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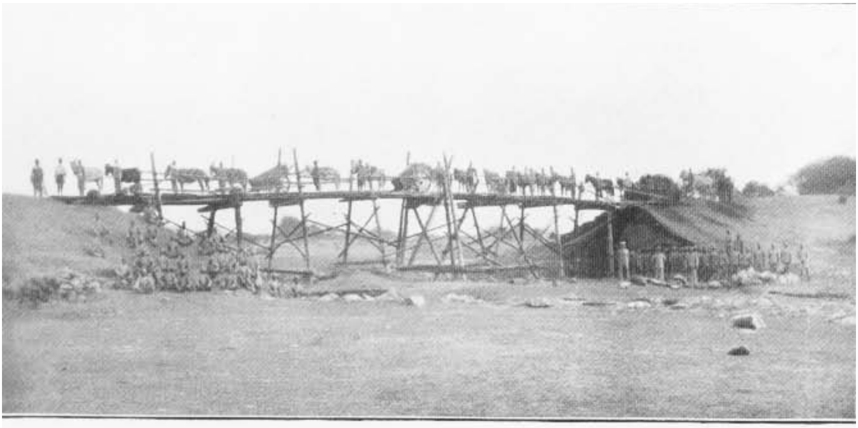
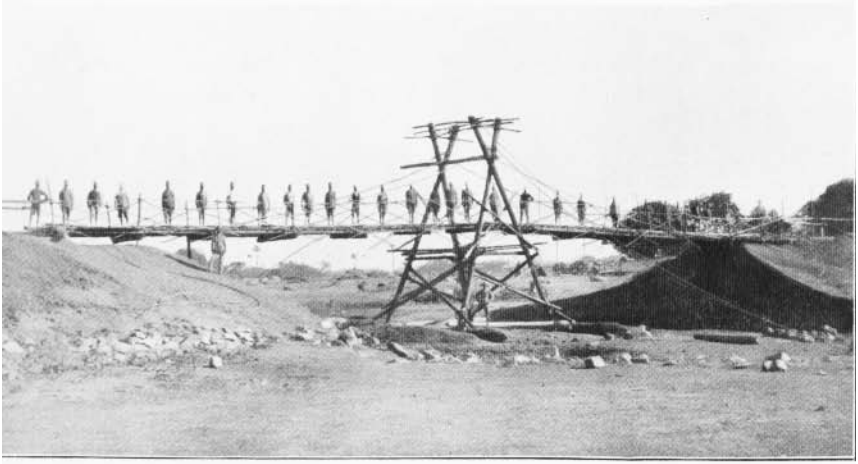


120-FOOT 15 FEET HIGH TRESTLE BRIDGE.
Some trestles and some bays of roadbearers from palm trunks.
10th Company, 2nd "Q.O." S. & M.



120-FOOT CENTRAL SUPPORT SUSPENSION BRIDGE.
Central support, 4 palm trunks.

Palm Trees

SOME EXPERIMENTS WITH PALM TREES AS BRIDGING MATERIAL.

By Brevet Major R. L. McClintock, d.s.o., R.E.

On first landing in Southern India a European cannot fail to be struck by the number of tall and slender palms, long and straight as the northern pine, which cover many parts of the country.

When he enquires as to their use, however, he is told by older residents that palms are no good as timber for building or bridging purposes. Reference to the *Manual* gives him no assistance, for although para. 20, Sec. II., of that work, puts him in possession of the Modulus of Rupture of some 50 varieties of timber—ranging from Singapore to Canada, or from Russia to Australia—it makes no mention at all of the palm.

The first and most obvious test of the quality of any unknown timber is to observe the use made of it by the natives. This fails in the present instance, as the palm family are far too valuable as food and drink producers to be felled for timber. So the enquirer is apt hastily to conclude from the fact that he does not see palm timber in local use, that it must necessarily be worthless—forgetting that neither do apple or pear trees figure extensively in the hands of European joiners. In the end he probably accepts without experiment the idea that palm trees are without value as timber, and in time transmits this delusion to his successors.

The above was the case with the writer, who for several years unquestioningly accepted this idea. A combination of circumstances however finally led him to experiment, and after devoting some months to the trial of palm spars in various forms of bridges, he arrived at the conclusion that the timber in question had hitherto been libelled in popular estimation, and that it was quite worthy of the attention of the military engineer.

This does not mean that a palm trunk is as desirable a spar for bridging purposes as one of Baltic fir, deodar, or teak; but the art of the military bridge builder largely lies in making the best of the material which he finds on the spot, and in South India the palm is very conspicuously on the spot—in many parts to the exclusion of almost all else. In the Deccan, for instance, other timber suitable for spar bridges is far from abundant. There are plenty of trees, but most of them are either short and stunted, or else thick and distorted (like the boabab, etc.), and, even in the Nizam's Government forests at Warangal, it is most difficult to obtain suitable bridging spars of over 25 feet in length.

The whole country is however profusely studded with various varieties of palms, from 40 to 60 feet in height, devoid of branches, and normally as straight as a mast.

Among the palms of the Deccan there are three main varieties, and as they are much alike to the casual eye, it may be as well to detail them here :—

1. Palmyra palm (*Talgachh*). Also known as the "fan palm," as its leaves supply the common palm fans so often seen in England.

The timber of this tree appears to be the best of the palm family. Practically its sole economic use is as the producer of a juice which, when fermented, gives an intoxicating drink called "toddy," and is largely consumed by the natives of the Deccan. Owing to the methods of extracting this sap being quite different from those employed in the case of the kajoor palm (an incision being made in the cabbage-like top of the palm, instead of in the trunk itself), the palmyra does not appear to suffer structurally from this practice, although its rate of growth is somewhat diminished. Whether tapped or not, a palmyra palm finally reaches the height of 40 to 60 feet, which is said to represent an age of from 120 to 150 years according to soil.

2. The wild date palm (*Kajoor*).

This tree also is principally used for the provision of palm wine, and as it is periodically tapped by deep incisions being made on alternate sides of the stem, it is totally ruined as a spar, as it becomes stunted and grotesquely distorted. The very few trees, which are spared this tapping for the sake of their fruit, grow from 30 to 40 feet in height, but the wood appears somewhat softer than the palmyra, and not so suitable for use as spars.

3. The cocoanut palm (*Narial*).

This tree in appearance, foliage, etc., is somewhat similar to the wild date, and likewise attains a height of from 30 to 40 feet. It is not so plentiful in the Deccan proper as the palmyra and date palms, as it is more generally found within reach of the sea. Most of the palms, which grow in the inland Deccan, have been planted in private gardens, and on this account, as well as on account of their large value as nut and toddy producers, it is very difficult to get permission to cut one down. For this reason I have so far been unable to carry out enough experiments with this timber to be conclusive, but from what has been done—together with information gathered from native sources—I should say that it ranked between the palmyra and the date in point of quality.

A curious feature of the palm family is that during its life a palm tree preserves a fairly constant diameter, being nearly as thick when 5 feet high as when 50. This thickness is usually about 9 inches, and is practically uniform all the way up. When quite young and only a few feet high, the tree consists of a hard outer case or rind some 2 inches thick, the remainder of the stem being filled with a soft, sappy and fibrous mass. As the tree grows older and taller, the hard shell thickens from the base upwards, till finally, when the tree is some 60 feet high, it will be practically solid for the lower 20 feet. The centre 20 feet will have a thick outer shell and a fairly dense and hard filling, whilst, in the top third, the thickness of the shell diminishes and the softness of the filling increases right up at the cabbage-like top of the tree, where it is of the same structure as when young. For this reason the top third of a palm tree should be eschewed as a spar. The centre portion does well enough for either trestle legs or road-bearers, whilst the bottom part—being dense and close grained (especially in the case of the palmyra)—will do for pretty well anything, and can even be sawn up into planks.

From the above description it will be seen that a palm-trunk is in structure like a pipe; the greatest strength is at the circumference, while the neutral axis is weak. Consequently when "tested to destruction" under a cross-breaking stress, it fails in the same way as a pipe—*i.e.*, by buckling—and not by splitting or snapping as would an ordinary spar.

Two photos are given to illustrate what can be done with palm spars as bridging material. Palmyras were used in both cases as being more easily obtainable than either of the other two kinds of palm.

The first photo is that of a heavy trestle bridge, 15 feet high, for infantry in fours, crowded or loaded carts. In this bridge on account of the expense some, though not all, of the trestles were made entirely from palm trunks. Several entire bays of road-bearers also (span 12 feet) were made from the same material.

This bridge was tested in excess of the full calculated load, and although three road-bearers—composed of palm trunks—were used in each bay, no symptoms of bending or buckling were observed. From this experiment it may be taken that palm timber is amply good enough for ordinary spar bridges.

The second photo is that of a central support suspension bridge for cavalry in file or loaded bullocks—span 120 feet.

In this case the four legs of the central support were made from four 30-foot palmyra trunks. As the total weight of roadway and load came to something like 21 tons, this was a pretty severe test, but the legs stood it successfully.

The use of a palm trunk as the transom over which the two cables pass on the top of the central support was also tried experimentally, but symptoms of buckling were observed, and a teak spar was finally substituted.

Finally a field observatory 100 feet in height was made by superimposing one 60-foot palmyra on the top of another still growing.

It may be interesting to note that in the above type of suspension bridge the shore struts shown in para. 208, *Manual*, III., do not appear to be necessary, as when one-half of the bridge is loaded and the other half empty, the bridge only deforms very slightly. In the present case, with 60 men on one half and nothing on the other, the cables ran over the central pier transom to the extent of half an inch only.

TRESTLE BRIDGING.

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

As a small supplement to Capt. Mozley's interesting article on trestle bridging in the May number of the *Journal*, it may possibly be of some use to mention another method of placing trestles in deep water, which was found successful at Chatham in 1898.

A tidal ramp was being constructed as part of a bridge across the Medway from the Dockyard to Upnor Hard. The large size of the trestles precluded launching in the usual way, and, owing to the strength of the current and the weight of the trestles, it was very necessary to get them into exact position as they were raised, since any movement afterwards was almost impossible. Each trestle had double legs, double diagonals, and three ledgers to prevent settlement in the mud. The legs of the largest were 33 feet long, so that the weight was considerable.

