the sluices themselves will stand the terrific velocities to which they are exposed.

Sir Hanbury's criticism (p. 87) of the 'double-weir' arrangement as adopted at the Nira dam appears to be perfectly justified, and it may be added that in a canal design it is desirable to avoid any construction likely to afford to an imprisoned hard substance (even a brick) the opportunity of doing mischief under the action of eddying water.

The next chapter (VI.) treats of the 'Means of Drawing on the Supply' and demands very careful perusal as it is one of the most important in the book.

It ought perhaps to be explained that the term 'anicut' (p. 112 and elsewhere in the book) is purely a 'Madras' word, which is neither used, nor even generally understood, in other parts of India. There is nothing in the word to commend it either to the expert or the layman and it would seem desirable that it should be consigned to oblivion.

On the other hand, Sir Hanbury Brown is undoubtedly right in preferring the term 'scouring sluices' to the more common but meaningless term 'under-sluices,' and it is to be hoped that engineers generally will adopt the former instead of the latter of these terms.

At page 113, the author states that 'the floor of these sluices is generally about river-bed level.' Would it not be more correct to say that it is usually fixed *at or about the level of the bed of the deepest channel of the river at the site of the works?*

As to the selection of the site for a weir, there can be no doubt that it is distinctly better to design a weir too short than too long, though it does not follow that an abnormally wide site should not be selected if otherwise satisfactory. It is always possible (as in the case of the Chenab weir at Khanki) to subsequently restrict the river (by means of a Bell's bund) to any width considered desirable.

Exception must be taken to the statement on p. 117 that the upward pressure of water passing below a weir falls to zero at the point of exit below the weir. If water in an enclosed space flows at all, it must exert some upward pressure, and at the point of exit this pressure is utilised in making the water bubble up to a certain height. The only point of practical importance in this connection would appear to be that the velocity due to the head must be so reduced by friction *as to be incapable of carrying sand along with the water.* So long as springs run clear and carry no sand, they are perfectly harmless.

As Sir Hanbury has no personal knowledge of the Narora works and must certainly be unacquainted with many details connected with them, it is to be regretted that he should have expressed so decided an opinion (pp. 116 and 119) as to the cause of failure of the weir. He may of course be right, but it is proper to say that the local officers, who were men of experience and fully acquainted with the facts, were by no means positive on the subject. In short, it seems quite possible that the failure did not occur in the precise way supposed by Sir Hanbury Brown. It may be added, moreover, that it is not quite correct to say that the only remedy adopted was to reduce the pressure under the floor. Doubtless this remedy was applied, but the damaged portion was also strengthened by additional masonry and the added water-cushion lent extra weight to the structure.

On p. 130, Sir Hanbury—speaking of an upstream extension of a weir—says that 'clay puddle, with its surface protected from scour, is as good as, or better than, masonry in such a situation.' He hardly seems to have appreciated the fact that *the* danger point is *the junction of the puddle and masonry at the crest wall.* If, as may well happen, any portion of the bed upstream is laid dry, the puddle may shrink and thus lead to the opening up of a dangerous fissure. It seems therefore preferable to pin one's faith on a masonry floor, or better still on a combination of both materials, rather than on puddle alone, although it must be admitted that there is a good deal to be said on both sides of the question.

The so-called 'hydraulic gradient' (on which so much stress has been laid in this chapter) must in the nature of things be so hedged round by assumptions as to seriously detract from its practical usefulness.

As regards the 2nd conclusion formulated on p. 121, it may be pointed out that the impermeable floor should be made long enough, and only just long enough, to obviate any 'blowing of sand' at the exit.

There need be no hesitation in agreeing with the dictum (p. 122) that unless upstream curtains (whether of wells or piles) can be made really water-tight, they are likely to do more harm than good, and are better omitted.

Attention may be invited to the 'Beresford's filter' inserted downstream of the footing wall in the Delta Barrage Weir. A somewhat similar arrangement has been in use for many years on the Punjab Canals, in connection with the protection of the slopes downstream of falls where there was considerable wave action.

The question raised (p. 134) as to the advisability of adopting in India the 'barrage' type as opposed to the 'solid weir' is one that depends almost entirely on the relative cost of the two types; and it must be borne in mind that it is not only the initial expenditure that must be taken into account but also that of subsequent maintenance. It seems probable that the statements in the Madras manual of 1906 represent merely the personal opinions of the author or, at best, the views of those of the officers of the Madras service with whom the author had come in contact. In any case it may be said that, at any rate on the Chenab Canal, no serious difficulty has been encountered in raising the 'six-foot' shutters against a 'three-foot' head of water.

Turning again from India to Egypt, attention must be invited to the information given on p. 135 as to the fact that in 1883 it was the intention of the Egyptian Government to adopt pumping from the river as the only method of supplying Nile water for irrigation. A contract to last till 1915 was actually concluded with a company to pump up 1,840 cusecs at Afteh and Khatatbeh at an annual cost of about £50,000. Moreover, 'as the Delta Barrage stood condemned as incompetent to serve the needs of irrigation, it was proposed to extend the same system of supply by pumping to the whole of Lower Egypt at an initial cost of £700,000 and an annual expenditure of £250,000. But, fortunately for Egypt, before a decision had been taken regarding this proposal, Colonel (now Sir Colin) Scott-Moncrieff was entrusted with the management of the irrigation of Egypt. He pigeon-holed the pumping project, declared himself in favour of a restored barrage, and forthwith took steps that led to its successful restoration.' For the detailed results of this momentous decision, the reader must be referred to the book from which the above extract has been made, but this at least may be said here: that even if Sir Colin had never in his life done anything else worth mentioning—and this is far from being the case—the action above recorded would sufficiently justify our pride in the fact that he belonged to the Corps of Royal Engineers.

On p. 139, Sir Hanbury records the statement that 'it is rather a remarkable fact that in India, hitherto, not an acre of land has been irrigated by Government otherwise than by natural flow.' Is it not possible that the explanation may be somewhat similar to that afforded by the author himself at p. 253?, where, in explanation of the failure to push on certain works, he says: 'there is so much else in Egypt that it pays better to reclaim or develop, that it will be many years yet before cultivation extends northwards from its present limit as far as the borders of the sea.'

Sir Hanbury is quite at his best in Chapter VII. which is one of the most delightful in the whole work. It deals with 'methods of construction'; and amongst the descriptions given may be mentioned those relating to the treatment of the Barrage springs by the process of grouting under pressure (pp. 145 and 163), the use of a special form of cast-iron pile (p. 151), the sealing of the Shubra wells (p. 156), the construction of the subsidiary weirs below the Delta Barrage (p. 157 *et seq.*), the Ismailia canal head (p. 165), and the laying of syphons under a running canal (pp. 167—169). One could wish for an almost indefinite extension of such instructive and suggestive matter so lucidly expounded.

The next two chapters (VIII. and IX.), on 'Means of Distribution' and 'Masonry Works on Irrigation Canals,' are extremely interesting and worthy of attentive perusal, although, as they embody for the most part views now generally held by irrigation experts, they do not appear to call for detailed comment. It may be mentioned however, with reference to the statements made on p. 196 in connection with the Bari Doab Canal rapids, that for many years past it has been the practice to bed the surface boulders in hydraulic mortar up to the level of their shoulders and also to seat them on a foundation of boulders in mortar

It may further be mentioned that all 'experimental' types (such as the 'cascade') have long since been remodelled and converted into the regulation pattern, *i.e.* with an even slope of 1 in 15.

The 'notch' fall (p. 198) was first employed on the Sirhind Canal by the late Colonel Robert Home, C.I.E., and was the outcome of a vast number of experiments and observations made under his orders by Mr. John Benton, F.C.H. (now also a C.I.E. and Inspector General of Irrigation in India).