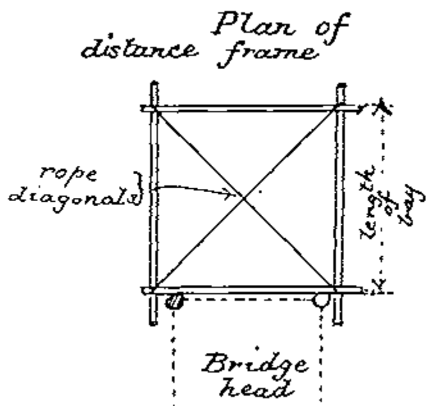


FIG. 1.

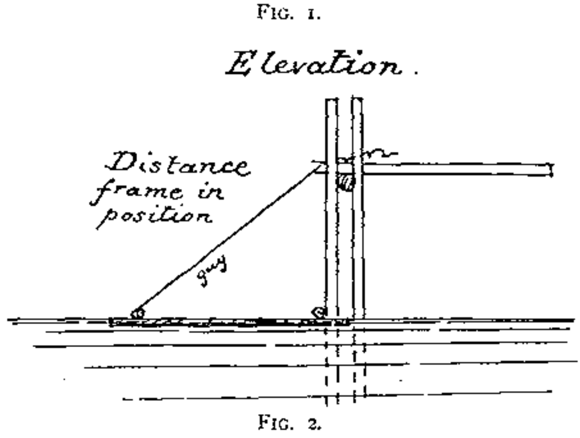


FIG. 2.

The first trestle was launched from the Dockyard wall in the ordinary way. For the remainder, the following method was adopted. A distance frame was made of four spars with diagonals of rope and floated to the head of the bridge as shown in *Figs.* 1 and 2. The trestle was then floated and towed, or warped out, to the bridge-head, and placed as shown in *Fig.* 3, the tips pointing away from the bridgehead, and the bottom of the legs floating underneath the front of the distance frame. Head guys were attached and two sets of

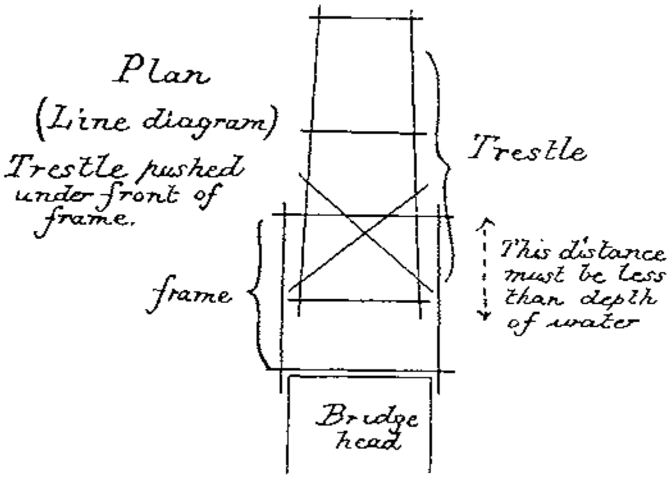


FIG. 3.

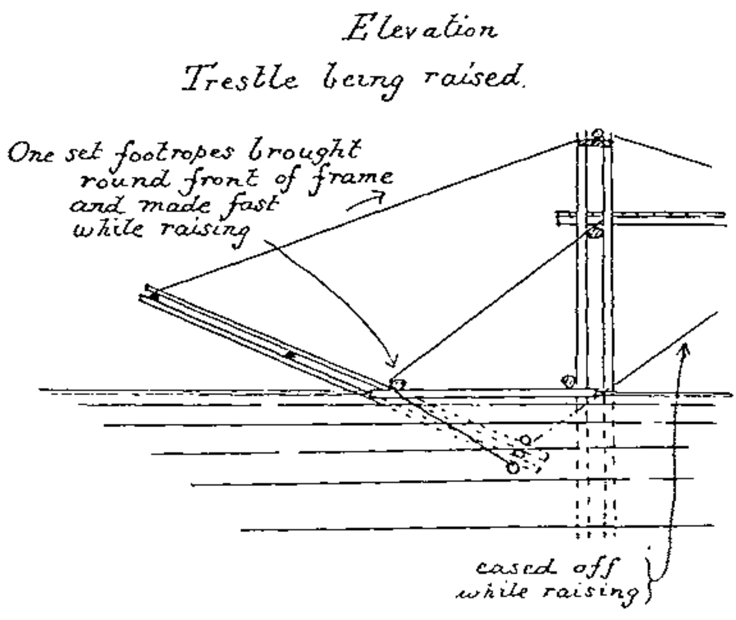


FIG. 4.

foot-ropes, one of which was brought up round the front spar of the frame on to the bridge. The trestle was then easily raised (*Fig.* 4) by hauling in the head guys and easing off the ordinary foot-ropes, the legs pivoting about the front spar of the distance frame. As the trestle became vertical, the extra set of foot-ropes was eased off and the legs took the bottom. No weighting of the feet was found necessary, which was an advantage. The distance frame ensured accurate position, the extra foot-ropes preventing it from rising when the head guys were hauled on.

Five trestles were placed in this manner without difficulty, except in the case of one which was raised when the tide was high and the depth of water about 18 feet or so. This trestle floated in a vertical position when raised, but it was kept vertical by the guys and foot-ropes, and was made to take the ground by getting the roadway out on to it.

BRIDGE OVER THE KHARMANA AT SUDDA, KURRAM VALLEY.

By COLONEL G. K. SCOTT-MONCRIEFF, C.B., C.I.E., R.E.

THE Kharmana is a stream which rises in the Safed Koh Range south of Jalalabad in Afghanistan, and which with its affluents drains the upper reaches of the Afridi Valley of Tirah. It is a tributary of the Kurram, which again is a tributary of the Indus. The highest peaks in the watershed run up to 14,000 feet, the height of the river at the bridge site being 3,300 feet. The catchment area is nearly 180 square miles.

Our knowledge of this country is limited to the operations of the campaign of 1897, so it is not possible to say much about it except that snow melts on the upper reaches early in the year, but that the cultivated nature of the valleys and the wooded slopes of the hills have a certain restraining effect on floods.

The road is the main line of communication up the Kurram Valley from Thal to the foot of the British boundary at the Peiwar Kotal. As this stream is the largest which is crossed on the way, and as it is frequently in violent flood for several days, it is a matter of much military and commercial importance that communication should be unimpeded.

The question of providing a suspension bridge was first considered, but the idea was rejected, as this class of bridge is even under the best circumstances subject to oscillation. Steel girders calculated to give a 12-feet roadway were also considered, and it was found after working out the cost of various types that 40-feet girders would be the cheapest.

Orders were, however, given, about the time that the author took over charge of the works in the N.W. Frontier Province, to consider whether an arched masonry bridge might not be better than a girder bridge. It was found that a masonry bridge with 40-feet spans and 16-feet roadway could be built more cheaply than any steel girder form, and the comparative estimates having been submitted to the Government of India, the masonry form was, of course, accepted. The reason why this form gave a cheaper bridge than a steel girder is that there happened to be near the site an excellent quarry of mountain limestone, whereas if girders had been used, not only would they have to be brought by railway for a long distance, but the terminus of the railway is 34 miles distant by road.

As regards other materials, limestone boulders in the bed of the stream were burnt for lime, and a bed of alluvial clay near the site gave very fair bricks and surkhi. At first it was feared that the bricks would be of little use, but after one or two trials, the quality improved so much that it was ultimately decided to use this material for the arches.

The stream flows in a fairly well-defined channel, and for some miles above the site there seems to be little variation in the bed. On either bank, near the bridge site, the country is cultivated in terraces; on the left bank there is a steep declivity, but on the right the country slopes gradually away from the river bed.

The longitudinal slope of the bed is about 1 in 50. The violence of floods has brought down boulders of great size. Taking the area of highest known flood section at 1,055 square feet with a wetted perimeter of 450 feet, and a value of the coefficient of roughness of 0·020, the calculated velocity is 18 feet a second, and the flood discharge 18,990 cubic feet per second. The bridge as designed could no doubt pass a greater flood than this, but inasmuch as the conditions of the rainfall and flood discharge were somewhat imperfectly known, it was considered advisable to adhere to the size given, rather than restrict it.

The question of the depth of the foundations was a matter or very careful consideration. The first proposal was to make these 10 feet deep. It was thought that the scour would then not be more than 6 feet. As a matter of fact, it proved during construction to be 8·5 feet, and as the floods did not reach nearly to the maximum as pointed out by the oldest inhabitants, the chances are that it will some day amount to 10 or 12 feet. However, this was not known at that time. The author proposed 13-feet foundations, basing his views on the behaviour of certain bridges which he had in former years built over somewhat similar streams. But subsequently this was increased to 14 feet.

As the bed of the stream was strewn with very large boulders, it appeared probable that little water would be found in the excavations. This was the case, and the water which was found was easily kept down with hand pumps.

The design of the arches, viz., 40-feet span with 10-feet rise was decided upon partly to raise the roadway on the left bank, and thus prevent too steep a fall from bank to bridge, and partly to allow room for floating matters brought down by the torrent. The springing of the arches was taken at 2 feet above the highest recorded flood.

The arches are arranged in three sets, so that there are two abutment piers. The reason of this was that during construction it was intended to let the stream flow through the centre set, while first one set of three arches at the left bank, and then the set of three arches of 40 feet and one of 25 feet at the right bank, were complete. All this time the ordinary flow of the stream would pass, as it usually does, through the centre, kept in place by training works. Then after both the end sets were complete the river could be trained to one or other, or both, of the completed parts, and the central portion could be finished.

The orders given were that centerings were to be left in position after the arch was finished, for at least a week. The reason of this order was that the author is convinced, both from theory and by careful experiment, that in every arch which is built on a circular arc there must be some joints where the line of resultant pressure falls outside the centre third, and where therefore inevitably some reliance must be placed on the tenacity of the mortar. To give the mortar some chance of setting, a week was the least time ordered, and it is remarkable that in those cases where more than a week was given there was absolutely no observed settlement whatever. In those arches which had been up for a week there was a slight observed settlement, under one inch in every case.