The Chenab Canal syphon, figured on page 211, is the design of Colonel Frederick Home, C.S.I., and has admirably fulfilled its purpose. With reference to the insertion of steel lining tubes into concrete barrels, it may be pointed out that, with anything but the fastest-setting cement, the lining may fulfil a very useful purpose during the earlier stages of use.

Chapter X. deals with the 'Methods of Distribution of Water, Assessment of Rates, and Administration.' It is believed that no meter or module (p. 213) has yet been invented that is at the same time reliable and cheap; indeed, it seems more than doubtful whether it will ever be possible to overcome the difficulties that face the inventor in this direction. Apart from the difficulty as to price—which must be low if the machine is to be generally acceptable—the other serious difficulties are caused by:—(1) the presence of silt in the water; (2) the objection to loss of head in the meter; and (3) the practical impossibility of making an article that cannot be broken or tampered with. Irrigation officers elsewhere will sigh for the time when their irrigators shall have attained the moral standard of those Italian farmers of whom it is recorded by Sir Colin Scott-Moncrieff that they consider it 'as discreditable to appropriate an unfair supply of water as to steal a neighbour's horse, as discreditable to tamper with the lock of the water-module as with the lock of a neighbour's barn.'

With regard to the best system of 'rotation' (p. 217), it may be said that, in the opinion of Indian experts, the system of closure by distributaries undoubtedly holds the field. A perusal of Sir Hanbury's comments on the subject of 'administration' will probably convince every impartial reader that even the management of the much-abused 'water commissioner' is on the whole preferable to the system whereby 'rights' were enforced by means of 'handy men from Arizona with guns,' or the *nabouts* of the fellaheen in the good old days before the British came to spoil sport on the Nile.

In Chapter XI., which deals with 'Flood Banks and River Training, information is afforded as to the sections adopted for flood embankments in Egypt and elsewhere; and attention is drawn to the danger attending the existence of ill-constructed culverts in the bank, and to the still more formidable danger arising from the undermining action of the river. The best way of meeting such attacks is explained and the construction of 'spurs' is discussed.

On page 247 a virtue is claimed for the Egyptian spur with sloping crest (*vide* p. 244) in that 'the eddy produced downstream is of comparatively little violence.' It would appear that a good deal depends on the slope of the crest. At Narora some spurs were originally made with a slope of 1 in 10. In these the downstream action was so violent that the nose was shortened and a slope of 1 in 5 adopted. This was a great improvement, but even so the action was still so severe in many cases that it was found desirable to adopt a T head. It is interesting to note that in Egypt a slope of 1 in 5 has been adopted, and it would be useful to know whether other slopes were experimented with and with what results.

A somewhat fanciful distinction is drawn (p. 245) between 'river *protection* works' and 'river *training* works,' it being asserted that 'the former, by strength of material, forcibly prevent the river from injuring its banks; the latter, by gentle persuasion, induce it to flow in the direction and behave in the manner desired.' Reference is made (p. 246) to the Lower Ganges training works, but it seems clear from the comments made that Sir Hanbury Brown has not appreciated the fact that, at Narora, everything depends on the berms (or platforms) of large blocks of *kankar* that are stacked on the slopes of the groynes to a thickness of from 10 to 15 feet. When the groynes are undercut by the stream, these blocks slide down at the point attacked and fill up the holes made by scour.

It should be understood that the Narora training works extend over a length of more than 20 miles of river, and are exposed to very varying attacks. Some groynes have never been in severe action, and possibly never may be attacked, but it is quite impossible to foresee years beforehand where serious scour may take place. To have made each of the 44 groyne heads of solid stone would have been a reckless waste of money, and the system adopted is undoubtedly the best in the circumstances.

The method adopted is this:—The groyne heads are made up of sand to cold-weather low water level, and on this sand platform is constructed a raised T head revetted on the slopes with a thickness of 2 feet of *kankar* (nodular limestone). In addition to this, great masses of *kankar* (from say 15 to 20 thousand cubic feet) are placed as berms on the slopes, the quantity depending on the liability of the groynes to be attacked. When a groyne is attacked by scour, the stone from the berms is automatically fed into the scour holes, and after the floods the deficit is made up ready for the next attack. In process of time, if a groyne is severely and repeatedly attacked, the spur-head rests on a solid foundation of stone down to the limit of scour.

It is quite certain that those officers in Northern India who have the largest experience in river work are of one mind in agreeing with Mr. Good that a river should be 'fought and not merely tickled.' For 10 or 12 years prior to 1887, 'persuasion' was tried at Narora and miserably failed; since 1887 the Ganges has been 'fought' with conspicuous success and at no greater an expenditure of money than before. It may also be remarked that those who are fully acquainted with the history of the Narora works during the last 30 years will be unable to agree with the author's suggestion (p. 246) that, if the stems of the groynes had been inclined at an angle to the thread of the current instead of being perpendicular to it, it would have been possible to shorten the upstream length of the cross-head. Inclined groynes were tried at Narora and thoroughly discredited many years ago.

An important factor in the design of spurs or groynes is the distance apart at which they should be spaced. This possibly depends on local conditions; but it may be said that on the Ganges—and also it is believed on the Indus and other Northern rivers—the *maximum* erosion in the loop between two groynes has never exceeded one-quarter of the distance between two such works. This rule at any rate furnishes a rough guide as to design.

The two concluding chapters deal with 'Agricultural Operations and Reclamation Works' and 'Navigation' and do not call for much detailed comment. It is interesting to note that it has been found in Egypt that—within limits—the less water is supplied to cotton, the better is the resulting crop.

Much the same thing has been repeatedly observed in India in regard not only to cotton but to other crops. The truth is that the cultivator is by no means the best judge of what is best for his crops. As regards 'navigation,' it may be laid down as a broad general rule that the same canal should never be asked to carry water for both navigation and irrigation, the requirements of the one being destructive of those of the other. The remarks on 'locks' are interesting and instructive.

By no means the least valuable part of this treatise are the 3 appendices which deal with 'Weights and Measures,' 'Formulas and Discharge Measurements,' and 'Books of Reference,' whilst at least a word of praise must be accorded to the excellent Index which concludes the volume and which, so far as it has been possible to test it, appears to be unusually complete.

Sir Hanbury Brown is to be sincerely congratulated on the success of his labours, and every officer of the Corps—especially all those who are likely to proceed to India—should read, mark, learn and inwardly digest this work which might well be included in their private professional libraries.

JOHN W. OTTLEY.

NOTICES OF MAGAZINES.

ENGINEERING RECORD.

May 25, 1907.

TRAIN RESISTANCE.—The American Railway Engineering and Maintenance of Way Association has been studying this matter, and has recently published a report, of which this issue contains some account. Until recently the mechanics of train resistance have been considered on rather arbitrary lines, and, according to the Committee's view, formulæ have been used deduced from insufficient data. Indeed, to judge from the diagrammatic illustrations, the actual amounts of resistance expressed in terms of drawbar pull vary immensely even in repeated experiments of the same kind.

Resistance is of course of three kinds, (1) on the level and straight, (2) grade resistance, (3) curve resistance. It is the former of these that more especially requires consideration.

Formulæ for resistance are usually of the form:—

(i.). $a + bV$.
(ii.). $a + bV + (cAV^2 \div t)$.
(iii.). $a + bV^2$.

i.e. either a straight line or a curve, a, b, c, being constants, A the area of the front of the train, V the velocity of the train, t the weight of the train. In the second class of formula the third term represents atmospheric resistance, but as it is slow heavy trains with which we have more especially to deal it is not very frequently applicable.

Experiments made by Professor Goss have led to the following conclusions:—

(1). Resistance offered by still air to the locomotive and tender is approximately 10 times that offered to the intermediate portion of the same train.
(2). Resistance by still air to the last car is approximately $2\frac{1}{2}$ times that to an intermediate car.

The Committee makes various recommendations, among which the following are notable:—

(*a*). In all further experiments the dynamometer method should be used.
(*b*). Speeds should be determined to 0·1 miles per hour.

(*c*). For heavy freight trains formulæ of the shape $r = a + bV$ should be used; a third term should be used to show the effect of loading.

(*d*). For determining the sum allowable to save curvature or to save rise and fall the average line for train resistance should be used.

It is practically essential that each Company should conduct its own experiments, so that the results should be properly applicable to the matériel, rolling stock, and physical conditions special to the line.

C. E. VICKERS.

MEMORIAL DE INGENIEROS DEL EJÉRCITO.

February, 1907.

IN THE ACADEMY OF SCIENCES.—A notice of the reception of Colonel D. Nicolás de Ugarte on his election as a member of the Royal Academy of Sciences, Madrid. Colonel Ugarte is now head of the fourth section (Fortifications and Works) of the General Staff, and a distinguished mathematician. The discourse which he pronounced before the Academy on this occasion is printed *in extenso* as a supplement of this number of the *Memorial*. It is entitled "Matter and Spirit, Mechanics and Justice," and is a learned metaphysical treatise. The author sums up his discourse by saying that "Absolute Justice is the supreme law which rules the universe; matter complies with it blindly, whilst spirit, man, and humanity only stumble towards its fulfilment."

MILITARY TELEGRAPHY IN JAPAN.—By Capt. A. Scandella.—Concluded from January number.

CORK BRICKS.—By J.G.—Cork bricks were first introduced abroad although the materials for making them are so plentiful in Spain. A factory has now been opened in Seville which turns out both cork bricks and other materials formed of cork dust mixed with coal tar and compressed. The product does not absorb water, is an excellent non-conductor of heat and sound, and forms an ideal lining for magazines and cold storage chambers. The cost in Madrid of cork fabric 2 inches thick is about 2s. 10d. per square yard.

REVIEW OF BOOKS.—The most interesting of the books reviewed is one entitled *Servicio Aerostatico Militär* by Major D. Francisco Rojas. The author, who is attached to the Military Balloon Establishment at Guadalajara, is a well-known authority on the subject, and successfully endeavours in this book to give a clear account of the present state of aeronautics as applied to military needs.

'M.'

NATURE.

May, 1907.

"PRACTICAL WILDFOWLING" BY FALLON (*p.* 30).—Thoroughly to enjoy his sport the wildfowler must be a good field naturalist, and this little work aims at making easy the identification of those species of birds he is most likely to meet with. The enjoyment of wildfowling lies, not only in killing, but in seeking to kill, by pitting one's skill against the wariness of the fowl. Unlike pheasants and partridges, they cannot be brought over the guns. Herein lies the essence of the sport, and hence the necessity of understanding the life, habits, and peculiarities of the various kinds of wildfowl. The identification of the different species is rendered more easy by the introduction of some lifelike figures. There is a good index.

INCANDESCENT ILLUMINANTS (*p.* 92).—One of the drawbacks to gas, compared with electric lighting, is that merely turning on does not light gas. This difficulty has been largely overcome by the use of the by-pass; but now Wellsbach has discovered that an alloy of cerium and iron gives off sparks on being scraped, and a burner has been designed in which the act of turning on the gas scrapes a little wheel of this alloy, causing a spark which lights the gas. This overcomes the drawback of having a jet always burning. The electric incandescent light is undergoing a great change. Carbon is being replaced by metal wires. It has been found possible to make wires of high enough resistance of tungsten, osmium, tantalum, and a few other metals. The tantalum lamp is now in great demand, made for 100 to 130 volts; it is more efficient than the carbon lamp, but it will not last long on alternate currents. One of the most interesting of the new lamps is the Zircôn; it has been made for 200 volts, with six separate loops of wire mounted in series inside a bulb; an extremely light spring is provided for each loop, so as to keep it taut, and the lamp can then be used in any position.

AERIAL LOCOMOTION (*p.* 103).—Dr. A. G. Bell considers that by his invention of a kite, built up of a great number of small tetrahedron cells, a distinct step in advance has been made. Each cell possesses in a remarkable degree the properties of strength and lightness. All the cells are alike in form and size; by connecting several of these figures by their corners a rigid structure is built up, and the whole possesses the same properties of strength and lightness inherent in the individual cells. The unit tetrahedral cell is bounded by four equal triangular faces; if two adjoining faces be covered with some kite material, the result is a winged cell, resembling a pair of bird's wings with their points raised upwards. By coupling four of these unit cells together at their corners a four-celled structure is formed, with an empty space in the middle, octahedral in shape. If now four four-celled structures be connected at their corners, a sixteen-cell structure of tetrahedral form results. A kite so formed behaves well in squally weather, the squall passing right through between the covered triangles, and lifting the other side of the kite, as well as the side first struck; the blow is thus counterbalanced before the kite has had time to upset. Dr. Bell has shown that it is possible to build a structure of *moderate* size, composed simply of these winged cells, that will support a man and an engine in an ordinary breeze.

MALTA FEVER (*p.* 104).—Every year some 650 sailors and soldiers have fallen victims to this fever, which has been the bane of the island. Now however all this has been changed by a simple application of the discoveries of science, and Malta fever may be said to have practically disappeared from the garrison of the fortress. A commission formed in 1904 ascertained that the minute bacterium, whose entry into the body of a man caused the fever, was remarkably prevalent in the goats of the island. In truth, it is probable that Malta fever is primarily a disease of goats, and that man is infected from the goat, and not the goat from man. There are 20,000 goats in Malta which supply practically all the milk used in the island. The goats show no outer signs of the disease, but continue, possibly for years, to secrete milk containing the poison. Evidently, then, to banish milk from the dietary was the way to stop the infection. This step was taken a year ago with the striking result that the cases of fever fell to one-tenth of what had been their normal number. It is hoped that this disease will now disappear, and some 80,000 days of illness be blotted out from the yearly hospital records of our army and navy.

W. E. WARRAND.

REVISTA DE ENGENHERIA MILITAR.

March, 1907.

TRIALS OF FITNESS FOR THE RANK OF MAJOR, ESPECIALLY IN THE CORPS OF ENGINEERS.—By Capt. d'Oliveira.—In the Portuguese army promotion examinations were first introduced in 1703, a decree of the 25th August of that year providing that aspirants to the rank of major should be subjected to a rigorous examination; but it was not till 1848 that a definite system was adopted in the cavalry and infantry, and not till 1868 that examinations were made compulsory for officers of the other arms.

The existing regulations were issued on 18th February, 1905. They require that an officer before promotion to the rank of major should have served for at least 2 years in command of a unit of his own arm and have attended a school of instruction for 2 months. The examination is divided into three parts:—(1) written, consisting of the working out of a problem on a map; (2) practical, in command of a unit in the field; (3) oral, again working out a tactical problem on a map and making a report on the field exercise.

The author considers that the syllabus of the examination is not a suitable one, and that engineer captains should be examined as to their technical qualifications. He proposes that active service projects should be worked out both in writing and in the field.

PROJECT FOR THE QUELIMANE RAILWAY.—By Capt. Monteiro.—Continued from p. 484 of the previous volume.—The working capital is 3,600 contos, and the estimate for the construction of the line 3,700 contos. The deficiency of 100 contos will, it is hoped, be met by savings.

A description is given of the bridges, the principal of which are those over the Chire, 200 yards long, and over the Lúalua, 290 yards long.