Before quitting the subject of the arches it may be mentioned that they were built of ordinary bricks, and two sorts of special taper bricks, as introduced by Mr. C. Richardson on the Severn Tunnel. The taper bricks were stamped I. and II. respectively, the former being nearest the soffit. Each of these bricks had exactly the same cubic content as an ordinary brick, and it was, therefore, equally easy to handle. Not only is bond given to the arch ring by this means both longitudinally and transversely, not only is cutting and rubbing of the surface of the bricks avoided, but the work is even cheaper than ordinary brickwork, for the bricklayers can lay the bricks without troubling themselves much as to keeping bond, putting in closers, etc.

It had, indeed, been intended to use concrete arches, but the idea was abandoned for several reasons, viz., the difficulty of satisfactory ramming on wooden centering, the somewhat uncertain nature of the material, and the relatively longer time that would be required in the concrete arch before the centering could be removed, and the ever present chance of a flood coming and carrying off the centering. The material for the matrix being only stone lime and surkhi (or crushed brick), it was necessary to make a series of experiments on the tenacity and adhesion, and although these experiments, which were at first unsatisfactory, gave subsequent results which would have justified the use of concrete in the arches, yet the other difficulties were so definite that it was ultimately decided to use brick, after it was found that the latter could be made locally of good quality.

The experiments showed that the most satisfactory concrete was obtained when the proportions were 1 lime, 2 surkhi, and 6 stone, broken to $1\frac{1}{2}$-inch gauge and rammed. To show how weak even the best of such mortar is as compared with cement, it may be mentioned that the best results gave only 18·2 lbs. per square inch *adhesion* after a month, and 50 lbs. tensile strength in six weeks. The means of testing, however, was very rough, only good enough to point to the best relative proportions. A very large number of experiments were made.

In connection with the design it was resolved to continue the cutwaters of the abutment piers up to and slightly beyond the level of the remainder of the parapet. This not only broke the monotony of the long wall of the parapet, but it afforded a convenient recess where pedestrians could wait while a stream of traffic—such as a long train of laden camels, or a regiment on the march—happened to be coming the other way. The advantage of some such waiting place is well known to any who have travelled in the East.

The only other features in the design of any architectural interest were the corbelling of the parapets, which was not only economical, but introduced a pleasing break in the surface of the wall above the arch, and the design of the parapet terminals, which was arranged so as to be as simple as possible. It is true that some most handsome examples of bridge architecture might have been borrowed from bridges on the N.W. Frontier Road, between Kohat, Bannu, and Dera Ismail Khan, but these depended very largely on finely finished ashlar, and it was hardly possible to do much of that work in so remote a spot as the Kurram Valley. At the same time the author regrets now that he did not attempt a little more in this respect, with the example of the other bridges before him. Even a string course at the springing of the arches would have improved the appearance.

The lower part of the foundations in the piers was built in lime concrete (1 lime, 2 surkhi, 6 stone), the same proportions being used in the spandrils of the arches.

Work was not actually begun on the bridge till February, 1903, although it was sanctioned in October, 1902, as it was found difficult to get a respectable contractor to take up the work in so remote a spot. The local people, though the bridge was close to a large village, and was very obviously for their advantage, not only produced no supply of labour or animals, but were a source of continual trouble owing to petty thefts. Petty contract work, which at first seemed the most promising method of carrying out the work, proved unreliable. A contractor, however, at last was found, who took up the work at very remunerative rates. As, however, the actual cost of the bridge (Rs.64,000) was Rs.8,000 less than the estimate, and only amounted to Rs.144 (say £10) per running foot, the cost cannot be said to be extravagant.

The floods, which gave so much trouble at other works on the frontier in the spring of 1903, frequently retarded progress on this work also. Fortunately the foundation work in the central group of piers had been satisfactorily done in a comparatively dry period, so that the floods passed through the central group of arches while the outer sets of arches were being made. Several times the training works were outflanked, and the centerings threatened, but there was no actual loss of any, and although it happened more than once that the flood water bore down on absolutely fresh masonry, the mortar behaved very well, and there was hardly any loss.

The ends of the centerings rested on projecting stones built into the piers. These were afterwards cut off. The ribs were 5 ft. 6 ins. apart.

Scarcity of labour was an ever-present difficulty. All skilled labour, and to a great extent all unskilled labour also, had to be imported. The prevalence of cholera, and the difficulty of getting supplies, caused men to desert frequently, while many of them became nervous about attacks at night from the marauding tribesmen of the frontier. On this score there was, however, nothing to fear, for the camp in which the workpeople lived was surrounded by a wall and strong wire entanglement, and it had a strong armed guard on it at all times.

It was realized, too, that mischievous tribesmen from across the adjacent border might easily tamper with the sand boxes under the centering ribs, and thereby destroy the arches. This was guarded against by keeping armed watchmen on the works at night, with orders to alarm the guard in case of any such attempt being made.

The work was, however, completed without accident in eight months. It was open for traffic in September, 1903.

Capt. A. R. Winsloe, D.S.O., R.E., was in charge of the works during the whole of the construction.

The estimated cost was Rs.72,000, and the actual cost Rs.64,000.

STUDIES ON THE USE OF FIELD TELEGRAPHS IN SOUTH AFRICA.

By MAJOR E. G. GODFREY-FAUSSETT, R.E.

II.—TELEGRAPHS AT COLESBERG.

A SECTION MAINTAINING THE INTERNAL COMMUNICATION OF A MIXED DIVISION.

AT the end of November, 1899, the headquarters of the 1st Telegraph Division was still camped at dusty De Aar. Of the four sections, Moir's (No. 3) was advancing with Lord Methuen on Kimberley, Henrici's (No. 2) was backing him up, and Jelf's (No. 1) and Mackworth's (No. 4) were awaiting orders.

Orders for a section to join General French's force at Naauwpoort arrived late on the 28th, and by 7.30 a.m. on the 29th No. 4 was on the train. A section of those days was of a composition differing considerably from what one is accustomed to in England—the marching-out strength was as follows :—

1 officer (2nd Lieut. Mackworth).
33 N.C.O.'s and men.
14 Cape boys.
11 ponies (riding).
39 mules.
24 oxen.
3 air-line wagons.
1 cable cart.
1 G.S. wagon.
1 Scotch cart.

It carried 15 miles of air line and 8 of cable, as well as some spare, and was then—as it is hoped it will always be—self-contained and independent.

A wearisome wait for a train at De Aar—a four hours' journey—another wait for an empty siding—and they were in camp at Naauwpoort.

General French, with a gradually accumulating force, was then at Naauwport, guarding the important railway junction, and reconnoitring towards Arundel and Colesberg. For the next week or two these "worrying" tactics went on, the telegraph section acting with them, sometimes with a cable cart, sometimes by tapping the railway telegraph line which ran northwards through Arundel to Colesberg.

On December 7th Arundel was occupied, the Boers holding a position across the line at Taaiboschlaagte. The bad news of Stormberg, Magersfontein, and Colenso tended to impose caution in advancing, and to increase the confidence of Schoeman, who commanded the Boer troops, so that it was not until December 29th that the incessant skirmishing led to the retreat of the Boers to a position covering Colesberg.

The position of the enemy was a very strong one, on the line of the Schietberg and across the railway, and General French, after a reconnaissance on the 30th, could do no more than occupy Porter's Hill with cavalry and guns, at the same time bringing up his headquarters from Arundel to Rensburg.

The section now maintained and worked the railway telegraph wire from Rensburg to Naauwpoort as part of the L. of C. At Naauwpoort the work was handed over to the Cape Colony Telegraph Service.

On December 31st an offensive movement against the enemy's right resulted, early next morning, in the capture of McCracken's Hill, which was held as an advanced post throughout the operations. Cable was run from Rensburg to Porter's Hill, to connect up the post there.

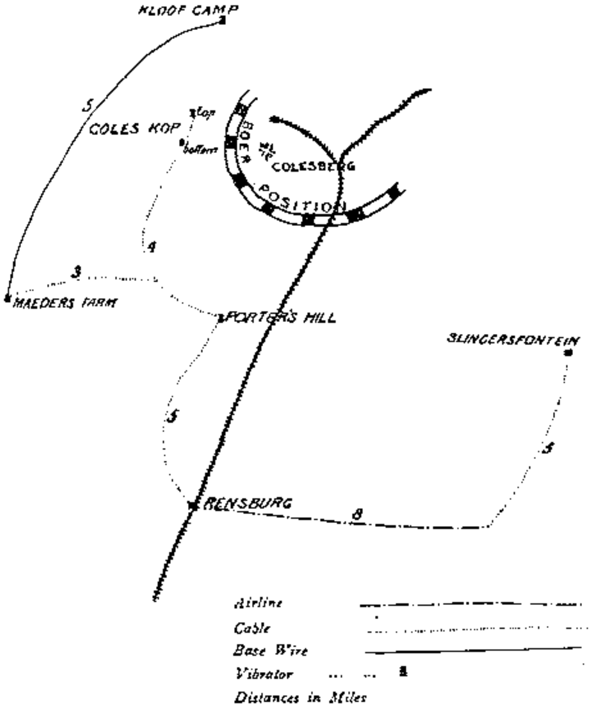
Attack and counter-attack went on all through the 1st January, and by the evening the British were well established from Kloof Camp and McCracken's Hill on the N.W. to Jasfontein on the east, with a supporting post at Maeder's Farm, and headquarters at Rensburg.

The 2nd and 3rd of January passed without any serious fighting, and advantage was taken of the pause to extend the telegraphic communications. The Porter's Hill cable was carried on to Maeder's Farm on the 3rd, and an office opened there, and an extension was made in the evening to Coles Kop, a conical hill which dominates all the country, offices being opened at its foot and on its top. This was a heavy day's work for one cable cart, but it was fortunately achieved in time to be of great importance, as early in the morning on the 4th the Boers made a strong attack on the extreme British left at Kloof. The detachment of the Suffolks there was outflanked, and was in serious danger for a time, but General French, who at this moment reached Porter's Hill, was able to telegraph to Maeder's Hill for the troops there to advance. The Boers were driven back with a loss of about 130.

On the 5th the line was extended by bare wire on the ground from Maeder's Farm to Kloof, the cable having all been used up.

Reinforcements had arrived, and on the evening of the 5th an unsuccessful attack was made on Suffolk Hill, in front of Kloof, resulting in a loss of 11 officers and 150 men of the Suffolk Regiment.

On the 7th a reconnaissance to the right had shown a good position at Slingersfontein Farm, and this was occupied on the 9th by cavalry and guns under General Porter. A cable cart accompanied this force, laying 13½ miles, and leaving an office at Slingersfontein. During this march General French, who was with the column, was in direct communication through 20 miles of cable with the C.R.A. who was on Coles Kop, and was thus able to issue instructions as to artillery fire to distract the enemy's attention.



CIRCUITS, 11th JANUARY.

Next day some of this cable was replaced by air line, the party laying six miles in four hours, though the ground was dry and stony, and Mackworth took more cable out to Slingersfontein, ready for a reconnaissance on the 11th. The Boers, however, were in too great strength on this flank for our lines to be pushed further on.

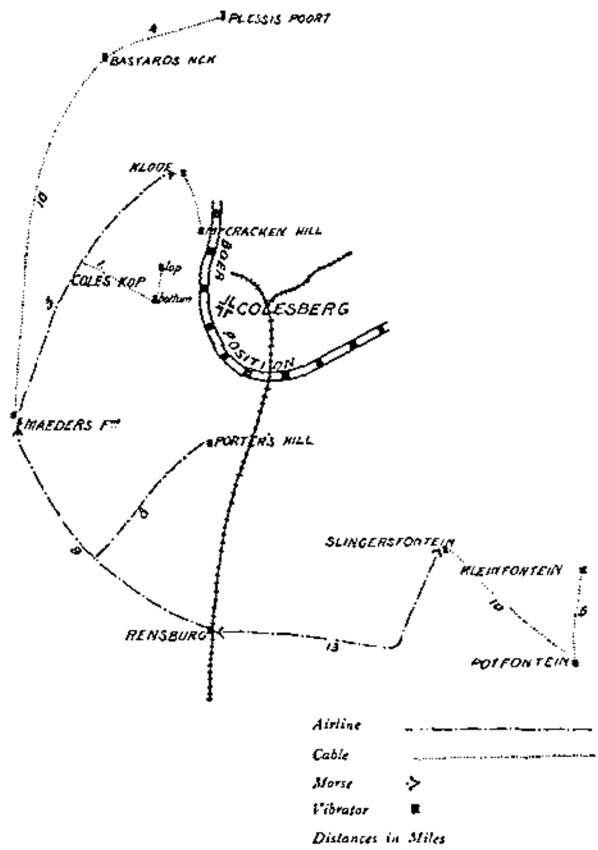
On the 11th also a 15-pr. gun was placed on Coles Kop by the 4th Battery, R.F.A.—a great feat, as the height commanded the whole of the Boer position. This peculiar kopje is almost a sugar-loaf, with sides nearly precipitous, and is difficult to climb even with both hands free. A wire rope was slung by the field troop to enable supplies and ammunition to be hoisted. This gun—assisted by a second one a few days later—fired straight into several of the Boer laagers, to their immense astonishment.

The next few days were devoted to replacing cable by air line. Three more miles were done on the Slingersfontein line, and air line was run to Maeder's Farm and Porter's Hill. Morse was substituted for buzzer at Kloof, and cable was laid to McCracken's Hill.

An attempt to destroy the railway line at Achtertang by Major Hunter-Weston very nearly succeeded, and a serious attack by the enemy on Slingersfontein was beaten off. On the 15th and 21st strong reinforcements joined under Major-General Clements, including two howitzers which shelled Grassy Hill on the 19th, their fire being directed by telegraph from an observing station on the top of Coles Kop. The cable on the right was pushed on to Potfontein and Kleinfontein.

On the 20th Mackworth wired for more cable, and the O.C. brought him down the cable detachment of No. 2 Section, which was not in use elsewhere as No. 2 was engaged in maintenance duties at Orange River. The detachment which had arrived from England under Capt. Fowler took over the permanent lines up to Rensburg, thus freeing men and *matériel* for fieldwork.

The cable from Porter's Hill to Coles Kop was still lying out, though not in use. This was reeled up by night on the 23rd—24th, the



CIRCUITS, 24th JANUARY.

experience being a rather exciting one, as it entailed approaching the sentries at Porter's Hill from the enemy's direction. An advanced guard was detailed, who whistled popular airs as loudly as possible when nearing the outpost line !

On the 24th Bastard's Nek was occupied, and on the 25th a strong column, accompanied by a cable cart, worked round towards Plessis Poort. In spite, however, of simultaneous attacks at Porter's Hill, and on the extreme right at Keerom Farm, nothing but information was gained.

At this point in the operations, Lord Roberts' advance on Bloemfontein entailed the removal of the cavalry and the bulk of the telegraphs. General Clements was left in charge at Rensburg, and a small telegraph detachment remained to maintain and work such lines as were still required.

The operations round Colesberg are of especial interest, as it was one of the few occasions during the war, when the Army Telegraphs were in sufficient local strength to undertake internal as opposed to external communications. That the tactical work was valuable, was shown by General French's statement that he would have been unable to hold his extended position without the telegraph lines.

The force was a mixed one, but at the close it amounted to seven battalions of infantry besides the equivalent of about six regiments of cavalry. This amounts practically to a division, and under the present telegraph organization it is probable that the following would have been available :—

Divisional Cable Company	...	3 cable detachments.
Section " "	...	2 " "
" Air-Line Company	...	2 air-line detachments.

Whereas all that were present were two cable and two air-line detachments.

This greater strength would have enabled the work to have been carried out more quickly, and at several points simultaneously, cable carts actually accompanying the several advances, instead of lines being run to posts the next day.

In addition there would have been two or three infantry mule telephone detachments, which would probably have been used for outpost work.

The fact that headquarters were not moved after arrival at Rensburg, simplified matters immensely; an advance when all the lines were out would have been a hopeless matter to deal with satisfactorily with so small a unit.

Similar cases of a comparatively small force actively engaged along a long line will doubtless occur in future campaigns, and a large percentage of telegraph troops will prove most economical on such occasions.

ECONOMIC PRINCIPLES IN FACTORY DESIGN.

By Major H. F. Thuillier, R.E.

A factory may be said to be any establishment where raw, or partially wrought, materials are converted into manufactured articles. Among the descriptions of factory which an engineer may be, and sometimes is, called on to design and construct are the following:—Single workshops; or large establishments for the manufacture of ordnance stores of all descriptions, such as guns, gun carriages, rifles, ammunition, harness, and saddlery; or arsenal stores. In wartime he may be required to construct, organize, and administer workshops for the building and repair of railway rolling stock; or establishments where structural steel work, bridge girders, etc., are manufactured. Large slaughter yards and bakeries—such as those at Aldershot—come also under the head of factories. Even the arrangements for mixing mortar and concrete and delivering them to the places where required, and the organization generally of large construction works, should follow in their inception the general principles set forth in this article.

In designing any engineering work the first end to be kept in view is to adapt it as completely as possible to the purpose for which it is intended. To this end regard must be had to the economic principles which govern the processes of manufacture of the articles to be produced at the factory.

Although these processes and methods may differ widely in the case of different manufactures, it is nevertheless true that whether it is steel that is being converted into girders; timber, iron, and brass into carriages; raw hides into saddles and boots; or live oxen and sheep into beef and mutton, the same broad principles govern the organization of the system of manufacture.

It is of the first importance that these principles be most carefully borne in mind in the design and siting of the buildings and other works which make up the factory establishment, and of the means of transporting, handling, and converting the materials. If they have been insufficiently attended to, the inevitable result will follow that the output cost of the finished product will be greater than it need be, and the difference in this respect between the produce of works scientifically arrranged and organized, and of those which either from avoidable or unavoidable causes are not so, will be very considerable.

The following are the main items which make up the output cost of manufactured articles :—

(1). The cost of the material, including delivery at the site of the factory.
(2). The cost of the manual labour employed in converting it into the finished products.
(3). The cost of the mechanical power employed in the same process.
(4). The cost of packing, loading, and delivery to the consumers.
(5). The standing charges of the establishment.
(6). Repairs and depreciation of the buildings and plant.
(7). Interest on the capital expended in purchase of land, erection of buildings, and provision of plant.

Of these the last would, in the case of a private business, represent the shareholders' dividends. It is easy to see that if Nos. (1) to (6) cost more than they need, the dividends will be reduced or may vanish altogether ; since the prices obtained for the output depend on the ruling market rates. Although in the case of Government factories the obtaining of dividends has not to be considered, yet item No. (7) must not on that account be disregarded. To ensure economic administration it is of great advantage to keep a capital and revenue account for manufacturing establishments, but even if this be not done it should be borne in mind that the taxpayers, who provide the funds, stand in the same position to the factory as shareholders, and a national manufacturing institution cannot be said to be established on a sound financial basis unless, when the interest on the capital outlay has been added to the manufacture charges, the total cost of the outturn is no greater than it would be if purchased in the open market.

We may now examine how the design of the establishment will affect each of the above subheads of the cost of the outturn. No. (1) is largely dependent on the situation of the factory, which affects the freights on the raw materials. The situation of the factory is generally decided for the designer by superior authority, and often on administrative or strategic grounds, rather than on economic considerations. The latter however are so largely affected by the situation, that it is worth while briefly to glance at this aspect of the question.

Firstly, as already mentioned, it is desirable to locate the factory near the sources of supply of the raw material. Similarly, by locating it near the source of fuel supply, item (3) obtains an advantage. By placing it near the consumers of the finished product, item (4) is reduced. The above are seldom compatible with each other, for the raw materials will usually not be found near the places where the products will be consumed. Moreover army stores have to be issued to all directions of the compass and perhaps to all parts of the world, so proximity to raw materials may in such cases offer the best advantage. A situation at an important railway junction giving several lines of direct communication to the points of consumption is desirable, and in countries where more than one gauge prevails (as in India), it is important to avoid a situation which will entail a break of gauge in the transit either of the raw materials, or of the products. If the stores are for use abroad easy access to a port of shipment is necessary, and if the factory can be on a navigable waterway, so that the goods can be loaded direct into the ships, a marked economy would ensue.