The best material for sleepers is considered. It is essential that they should be able to resist the attacks of white ants. The most suitable native woods are the m'bila, the m'pinque, and the m'conite; but they are rare, and the trees are generally small, crooked, and growing at a distance from the places where they are required. It is therefore considered better to use either Java timber or Jarrah, though the cost of these is somewhat higher.

As the line is eventually to join the Cape to Cairo railway the gauge of the latter will be adopted. It is proposed to lay 30 kilo. rails.

The following will be the stations:—Quelimane (1st class) near the Muanange (3rd class), at Mómbula on the Momede (4th class), at Naquexa on the Lúalua (3rd class), at Murrúa on the Lumba (4th class), at Colini on the Naterre (4th class), close to Mezengrera on the Nhatedze (4th class), and at Chantengo on the Chire (2nd class).

It is proposed to run a branch to Tangalane at an estimated cost of 300 contos. The construction will be easy, the only difficulty being to find good foundations for the bridges.—(*To be continued*).

April, 1907.

RAILWAYS AS AUXILIARIES TO TROOPS IN THE FIELD.—By Colonel Pereira Dias.—Such railways must satisfy the following conditions:—

1. They must permit of the transport of troops and stores more rapidly than by road.
2. Transport by them must be effected in complete security.

The first condition may be said to be strategical, and the requirements are:—

(i.). The lines should be sufficiently long.

(ii.). On the offensive, the lines should lead as directly as possible to the frontier.

(iii.). On the defensive, there should be more than one line to those points on the frontier which are most likely to be on the lines of invasion.

(iv.). No part of the railway system should be isolated.

(v.). There should be as many lines radiating out from the centre of the country as there are frontiers across which invasions are possible.

The second condition may be said to be tactical, and the requirements are :—

(i.). The main lines leading to the frontiers should not end on salient portions of the frontiers.

(ii.). The lines should pass through fortified or defensible positions where they approach the frontiers.

(iii.). Lines parallel to the frontier should, where possible, be protected by rivers, mountains, or other obstacles.

(iv.). As a rule, railways should not cross natural obstacles such as hills and forests, but should pass round them.

(v.). In the passage of defiles, lines should not be run through deep cuttings, but should be swept by the fire of works established for the purpose.

(vi.). In the neighbourhood of fortresses, the railway lines should be as straight as possible and enfiladed by fire from the works.

(vii.). Railway junctions should be established at points easy of defence.

(viii.). The railway stations of garrison towns and fortresses should be situated within those places.

(ix.). A military railway system should be defensible over the greater part of the area covered by it.

Reference is made to the instructions contained in the Portuguese *Field Service Regulations, Part II.*, of 1904, which deal with railway services, and to *Études sur les Chemins de Fer et les Télégraphes Électriques considéré au Point de Vue de la Défense du Territoire* by Capt. J. B. Eugène of the Belgian Engineers.

The author recommends the appointment during peace time of an officer styled "Director of Military Studies relating to Railways," who would officiate in war as Director of Railways.

SOME EXTRACTS FROM THE REPORT OF ENGINEER REGO LIMA ON HIS MISSION TO THE MINES OF CASSINGA IN 1898.—Continued from the February number. Describes the route between Quipungo and Cassinga.

PROJECT FOR THE QUELIMANE RAILWAY.—Continued from the March number. Gives an estimate for the construction of the Tangalane branch. There are tables showing the values of the exports and imports of the port of Quelimane from 1870 to 1904 and of Chinde from 1895 to 1904; also a sketch map of the district traversed by the railway.

'M.'

REVUE DU GÉNIE MILITAIRE.

May, 1907.

AEROPLANES.—Many experiments have been made to discover the laws that govern the resistance of the air to a moving body, but unfortunately with very divergent results. If a plane surface, inclined at an angle α, is opposed to a current of air, moving with a velocity V, the resulting pressure will depend not only on α and V and on the area of the plane, but also on the nature of its surface, its shape, and the density and viscosity of the air.

In general terms the pressure varies directly as the area of the surface and the square of the velocity. $P = KSV^2$, where P is the pressure, S the area, and K a coefficient depending on the nature of the surface. The mean value of K, as found by experiment, is about ·082, though results as divergent as ·05 and ·125 have been obtained. It has been suggested that for rapidly turning screw blades the value ·085 should be used, and for aeroplanes ·135.*

The pressure on a plane surface depends, for a given velocity, on its angle of inclination, and also on the proportion between its length and breadth. No formula has been deduced which will agree with the experimental results, and it is therefore only possible to express the relationship in the general terms $P_\alpha = KSV^2 (f) \alpha$, where P_α is the pressure produced by an angle of inclination α. The position of the centre of pressure varies with the angle of inclination. The smaller the angle the more nearly does the centre of pressure approach the front edge of the plane. Its exact position can only be found by experiment. Various experiments have been made with curved surfaces, but the results have been as contradictory as those with planes.

The general behaviour of an aeroplane may be described as follows. A free stable aeroplane allowed to fall through the air will, after a short interval, follow a straight path with a uniform velocity. The inclination of this path to the vertical is independent of the weight carried and the velocity. As the inclination of the plane to the vertical increases from 0° to 90°, the inclination of the path to the vertical increases, attains a maximum, and then decreases to zero.

The velocity increases as the angle of inclination to the vertical decreases, and it varies as the square root of the weight carried.

The pressure on the plane is proportional to the weight. If an exterior cause momentarily checks the velocity, the aeroplane will fall, and will finally resume a course parallel to but below its original one. If the velocity is momentarily increased, the plane will rise, and then resume a course parallel to its original one.

It is clear that, to maintain the stability of an aeroplane, the car must be suspended from a horizontal axis through the centre of pressure. But as the centre of pressure varies with the angle of inclination, the point of suspension must be adjusted to each alteration of the inclination.

PHOTOGRAPHIC RECONNAISSANCE.—A continuation of the previous articles. A description is given of the various types of camera used with kites and captive balloons, and of the methods of using them.

* The difference could be explained on the supposition that the screw blades work in disturbed air.

June, 1907.

AEROPLANES.—A continuation of the article commenced in the May number. The author, with the help of mathematical formulæ, investigates the behaviour of aeroplanes under varying conditions. The following are the most important of his deductions:—

An aeroplane should come to earth, head to wind. When the wind is variable, the aeroplane should be kept on a horizontal course. In a variable wind the velocity of the aeroplane should not be less than the greatest variation in the velocity of the wind. To increase the angle of attack, the point of suspension of the car should be moved away from the leading edge of the aeroplane.

The length of an aeroplane, in the direction of its motion, may be economically reduced by substituting for a single plane two small parallel planes, placed one above the other. When the angle of attack is small, the stability of an aeroplane may be increased by fixing in front of it a smaller, but wider plane, with a larger angle of attack. When the angle of attack is large, the stability may be increased by adding to the aeroplane a long tail, of which the angle of attack is small. With a concave aeroplane, the car should be as close to the plane as possible, to increase its stability. The article will be continued.

PHOTOGRAPHIC RECONNAISSANCE.—A continuation of the previous articles. The author describes various methods of locating coast defences by photographs taken from moving ships.

Under favourable conditions, it is possible to produce a complete plan of a coast fortress in twelve hours. The actual photographic work occupies only two hours, the measurement of the plates and plotting of the detail takes the remaining ten.

The value of the photographs is much increased if the camera can be raised by kites flown from the ship. The article will be continued.

J. E. E. CRASTER.

CORRESPONDENCE.

ORGANIZATION WITH REFERENCE TO FIRE TACTICS.

SIR,

With reference to the article by 'O.Y.' in the June number, and the question of working in pairs therein referred to, perhaps the following extract from *Indiscreet Letters from Pekin* by "B. L. Putnam Weale," descriptive of work during the defence of the Legations, may be of interest.