The prevailing rates for labour, and the presence or absence of an artizan population, may make a considerable difference to item (2). This is a consideration that is sometimes overlooked. If a factory is established in a thinly populated or a purely agricultural district, skilled labour, and possibly unskilled labour also, will have to be imported, and imported labour always costs more than that which is indigenous to the locality. Also dwellings will have to be erected for the operatives, with the result of adding to the capital cost and increasing item (7). On the other hand, in towns land is expensive, and this might partially or wholly counterbalance the extra cost of an establishment in the country. Cheapness or dearness of building rates will also diminish or increase the capital cost.

Item (5), standing charges, may also be affected by the situation in respect of the cost of water and of lighting. In non-Government concerns local rates, rents, etc., would similarly bear on this item.

It is evident that it is very seldom that a locality will be found in which all the above considerations can be satisfactorily met. For instance in one place railway freights may be low but labour dear, or *vice versâ;* in another land may be cheap, but the place may be inconveniently situated. It will generally be necessary to balance the advantages and disadvantages of alternative localities, noting which of the considerations has the greater influence on the financial working of the establishment. Often, however, considerations of army organization, of strategy, or of security from hostile attack, will be the governing factor in the decision.

Assuming now that the locality is decided, we may return to the subject proper of this article, namely, an examination of the manner in which the design and arrangements of the buildings and other works of the factory affect the cost of the project.

The main general principle to be borne in mind in these cases is that the arrangements must be such as to reduce to an absolute minimum the transport or movement, and the handling in any way of the materials during the process of manufacture. In the great majority of manufactures the cost of the materials is comparatively small in proportion to the labour required in its conversion to the finished article. It is not only in western countries, where labour is dear and materials cheap, that this is the case, but it is also so, though in a somewhat less degree, in the east, where materials may have to be imported from Europe and wages are extremely low.

The first requisite therefore, if operations are going to be on anything of a large scale, is a standard gauge railway siding right into the works. In a very few years indeed the capital cost of the siding will be recovered by the saving in charges for cart transport, shifting from railway wagons to carts, and the waste or breakage which often accompanies such operations. In cases where the material is to be kept on stock for some time before being used, the siding will run into the yard or sheds, where it will be stored, but if it is to be used directly on arrival, it is economical to carry the siding right alongside the shop or other place, where the first operation will be performed on the material. In any case where bulky or heavy articles are sometimes dealt with—such as guns for re-tubing—a siding into the shop is required, in addition to the branches into the store yard for the lighter articles.

It is an advantage to have the line at the unloading places in about 3 feet of cutting, or the floors of the store sheds may be made up to ordinary platform level so as to facilitate unloading; but this may not always be practicable, as it may affect the subsequent movement of the materials. Cranes, hand or power, according to the materials dealt with, will usually be provided for unloading goods.

Similarly, for removal of the finished products, the siding must be run alongside the place where the last process is performed, so that no intermediate handling is necessary before it is transferred to the railway wagons. Also a branch siding will be required alongside the coal bunkers where the fuel supply for the power house is kept. Double sidings with crossovers should be provided, wherever it is possible that wagons unloading may block access to other parts of the yard. Delays may be caused to the work if a sufficiency of passing places have not been provided.

While on the subject of sidings it may be mentioned that in a factory yard gradients of any sort should be avoided as far as possible, and if practicable the siding system should be dead flat. There is bound to be a good deal of hand shunting of wagons, and even a slight grade may, in such circumstances, lead to accidents. Another point is to take care, when setting out the sidings on the plan, that the curves are practicable as regards radius. The minimum curvature admissible will depend on the maximum rigid wheel base of the locomotives and rolling stock to be employed, and the necessary information can be obtained from the railway company which will supply them. Sometimes in large works special yard engines are employed, or a locomotive crane may use the sidings; in such cases the suitability of the curves to the special engines should be ascertained. If this precaution is neglected the planning may be seriously affected at a later stage.

The arrangement in relation to each other of the various shops or buildings where the processes are to be carried out, should be such that the operations performed on the materials form a continuous progress from the first stage to the last. Thus the shop nearest the point where the materials enter the works should be that where the first process is carried out; the next should be for the next process, and so on. The path taken by the material, in transit from shop to shop, should be as short and direct as possible; circuitous or zigzag routes should be avoided, and on no account should the material have to return and go twice over the same line. The aim is to secure a steady continuous "flow" of the work in one direction. The longer axes of the shops should, when practicable, be arranged to facilitate this "flow," and the arrangement of the machines inside them should as far as possible be on the same principle. For instance, in a shop where riveted steel work is to be made up, the marking-out benches should be near the end where the material enters, the punches would be next, then the reamers and drilling machines, and the hydraulic or pneumatic riveters near the exit. It would be a bad arrangement to have to carry the plates and bars past all the machines to the marking-out tables, then bring them back to the punches and drills, and then return again to be riveted up.

The means selected for transportation about the factory of the materials and parts, will depend on the nature of the latter. For heavy and bulky articles, and where the factory covers a large area, the standard gauge sidings will probably be used, a locomotive crane being very economical in such cases. For light loads, small gauge tramways with trolleys for man haulage will often be suitable, and the various shops will be connected by a network of these. Inside the shops there will no doubt be overhead travelling girder cranes of a capacity to suit the objects handled. The lines of rail or tram which bring the articles up to the shops should carry them under the cranes, so that the latter can take them to any of the machines in the shop. For light loads up to one or two tons overhead runways with pulley blocks are of very great service. The runway is generally an ordinary I joist, and the pulley is suspended from a little carriage which runs on the lower flanges. These runways can be carried round curves, and automatic switches permit of turning out on to branches. They are therefore extremely useful, as they permit of articles being delivered to machines in almost any situation. In small establishments they can be used all over the works, outside as well as inside the shops. The arrangement of the various classes of transporting gear should be such that manual lifting and handling is reduced to the minimum.

The buildings should be placed fairly close together, both in order to reduce the distances traversed by the materials and to economize in the area of land to be purchased. On the other hand it is important not to crowd them so as to cramp further development. Institutions of this nature are almost certain to grow in course of time, and very great expense and inconvenience will be entailed if space has not been left for extension. To argue, as some do, that extension will never be necessary, because it cannot be foreseen at the present moment, is to display a lamentable shortness of sight. One has only to consider any of our present manufacturing establishments, and ask oneself whether 30 years ago they were of the same extent as they are now, and what grounds there are for assuming that the development of the Army and its administrative services is about to cease.

The question of the supply of power to the different machines is one that may require a good deal of consideration. If electric power is used, a central station will be best, but for steam, gas, or oil engines, and for hydraulics and pneumatics, the closer the source of power to the place where it is used the better. With machinery driven off lines of shafting, as is generally necessary with steam, oil, or gas as motive power, there is the disadvantage that energy is wasted in turning the shafting and overcoming friction in gearing, and that even when machines are not in use power is wasted in uselessly turning shafting. Electricity can often be applied direct to machines without shafting, and when the motors are not running no power is used. On the other hand electric power is more costly to generate than that from steam or oil or gas, so from this it may sometimes happen that for machines used intermittently, electricity would be cheaper; while for machines for continuous heavy work, the other agents might be the cheaper; although the other advantages of electricity, particularly the power of applying it in any situation and even to portable tools, may often outweigh the difference in cost. For certain work hydraulic or pneumatic power is particularly suited, such as (in the case of engineering works) to presses, punches, riveters, chipping hammers, and others with reciprocating instead of rotary motion. The whole question is entirely one for practical consideration according to the requirements of each case, and in large works it might pay to have two or three different descriptions of power to deal with different classes of work.

A few words will not be out of place on the design of shops—not as regards details, but only in so far as it affects economic principles. As soon as circumstances require the width of a shop to exceed a certain amount, it becomes necessary, in order to avoid excessive and eventually prohibitive cost, to divide it into two or more spans. In many cases, however, the existence of the lines of stanchions between these spans is a considerable objection. Travelling cranes can work along each span, but movement of loads from one span to another is a matter of difficulty. Overhead runways are very useful for this purpose, but they can only deal with light loads. Although in some cases the stanchions will be unobjectionable, or even of advantage in affording supports for shafting, yet in cases where large pieces have to be handled they may be extremely in the way. The question of whether to adopt two or three large spans or a larger number of smaller ones may thus be one of considerable moment. Besides the increased cost of the roofing in the larger spans, that of the travelling cranes also rises considerably, both in initial cost and in power required to work them. Generally speaking, except when special circumstances require in any case an extra large span, it is desirable to give all the shops in a factory bays of the same roof span. This will tend to simplicity, will lessen the cost of roof trusses (since repetition work is always cheaper than different designs), will admit of interchangeability of cranes and travellers, and will enable the latter to be run direct from one shop into another, as will be described later on.

To describe in any further detail how the economic principles referred to above may be applied in practice to the planning of a factory or works yard, would be a matter of difficulty. It may, however, be possible to throw a light on it by means of an illustration.

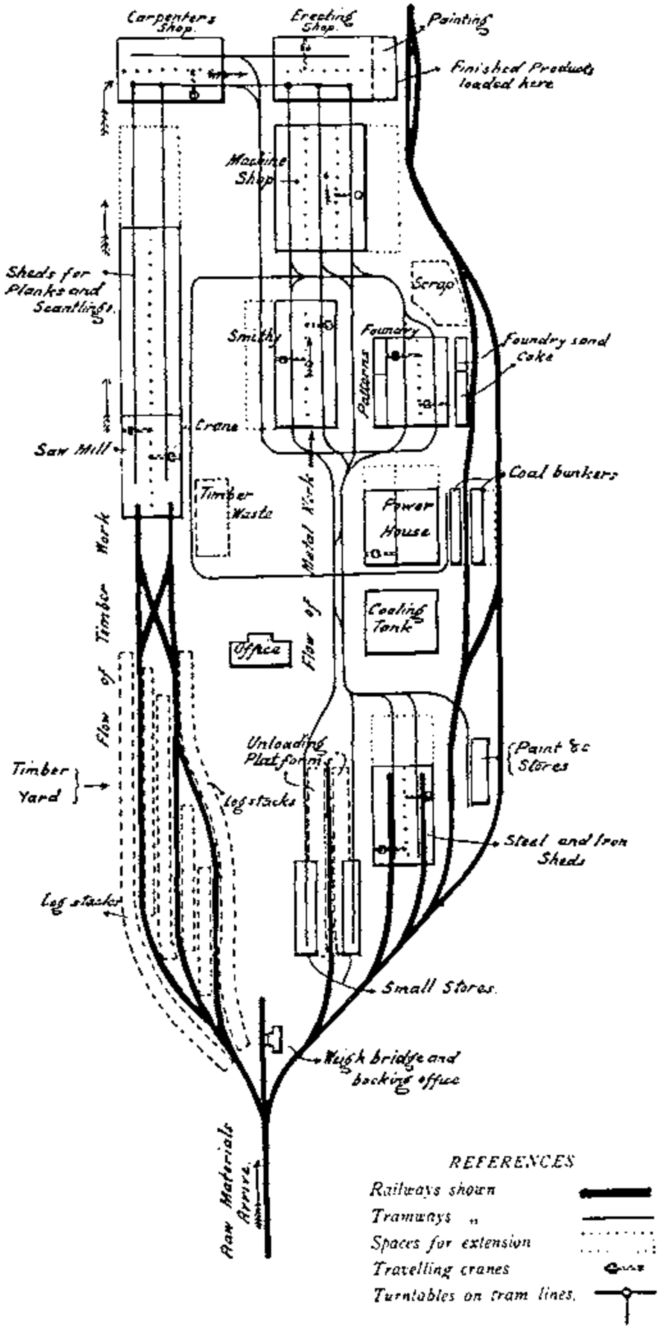
The accompanying diagram is a block plan representing a large factory or work yard, where it is assumed—for the sake of illustration—that the raw materials are timber, and steel or iron. It makes no difference in principle whether the products are railway wagons, rifles, barrack furniture, gun carriages, or anything else which has the above materials for its constituents. It should be understood that this plan is a purely imaginary one, and does not resemble any establishment with which the writer is acquainted. Exigencies of site generally prevent the adoption in their entirety of the arrangements which would be most suited to economic working. It is not, however, claimed that this plan is an ideal one. An experienced works manager would, no doubt, be able to point out defects in it and to suggest improvements. It is merely intended as a graphic method of expounding the general principles previously discussed.

We may do this by following the progress of the materials from the time they enter the factory. Close to the point of entrance we find first of all the wagon weighbridge, with a small office for the clerk who receives, issues, and checks the consignments coming in and going out. It may conveniently be on a short branch or loop, so that the weighbridge may not be constantly run over by vehicles which it is not required to weigh. The timber conversion processes are shown as taking place up the left side of the works. It is assumed that the timber arrives in logs, or large baulks, and that a considerable stock is kept to allow of a period of seasoning before it is cut up. This necessitates a timber yard where the logs or baulks are stacked,

PLAN OF A FACTORY

Illustrating Economic Principles in Planning.

Scale—Approximately 155 Feet=1 Inch.



and this must be served by sidings, arranged so as to get the maximum of stacks into the minimum of area. About 60 feet of space between sidings, will permit of a double line of log stacks, and a locomotive crane working on the sidings can pile up, or pick off, logs very conveniently.

The first operation to be performed on the logs or baulks is to convert them into scantlings or planks, so the first building next to the timber yard will be the sawmill. It is connected by a railway siding with the timber yard, and, if in more than one span, the siding should be arranged so as to serve both, so that the overhead travelling cranes can pick up the logs and take them to the various saws.

Next to the sawmill are the sheds where the scantlings, planks, etc., are stored, and undergo a further seasoning. If these can be made in prolongation of the sawmill, and of the same spans, the travelling cranes can take the cut pieces from the saws, and carry them straight to the stacks in the scantling sheds. This will be a considerable advantage. A tram line down the centre of the bays will also be useful for light loads. Somewhere near the sawmill a shed or enclosure is required to deposit the sawn outsides of logs and other waste pieces from the saws. These would be disposed of perhaps by sale, or perhaps by consumption in the boilers of the power house. A tram line to the latter place will facilitate this.

Beyond the scantling and plank sheds, we come to the carpenters' shop, fitted probably with benches, circular saws, planing, grooving, and rebating machines, and any other special plant required for the manufacture in view. Here again it would probably be an advantage to site this building with its long axis in prolongation of the scantling sheds, so that the travelling cranes can bring the material direct to the machines; but site considerations will seldom allow of a series of large shops to be arranged end on to each other. It will probably not be necessary to carry heavy loads from the scantling sheds to the carpenters' shop, so that tram lines or overhead runways will generally afford a sufficient connection between the two. Moreover the relation of the carpenters' shop to the one where the next operation will be performed, has to be considered, and this also affects the siting. Before proceeding to this, however, we will, as we have now reached the penultimate stage in the timber portion of the manufacture, leave it for the present and go back to the steel and other metals.

The steel and iron will arrive in bars, blooms, plates, etc., and sheds will be required for its storage. Also closed sheds will no doubt be wanted for small stores, paints, etc. These buildings should be sited so as to fit in with the economical arrangement of the sidings which serve them. If they are sited and built without reference to the sidings, there may be difficulty in bringing the latter to them later on, and the area occupied will be greater than it need be. Sidings may conveniently be taken right inside the sheds for storing steel, where a travelling crane can unload the bars and carry them to their place of storage. An enclosure for scrap and pig for the foundry will be required, but it will probably be convenient to place these near the foundry and smithy, rather than with the other stores.

The power house has to be placed somewhere, and in the plan it is shown next after the iron and steel stores. It might, however, be better to place it more centrally in regard to the various shops where the power is used, though with electricity the loss in a work yard, even of fairly large size, would be inappreciable.

The iron and steel will first be dealt with either in the foundry or in the smithy. The latter will contain the forges, hammers, presses, and similar plant. The foundry is so placed that its coal and coke bunkers, and the store for sand, may be served by the same siding as the power-house bunkers. From these two shops the castings and forgings will go to the machine shop, in which are the planing, shearing, bending, punching, drilling, and suchlike machines, and the lathes. In this case again, as on the timber side, facility of transport from the two former to the latter shop, has to be sought for. It would not be possible to have a traveller from both of them into the machine shop, but it would be practicable to arrange it from one of them, choosing, if other conditions permitted, the one from which the greater weights have to be carried. It is to be remembered that to run an overhead travelling crane from one shop into another, it is not necessary that they should be touching each other, as the traveller can be carried on a gantry across the open space between.

Last of all comes the shop where the metal component parts from the one side, and the wooden component parts from the other side, are assembled, fitted, put together, and made into the final finished article. This shop requires to be sited for convenience of access from both the machine shop and the carpenters' shop, overhead cranes, or tram lines, or runways being used as circumstances dictate. The painting of the finished article may be carried out on a portion of the erecting shop, or a separate painters' shop may be provided contiguous to it. The product is then in a finished state, and only requires to be loaded on to the railway wagons on the siding, which is provided close alongside the place where the final operation is performed.

It has now been shown how economic principles enter into the planning of a factory for a certain class of output, and it is not difficult to see how the same principles may be applied in the case of manufactures of an entirely different character. Whether the operations under consideration are to be on a large scale or a small scale, and whatever are the materials to be dealt with, it will be possible so to arrange the design as to reduce to a minimum the handling, lifting, and carriage of the materials, and to secure the continuous "flow" of the latter in one direction. In small works in particular, which are carried on in single buildings, this last principle is of particular importance, and care should be taken that in any particular room or shop the flow of material in one state of manufacture does not cross the line of flow of another stage of the manufacture, since such an arrangement will generally interfere with the mechanical arrangements for transporting the materials and will cause confusion and delay in the operations, and both of these are opposed to economy.

In works comprised in a single building of several storeys, it is generally economical to raise the raw material to the top storey by a hoist, starting the manufacturing processes there, and letting the materials descend by gravity from storey to storey, undergoing successive operations till they arrive completed on the ground floor. We have heard how, in the great Chicago packing establishments, the live animals are driven up an inclined plane or ramp, slaughtered at the top of it, and as the carcasses are carried down the opposite side on runners, all the operations necessary to prepare them for the market are carried out.

In the organization of the arrangements for the execution of large engineering or building works, the principles to be kept in view are precisely similar to those already described. In the removal of excavated earth, the formation of banks, the mixing of concrete and its conveyance and deposit in site, the lifting of materials and heavy articles such as stone or steel, hand labour has long been superseded by trolley systems, either on the ground or on gantries and by hoists, mechanical mixers, and such contrivances. In the arrangement of these we require in the same way to avoid the necessity for twice handling or picking up spoil and materials, and to arrange that the flow of the latter is continuous, direct, and in one direction.

It will be evident, from a consideration of the conditions to be borne in mind by the designer of an establishment for manufacturing purposes, that the fullest co-operation and consultation between the latter and the persons who will superintend the working of the factory is necessary. The designing engineer is not likely to be acquainted with the details of the processes that will be employed in all the establishments he has to plan, and no one but the experienced manager can tell where labour may be saved and economy effected by judicious planning. Moreover the question is intimately bound up with that of the nature and amount of the machinery and plant to be used.

At the same time it would not as a rule be expedient for the engineer to comply blindly with every demand of the manufacturing staff. One of the inevitable defects of Government methods is that the administrative services have a tendency to work in what have been aptly termed "watertight compartments." Thus the manufacturing departments naturally desire to have installed every convenience that will facilitate their operations, and may sometimes not sufficiently consider the question of whether the anticipated saving in recurring expenses, is commensurate with the increased capital cost involved. On the other hand, the building department, who has to provide the funds for the capital outlay, naturally desires to keep the latter down, and may possibly not give due weight to ultimate savings which may be obtained by an increase in initial cost. The only proper point of view in such cases is the financial one. When, therefore, the manufacturing department asks for additional buildings or plant, or for an alteration in the planning, which will seriously affect the cost, they should be asked to show that the actual saving which they anticipate in labour charges will at least equal the interest on the additional capital cost involved. The most alluring propositions often look very different when reduced to cold hard figures. Hand-in-hand working of the two departments concerned is of the highest importance, but each must learn to consider the undertaking in its entirety, not only its own share in it, and to this end each must look at it from the other's point of view.