H. V. BIGGS,
The Editor, *R.E. Journal*. *Lt.-Col.*, *R.E.*

"Men were wanted to drive back, or at least intimidate, a whole nest of Chinese riflemen, who had cautiously established themselves in a big block of Chinese houses across the dry canal, which separates the British Legation from the Su-wang-fu. This block of houses is so placed that an enfilading fire can reach a number of points which are hidden from the Japanese lines; and this enfilading fire was badly needed, as the Chinese riflemen were becoming more and more daring, and had already made several hits. Half a dozen of the best American shots were requisitioned.

The six men who came over went deliberately to work in a very characteristic way. They split into pairs, and each pair by some means got binoculars. After a quarter of an hour they settled down to work, lying on their stomachs. First they stripped off their slouch hats and hung them up elsewhere; but instead of putting them a few feet to the right or left as everybody else, with a vague idea of Red Indian warfare, within our lines had been doing, they placed them in such a way as to attract the enemy's fire and make the enemy disclose himself, which is quite a different matter. This they did by adding their coats and decorating adjacent trees with them so far away from where they lay that there could be no chance of the enemy's bad shooting hitting them by mistake—as had been the case elsewhere where this device had been tried.

All this byplay took some time, but at last they were ready, one man armed with a pair of binoculars and the other with the American naval rifle—the Lee straight-pull which fires the thinnest pin of a cartridge I have seen and has but a two-pound trigger pull. Even then nothing was done for perhaps another ten minutes, and in some cases for half an hour; it varied according to individual requirements. Then, when the quarry was located by the man with the binoculars, and the man with the rifle had finished asking a lot of playful questions so as to gain time, the first shots were fired. The marines armed with binoculars were not unduly elated by any one shot, but merely reported progress in a characteristic American fashion—that is, by a system of chaffing. This provided tonic, and presently the bullets crept in so close to the marks that all chaff was forgotten.

Sometimes it took an hour, or even two, to bring down a single man; but no matter how long the time necessary might be, the Americans stayed patiently with their man until the sniper's life's blood was drilled out of him by these thin pencils of Lee straight-pull bullets. Once, and once only, did excitement overtake a linked pair I was watching. They had already knocked over two of the enemy aloft in trees, and were attacking a third, who only showed his head occasionally above a roof-line when he fired, and who bobbed up and down with lightning speed. The sole thing to do under the circumstances was to calculate when the head would reappear. So the man with the binoculars calculated aloud for the benefit of the man with the rifle, and soon, in safety below the wall-line, a curious group had collected to see the end. But it was a hard shot and a disappointing one, since it was essential not to scare the quarry thoroughly by smashing the roof-line instead of the head. So the bullets flew high, and although the sharpshooter was comforted by the remarks of the other man, no progress was made. Then suddenly the rifleman fired—on an inspiration, he said afterwards—and lo! and behold, the head and shoulders of a Chinese brave rose clear in the air and then tumbled backwards. 'Killed, by G—; killed, by G—!' swore the man with the binoculars irreverently; and well content with their morning's work, the two climbed down and went away."

RECENT PUBLICATIONS.

Military Engineering. Part V. Miscellaneous. Official. ($8\frac{1}{2} \times 5\frac{1}{2}$. 1s. 3d. Wyman).

Hints on Solving Tactical Problems, by Lieut.-Colonel H. M. E. Brunker. 6th edition. (12mo. Portsmouth).

Notes on Organization and Equipment, by Lieut.-Colonel H. M. E. Brunker. 5th edition. (8vo. 7s. 6d. Clowes).

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Trafalgar. La Campagne Maritime de 1805, par E. Desbrière. Published under the direction of the Historical Section of the French General Staff. ($10 \times 6\frac{1}{2}$. Chapelot, Paris).

Report of the Joint Committee on Reinforced Concrete. With appendices by Prof. W. C. Unwin, F.R.S., and W. Dunn. ($11 \times 8\frac{1}{2}$. 1s. R.I.B.A.).

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Practical Earthwork Tables, by C. E. Housden, Suptg. Engineer, P.W.D., India. (2s. 6d. Longmans, Green).

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Service Chemistry. A Short Manual of Chemistry and its Applications in the Naval and Military Services, by Vivian B. Lewes, F.I.C., F.C.S., and J. S. S. Brame, F.C.S., respectively Professor and Demonstrator in Chemistry at the R.N.C., Greenwich. 3rd edition. (Henry Glaisher).

A Manual of Petrol Motors and Motor Cars. The Designing, Construction, and Working of Petrol Motors, by F. Strickland. (9×6. 18s. Griffin).

PLATE I.

JAPANESE TELEGRAPH EQUIPMENT.

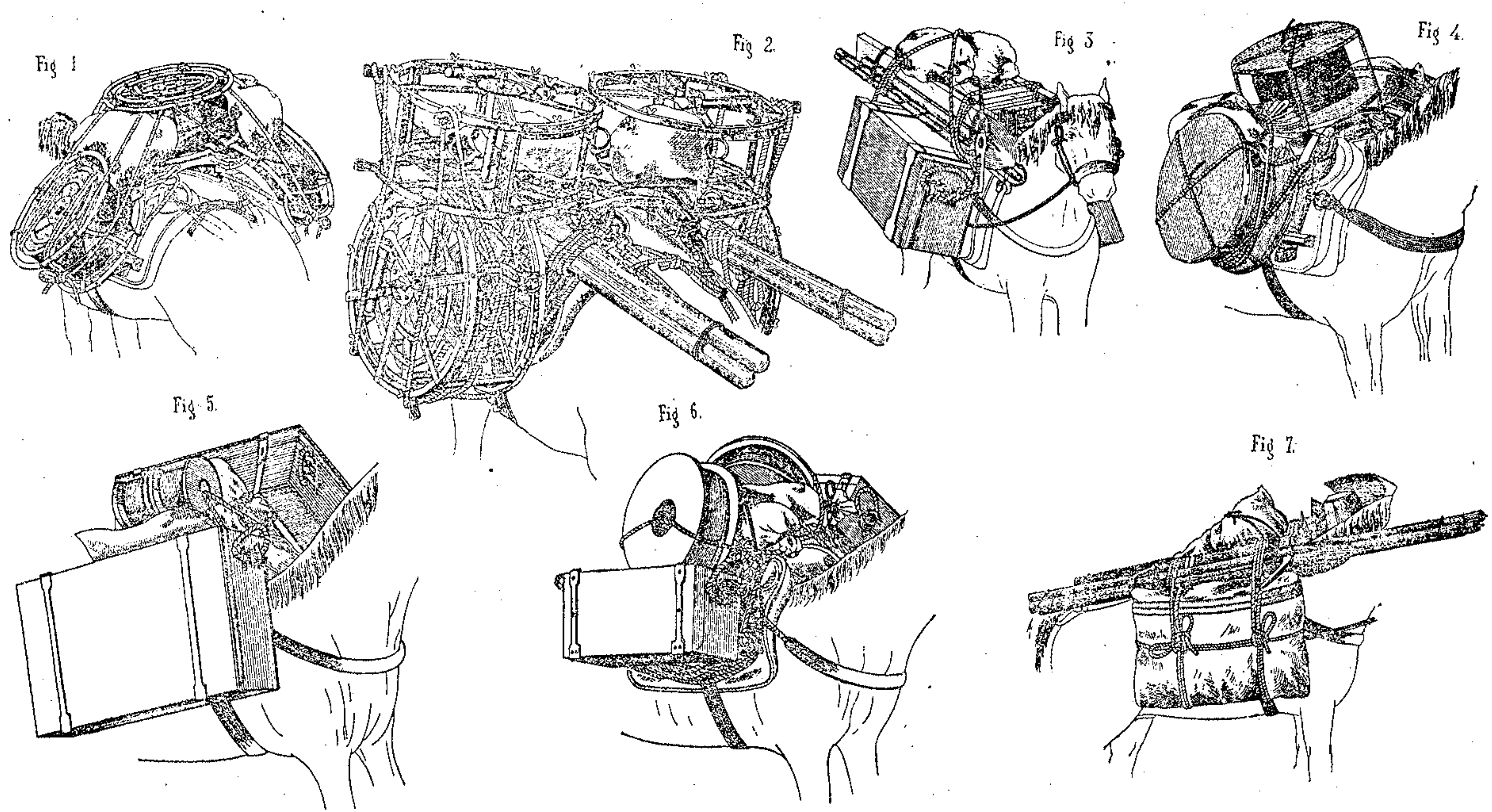
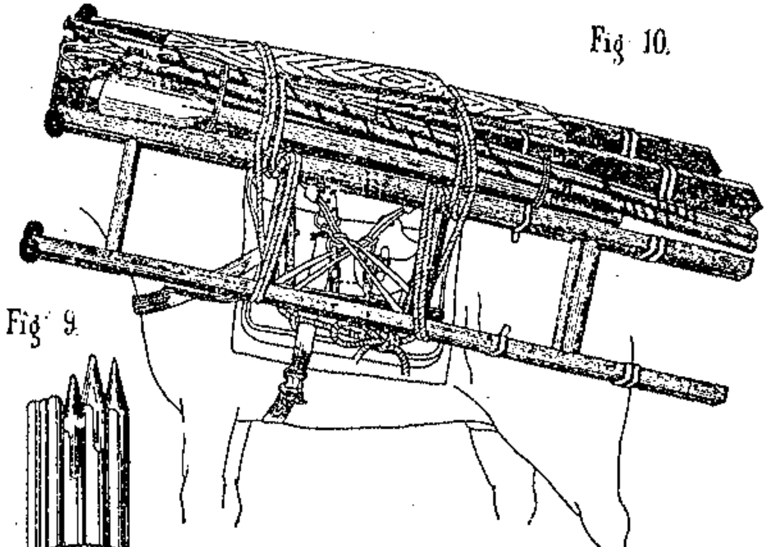