Excessive capital cost is an important point to guard against in inaugurating a manufacturing institution. In the commercial world, over-capitalization means reduced dividends, and often leads to failure and liquidation. Notwithstanding that this result is clearly in view, it is one of the commonest mistakes made, and is probably more often the cause of failure than anything else. The tendency of the present day is all towards over-capitalization. From what one often sees it would appear that an institution cannot consider itself modern and up to date without substantial buildings, handsome—sometimes palatial—offices, all the latest inventions in plant, and "everything of the best" all round. Whatever may be said for this in the case of a private business from the point of view of advertisement—and that probably is very little—there is no possible justification for it in the case of Government business, which does not require to advertise itself. Although in the latter case neither the necessity for dividends nor the fear of bankruptcy need be borne in mind, yet the financial principle which governs the sound investment of national funds is exactly the same. The secret of the successful conduct of a commercial enterprise lies in restricting the capital invested in it to the absolute minimum required to earn the largest percentage on the outlay. In Government enterprises every pound expended beyond this minimum is a wanton diversion of national funds from other directions where they are urgently required.

One direction in which the danger of excessive capital cost must be rigorously guarded against, is in the nature of the buildings provided. One often sees brick or stone buildings of solid construction, in every way fitted to last a couple of hundred years, and yet it is quite probable that in less than a quarter of that time they will be entirely out of date, will have to be abandoned, or, at all events, entirely remodelled in order to fit them to the altered requirements of the time. Mechanical sciences, manufacturing methods, and constructional materials are constantly changing. Systems that were only introduced 30 years ago are dead to-day. Every great war leaves an after effect on military equipment, and details in the organization, numbers, and distribution of the Army constantly change with the changes in military opinion. Who can say of what materials, by what processes, and in what locality, any military equipments will be manufactured a generation hence? In the accounts of engineering and manufacturing companies five per cent. depreciation is generally allowed on buildings. This means that their owners only look to a life of 20 years for them. It is not likely that this is because they anticipate their wearing out in that time, but that the evolution of the trade methods will necessitate their reconstruction. Now bricks and mortar in 20 years have only got through about a tenth of their natural life, and buildings of this material are uneconomical and expensive to remodel. Ferro-concrete, though it may be cheaper in first cost for buildings of a certain type than brick, is otherwise open to exactly the same objection.

In the present stage of development of constructional methods steel framing seems to be the most suitable form for factory buildings. Even if brick or concrete is used to fill in the sides, the walls will be lighter in section and require less foundations than if they supported the roof. They can be pierced or removed in any way for extensions or alterations without affecting upper floors or roof. Cheaper materials than brick will, however, usually answer all purposes. Corrugated iron sides and roof covering is suitable for workshops in many cases. In hot climates, or where furnaces are concerned, the sides may be filled in with sloping sheet-iron slats, which exclude sun and rain and admit air. Such buildings are cheap, will last quite as long as they are likely to be required, and when reconstruction is necessary can be extended without difficulty; if necessary the framing can be taken down and rearranged on another plan to suit modern needs, or even put up in another place. Steel construction has also the advantage that it affords facilities for the attachment of shafting, for gantry ways for travelling cranes, for lifting tackle, and for securing machinery. It adapts itself particularly to the needs of large shops which have to be in several spans.

It will be evident that, in work of this sort, the material and labour put in should be only just what is required to do the work and no more. Everything spent on unnecessary strength and durability, on appearance or finish, is wasted. It is even more important than in the case of other buildings, rigorously to proportion the means employed to the end in view. This after all is the true function of the engineer. Anyone can put up a building, but it takes an engineer to design one that is exactly adapted to the purpose for which it is built, with the minimum expenditure of money and time. Let the designer, however, expect little credit and no glory in return for his efforts. No massive pile, no handsome façade, will advertise his skill, or cause the visitor to ask his name. To the uninitiated the results will be a collection of great ugly sheds; the subordinate members of the manufacturing establishment will complain because they cannot hang 5-ton loads to the truss tie-bars; to the managing staff the economy effected will not appeal, and if by chance in his zeal for economy in initial cost—dictated probably by stringent orders from headquarters—he has in a few cases run his calculations too fine, with the result that some structural members have buckled or some foundations settled, he will come in for more than his fair share of blame. But he has the satisfaction of knowing that the brother expert will recognize the nice proportionment of the parts, will realize the difficulties overcome, and will award the credit where it is due.

THE FIRST MOUNTED UNITS OF THE CORPS ORGANIZED AT CHATHAM.

By Lieut.-Colonel B. R. Ward, R.E.

The first mounted unit of the Corps was organized at Chatham in 1855, and was trained at the Royal Engineer Establishment for the next 16 years. These units now include field companies, balloon companies, field troops, and telegraph companies (air line, cable, and wireless).

Of these the first two originated at Chatham; the remainder were organized at Aldershot, now the headquarters of all R.E. mounted units.

Pontooning was one of the earliest subjects taught at the R.E. Establishment. During Pasley's time however, and for many years afterwards, no attempt was made to organize complete companies of Sappers capable of carrying bridging equipment in the field. One of the reforms most strenuously advocated by Pasley, was that Engineer units should be organized with their own horses and drivers complete. The experience of the march to Paris, after the Waterloo Campaign, had sufficiently demonstrated the inconvenience and inefficiency inseparable from the system of hiring horses and civilian drivers for work in a campaign. It was not however until the further experience of the Crimean War had again proved this almost self-evident proposition, that steps were at last taken to carry out Pasley's recommendations on this point.

In the *Official Account of the Siege of Sebastopol*, Part I., "Engineer Operations," page 149, will be found a memorandum by Sir John Burgoyne, then in his 72nd year, and C.R.E. in the Crimea. In this he recommends the establishment of a "Royal Engineer Train," and his recommendation having been adopted by the War Department, the organization of the new unit was entrusted to Capt. H. T. Siborne in 1855, Lieut. H. Savile being appointed Adjutant, R.E. Train, in the same year. Lieut. Savile was succeeded by Lieut. Mathias Moore in 1859, and in 1868, when Sir Francis Head visited the R.E. Establishment at Chatham, Capt. R. W. Duff—who had been posted to the train when it was first organized in 1855—was in command of it, Lieut. A. K. Haslett being his adjutant. The organization of the R.E. Train is described by Sir Francis Head on pp. 180 to 182 of his chatty book, *The Royal Engineer*, published by John Murray in 1869. It was divided into two troops, lettered A and B.

A—the Pontoon Troop—was in 1868 commanded by 2nd Capt. E. Micklem. An illustration facing page 34 of *The Royal Engineer* shows A Troop in column of route with two cylindrical Blanshard pontoons on each wagon. Until 1862 pontooning had been carried out in the Medway close to the barracks, but the extension of the Dockyard in that year, necessitated the provision of a new practice ground. A piece of ground some 27 acres in extent, and on the Medway, was therefore purchased by the Government at Wouldham, a village some three miles above Rochester. It was here that A Troop was annually encamped, until the headquarters of the R.E. Train were moved to Aldershot in 1871, and there reorganized by Colonel FitzRoy Somerset, who was specially sent from Chatham to take up the appointment of Commandant of the R.E. Train.

In 1868 A Troop consisted of 1 captain, 3 subalterns, 122 N.C.O.'s and sappers, 95 drivers, and 140 horses. It carried 24 pontoons on its 12 wagons, and could lay a bridge 100 yards long capable of taking infantry in fours. A Troop (Pontoons) continued to exist until 1888, when it was reorganized as the Bridging Battalion.

B Troop—the forerunner of the original field companies—was in 1868 under the command of Lieut. G. W. Tisdall.

An illustration, showing B Troop on the march, forms the frontispiece to *The Royal Engineer*. In its 22 two-horse carts and 11 four-horse wagons, as well as on the backs of its 30 pack horses, it carried entrenching and technical tools and stores. Like A Troop, it was divided into three sections, each one of which could be detached under the command of a subaltern.

The complete establishment of B Troop in 1868 was as follows:—1 captain, 3 lieutenants, 211 N.C.O.'s and sappers, and 145 horses. Sections both of A and B Troops were detached at Aldershot for work in the camp—being employed on work in connection with the construction of huts, rifle ranges, etc.—throughout the period 1855 to 1871. On this latter date the R.E. Train in its entirety—comprising both A and B Troops—was moved to Aldershot, which has ever since been the headquarters of the mounted branches of the Corps.

A portion of B Troop remained on detachment at Chatham until 1878. In that year the first field companies—the 2nd, 5th, 17th, and 31st—were organized at Chatham, the Curragh, and Shorncliffe, the horses of B Troop being transferred to them. From that date B Troop (Equipment), to give it its full official title, ceased to exist.

A detailed account of the origin and progress of ballooning in the British Service is given in a Paper by Colonel C. M. Watson, C.B., C.M.G., published in Volume XXVIII. of the *Professional Papers*, and the following notes are compiled principally from this source.

The first balloon factory was established at St. Mary's Barracks in 1882. Experiments had been carried out by Lieut. C. M. Watson, R.E., at Woolwich Arsenal as early as 1872, in order to determine the best apparatus for the production of hydrogen gas.

In 1882 further experiments were carried out at Chatham under Capt. H. P. Lee, who was in command of the 38th (Depôt) Company. In 1884 a Balloon Detachment, under Major H. Elsdale, accompanied Sir Charles Warren's expedition to Bechuanaland. Another detachment was sent out to the Soudan in 1885 under Major J. L. B. Templer, of the 7th King's Royal Rifles. In the summer of 1885 the two detachments returned to Chatham, and in 1886 Major Templer purchased some land at Lidsing, about five miles from Chatham, where summer camps for the Balloon Detachment were held for the next three years.

In 1887 Major Templer was gazetted Instructor in Ballooning, and in 1889 the Balloon Detachment took part in the Aldershot manœuvres under Sir Evelyn Wood. As a result of his report it was decided to introduce ballooning definitely into the British Service. A Balloon Section was accordingly authorized in the Army Estimates of 1890–91, and the Balloon Factory and School were removed from Chatham to Aldershot in 1892, and have remained there since that date.

OFFICERS OF THE R.E. TRAIN AT CHATHAM.

OFFICERS COMMANDING R.E. TRAIN.

Capt. H. T. Siborne	1855-1863
Lieut. R. W. Duff	1863-1871

ADJUTANTS, R.E. TRAIN.

Lieut. Henry Savile	1855-1859
„ Mathias Moore	1859-1864
„ A. K. Haslett	1864-1869
„ Sir A. Mackworth	1869-1873 (at Aldershot).

BALLOONING OFFICERS AT CHATHAM.