Fig 1 Fig 2. Fig 3 Fig 4. Fig 5. Fig 6. Fig 7.

JAPANESE TELEGRAPH EQUIPMENT.

Fig 10.



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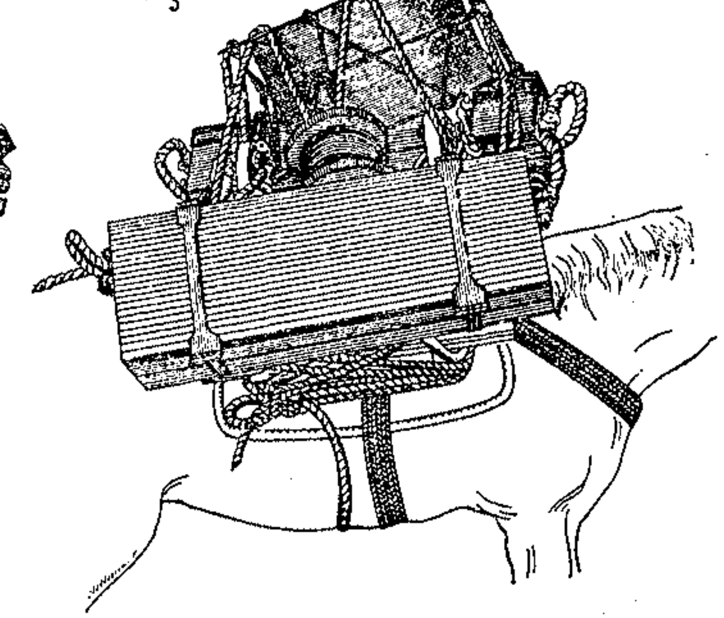

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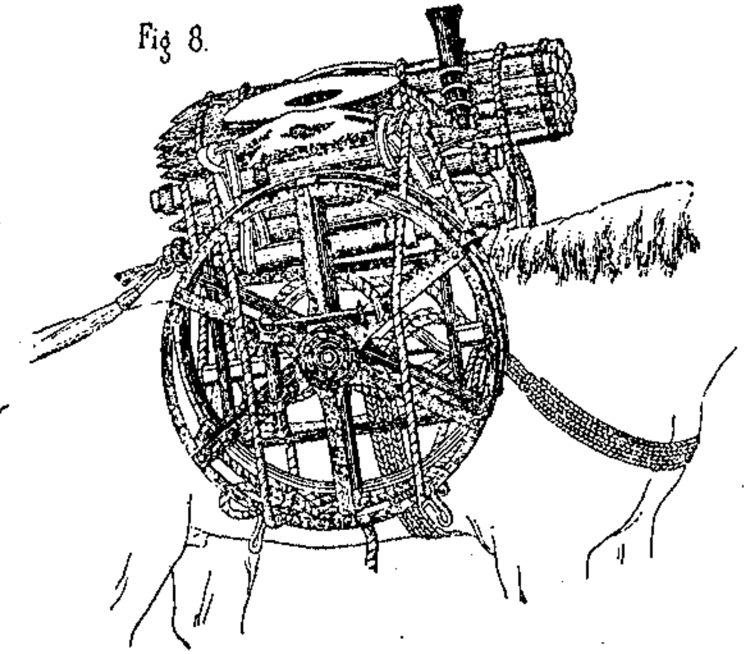

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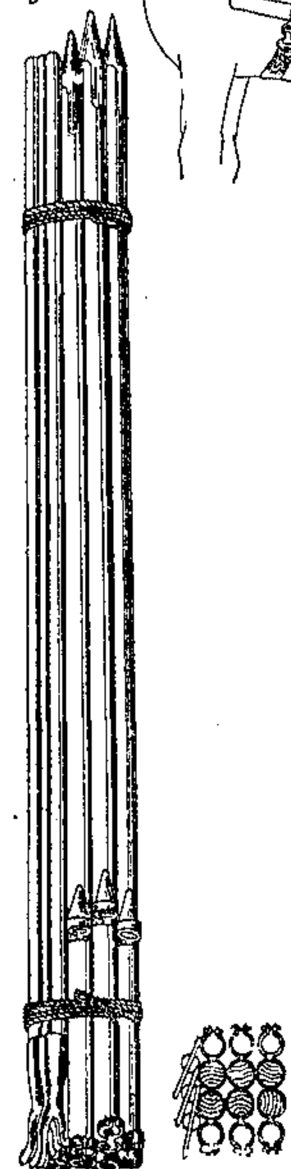

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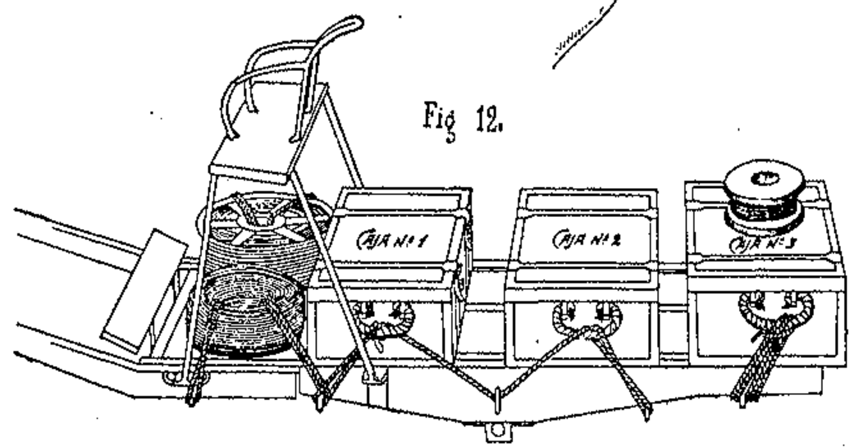

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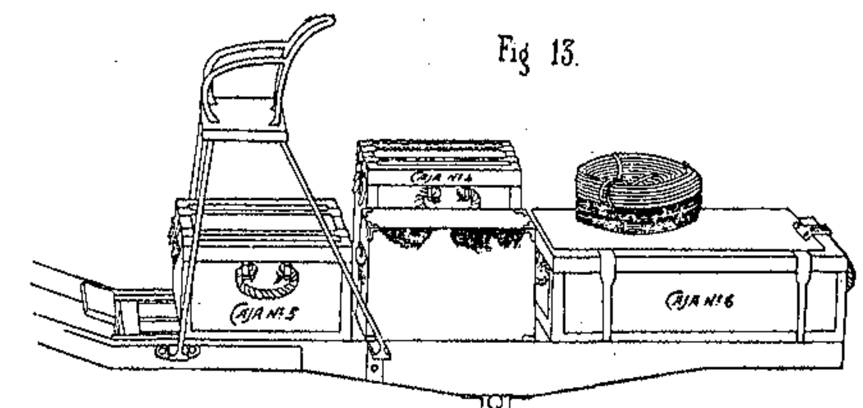

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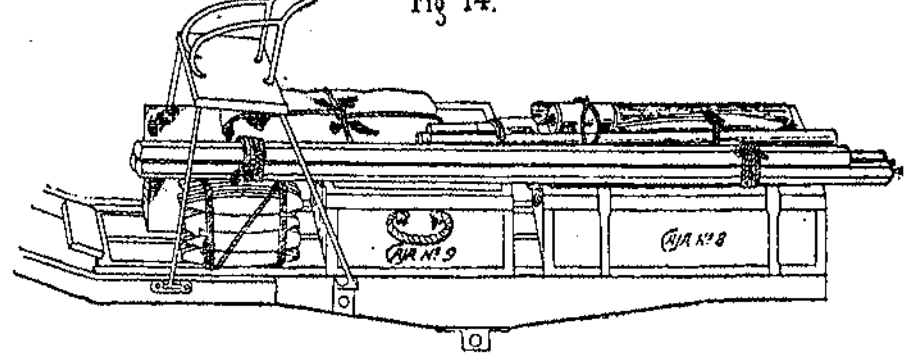

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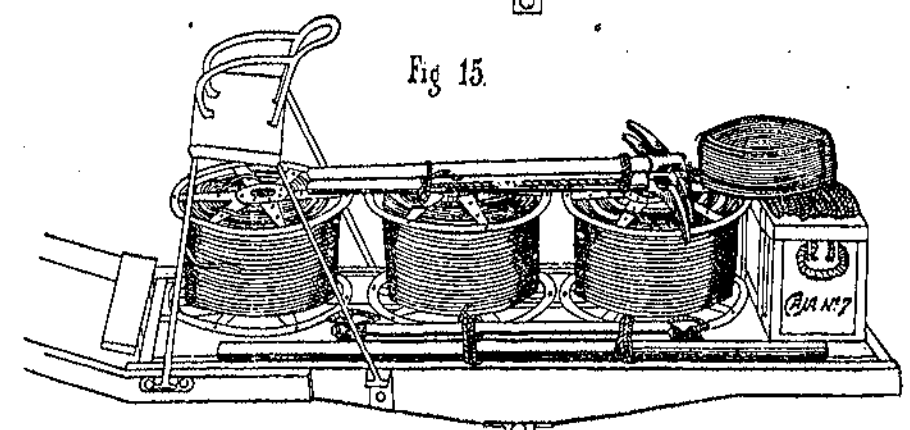


JAPANESE TELEGRAPH EQUIPMENT.

PLATE III.

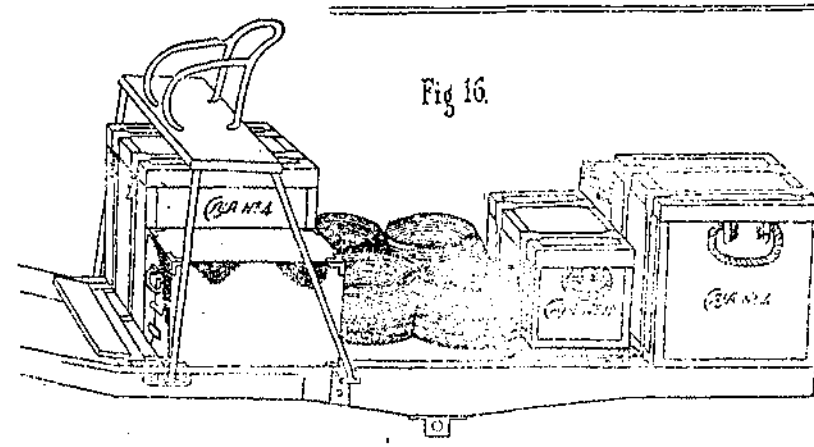


Fig 16.

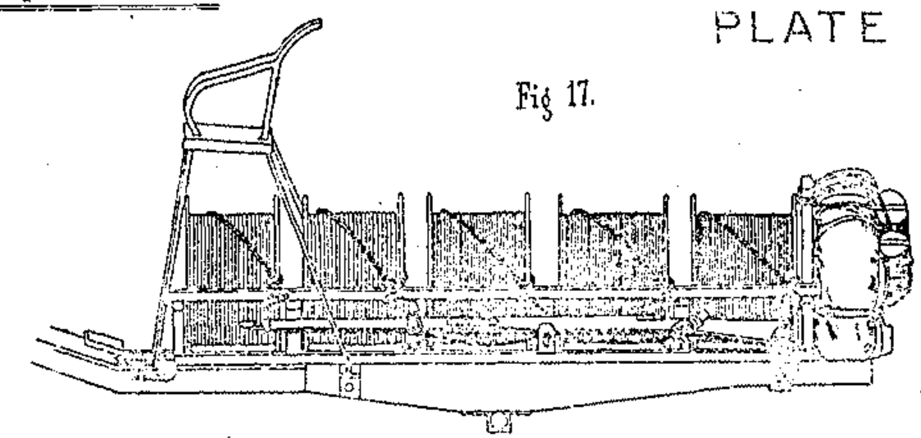
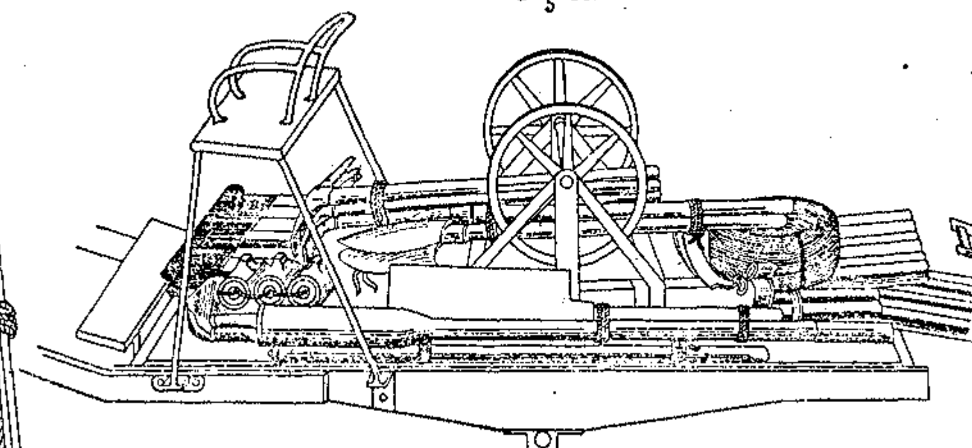


Fig 17.



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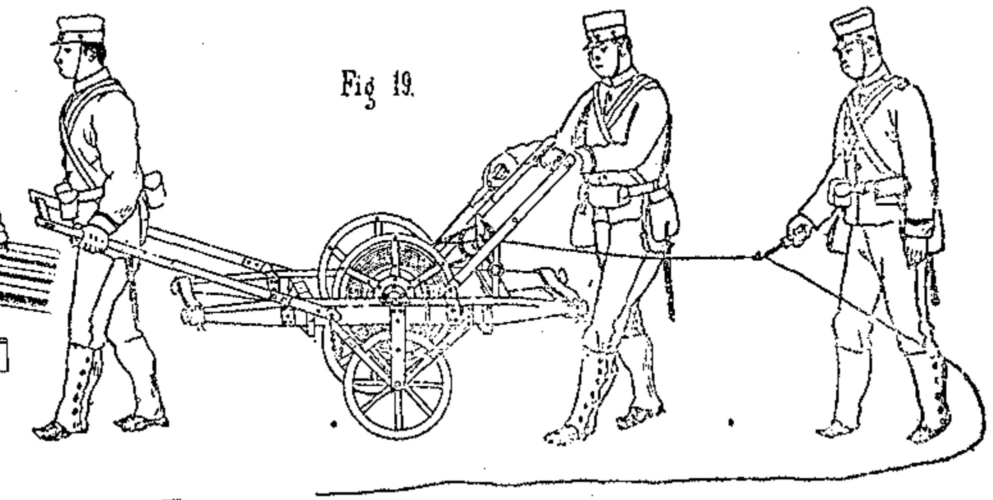

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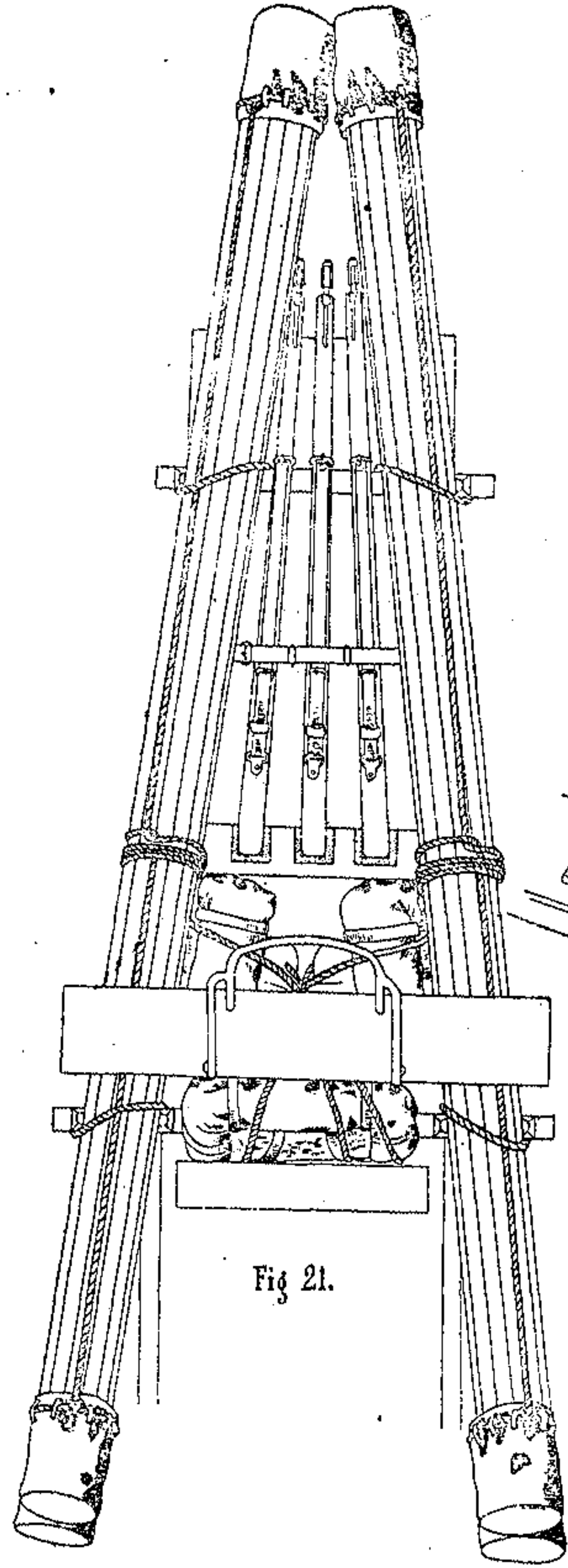

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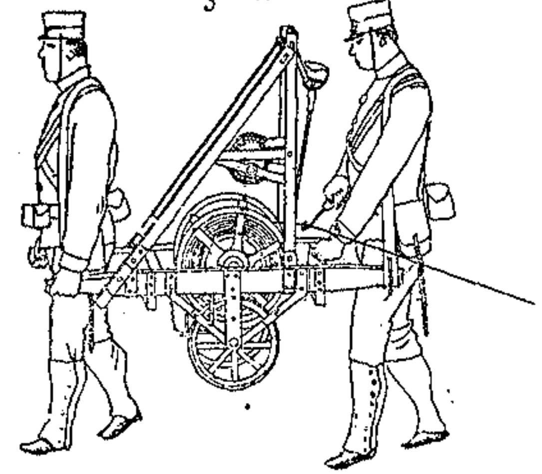

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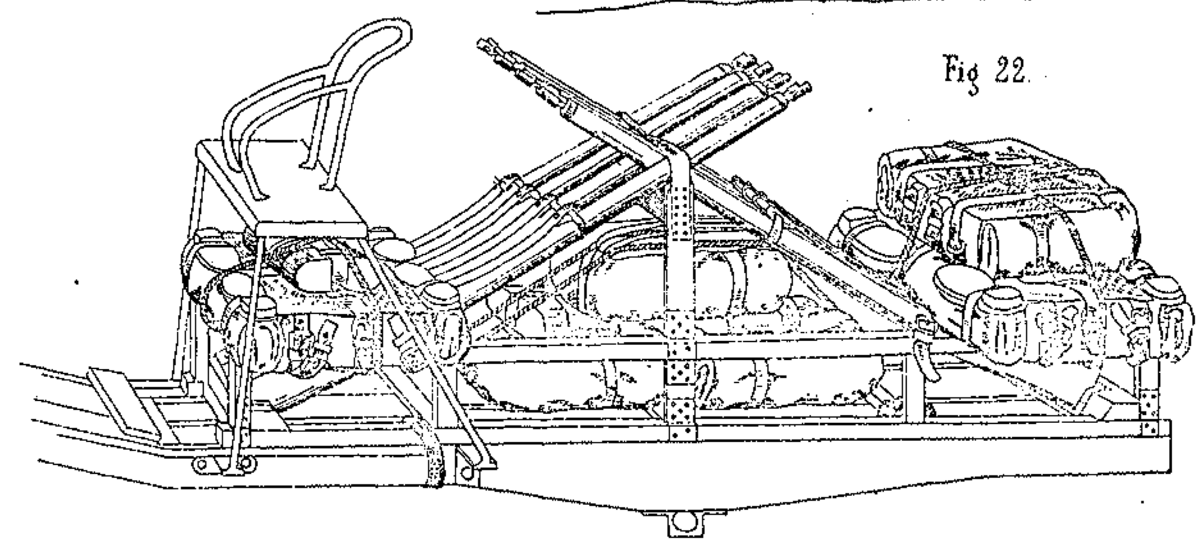

Fig 22.

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