OFFICERS COMMANDING BALLOONS.

Major H. Elsdale	1884-1888
„ C. M. Watson	1888-1889
Lt.-Col. J. L. B. Templer (7th K.R. Rifles)	1889-1891

INSTRUCTOR IN BALLOONING.

Lt.-Col. J. L. B. Templer (7th K.R. Rifles)	1887-1891

OFFICERS COMMANDING BALLOON DETACHMENT.

Lieut. B. R. Ward	1889-1890
„ H. B. Jones	1890-1891

In 1891 the Balloon School was moved to Aldershot.

The following officers were employed in connection with balloons at Chatham :—

Capt. H. P. Lee	1882-1884
Major J. L. B. Templer (7th K.R. Rifles)	1882-1891
Lieut. Trollope (Grenadier Guards) ...	1883-1885
Major H. Elsdale	1884-1888
Lieut. J. R. L. Macdonald	1884
" R. J. Mackenzie	1884-1886
" G. E. Phillips	1886-1888
" C. F. Close	1887-1888
" H. B. Jones	1887-1891
" B. R. Ward	1888-1890
" A. B. Hume	1890-1891

ERRATA

In last month's article on the Electrical School :—

Page 32, line 22, *for* "Capt. J. C. L. Campbell" *read* "Capt. C. A. Lyon-Campbell."

Page 36, line 21, *for* "Capt. A. F. Le Mesurier" *read* "Capt. F. A. Le Mesurier."

Page 36, line 22, *for* "Capt. J. C. L. Campbell" *read* "Capt. C. A. Lyon-Campbell."

TRANSCRIPTS.

A PROPOSED NEW METHOD OF MEASURING THE RESISTANCE OF PROJECTILES.

By C. E. Wolff, B.SC., A.M. INST. C.E.

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The resistance offered to a bullet in its flight through the air is in the nature of things incapable of direct measurement. The only methods at our disposal are to measure the change of velocity over a short interval of time or distance, and to calculate the resistance from the figures thus obtained. In practice we are confined to the measurement of change of velocity over a measured distance, as the screens from which the chronograph is actuated must be fixed points.

From the above considerations it will be seen that the retardation of the bullet is of the nature of a second difference in the time required to reach the fixed points (or screens), and, therefore, an extremely small error in the time measurements may result in a very serious error in the calculated resistance.

In the case of the tables for the resistance offered to a standard bullet at different velocities given in the *Text Book of Small Arms*, which are obviously calculated from Mr. Bashforth's classic tables, the probability of error is very great. Indeed, an error of one-thousandth of a second in the case of a velocity of 2,400 feet per second will lead to an error of 10 per cent. in the value of the resistance, and from its design it is very unlikely that Bashforth's chronograph could be relied upon to more than one-fourhundredth of a second at the outside. Errors of 25 per cent. are, therefore, quite possible, and although this figure will be reduced by repeating the experiments, the probable error is still very considerable. Thus, if every measurement was repeated six times, the probable error will still be about 10 per cent., and this without taking into account the variation in the ammunition.

A consideration of the above points has suggested the following investigation as to whether we are not likely to obtain better results from a study of the angles of elevation required for different ranges, since this is by far the most accurately known characteristic of the trajectory. It will be seen from what follows that if we can express the tangent of the angle of elevation as an algebraic function of the range, the results are extremely promising.

Form of Equations.—Let OPM (*Fig.* 1) represent the curve of the trajectory, and let P be any point on the same. OA represents the initial direction of motion making an angle α with the horizontal. We will write x for the horizontal distance from the origin O, and y for the distance measured vertically *downwards* from OA. Thus at the point P OX $=x$ and AP $=y$.

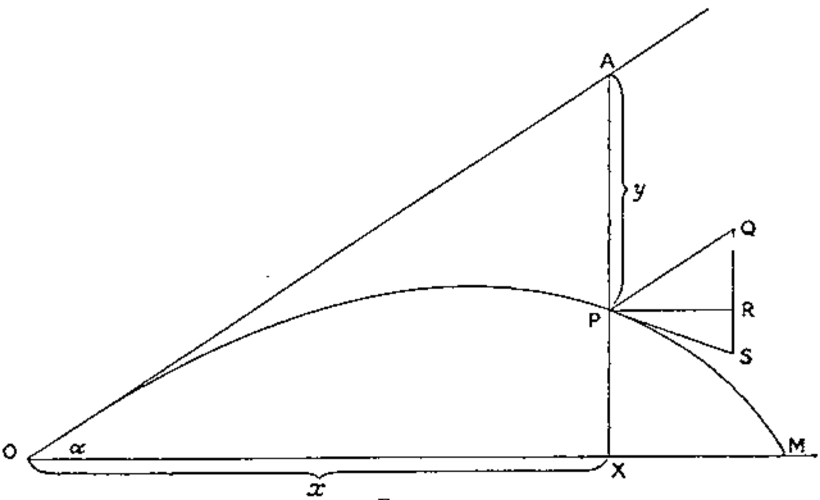


FIG. 1.

Then considering the forces acting at P we have

$$\frac{d^2y}{dt^2}=g-\frac{\text{SR}}{\text{PR}}\cdot\frac{d^2x}{dt^2}$$

And since

$$\frac{\text{QS}}{\text{PR}}=\frac{dy}{dx}$$

$$\frac{d^2y}{dt^2}=g-\left(\frac{dy}{dx}-\tan\alpha\right)\frac{d^2x}{dt^2}$$

Multiplying by $\frac{dx}{dt}$ and transposing this becomes

$$\frac{dx}{dt}\cdot\frac{d^2y}{dt^2}+\frac{dy}{dt}\cdot\frac{d^2x}{dt^2}=g\cdot\frac{dx}{dt}+\tan\alpha\,\frac{dx}{dt}\cdot\frac{d^2x}{dt^2}$$

Integrating this equation we get

$$\frac{dx}{dt}\cdot\frac{dy}{dt}=gx+\tfrac{1}{2}\tan\alpha\left(\frac{dx}{dt}\right)^2+c$$

or

$$\left(\frac{dx}{dt}\right)^2\left(\frac{dy}{dx}-\tfrac{1}{2}\tan\alpha\right)=gx+c$$

where c is the constant of integration.

Now write v for the horizontal component of the velocity and v_0 for the horizontal component of the initial velocity. Then putting $x=O$ we have (since $\frac{dy}{dx}$ also $=O$ when $x=O$)

$$c=-\tfrac{1}{2}\tan\alpha, v_0^2$$

$$\therefore\quad v^2\left(\frac{dy}{dx}-\tfrac{1}{2}\tan\alpha\right)=gx-\tfrac{1}{2}\tan\alpha\,.\,v_0^2$$

$$\therefore\quad v^2=\frac{2gx-\tan\alpha\,.\,v_0^2}{2\frac{dy}{dx}-\tan\alpha}.$$

Now if we take a table of elevations necessary for different ranges, we find that tan α can be very accurately expressed in the form ar^3+br^2+cr+d, where r is the range on level ground, *i.e.*, the value of x when the bullet is in the same horizontal plane as the point of projection. Indeed, in the case of Metford's Table, the relation is an exact one. From this we notice at once that since tan $\alpha=o$ when $r=o$, therefore $d=o$, and if in any series d does not disappear, it must be that the rifle is not exactly aimed in the supposed direction when the bullet leaves the muzzle; that is to say, d is the "jump" or "flip" of the rifle due to barrel vibrations, etc.

Further, if h is the height of the line of projection above the horizontal plane through the point of projection when $x=r$

$$h=r\tan\alpha$$
$$=r^2(ar^2+br+c).$$

Also $\frac{dy}{dx}$ becomes $\frac{dh}{dr}$ at this point.

$$\therefore \qquad \frac{dy}{dx}=r(4ar^2+3br+2c).$$

Substituting these values in the equation for v^2, we get

$$v^2=\frac{2gr-r(ar^2+br+c)v_0^2}{2r(4ar^2+3br+2c)-r(ar^2+br+c)}$$
$$=\frac{2g-(ar^2+br+c)v_0^2}{7ar^2+5br+3c}$$

When $r=o$ this reduces to

$$v_0^2=\frac{2g-cv_0^2}{3c}$$

or

$$v_0^2=\frac{g}{2c}$$

and hence

$$v^2=\frac{g}{2c}\cdot\frac{3c-ar^2-br}{7ar^2+5br+3c}\ldots\ldots\ldots\ldots(1).$$

It must be noted that this relation is only strictly accurate on condition that the bullet is in the same horizontal plane as the point of projection. It will, however, be nearly exact as long as the difference of level is small, since the vertical forces are very small compared to the horizontal resistance.

To find the resistance we have

$$\text{Resistance}=-\frac{W}{g}\cdot\frac{dv}{dt}=-\frac{W}{g}v\frac{dv}{dr}=-\frac{W}{2g}\cdot\frac{d(v^2)}{dr}$$
$$=\frac{w}{4c}\cdot\frac{(7ar^2+5br+3c)(2ar+b)+(3c-ar^2-br)(14ar+5b)}{(7ar^2+5br+3c)^2}.$$
$$=\frac{w}{2c}\cdot\frac{abr^2-24acr-9bc}{(7ar^2+5br+3c)^2}\ldots\ldots\ldots\ldots(2).$$

Hence by taking a number of ranges we can obtain corresponding values for the velocity and the resistance, and plot the results in the form of a curve.

It must, however, be noted that v_0 is the horizontal component of the initial velocity, and that this has been taken as constant. This is quite sufficiently accurate as long as α is small, the error being under ·016 per cent. when $\alpha = 1^\circ$.

Another point which should be borne in mind is that there will probably be a change in the law of resistance on passing through the velocity corresponding to that of sound, or about 1,100 feet per second. It will, therefore, be desirable to make all the experiments of one series either above or below this value.

First Results of the Method.—In order to test the formulæ obtained above, Table I. has been calculated from Metford's Table of Elevations for the ·303 Metford barrel. The figures have only been given up to 700 yards range, as beyond this the velocity falls below 1,100 feet per second.

The retardation is found by substituting g for w in the formula for the resistance, and from this the resistance of the 1-inch standard bullet has been calculated for comparison with the results given in the *Text Book of Small Arms.* The comparison is also shown graphically in *Fig.* 2, from

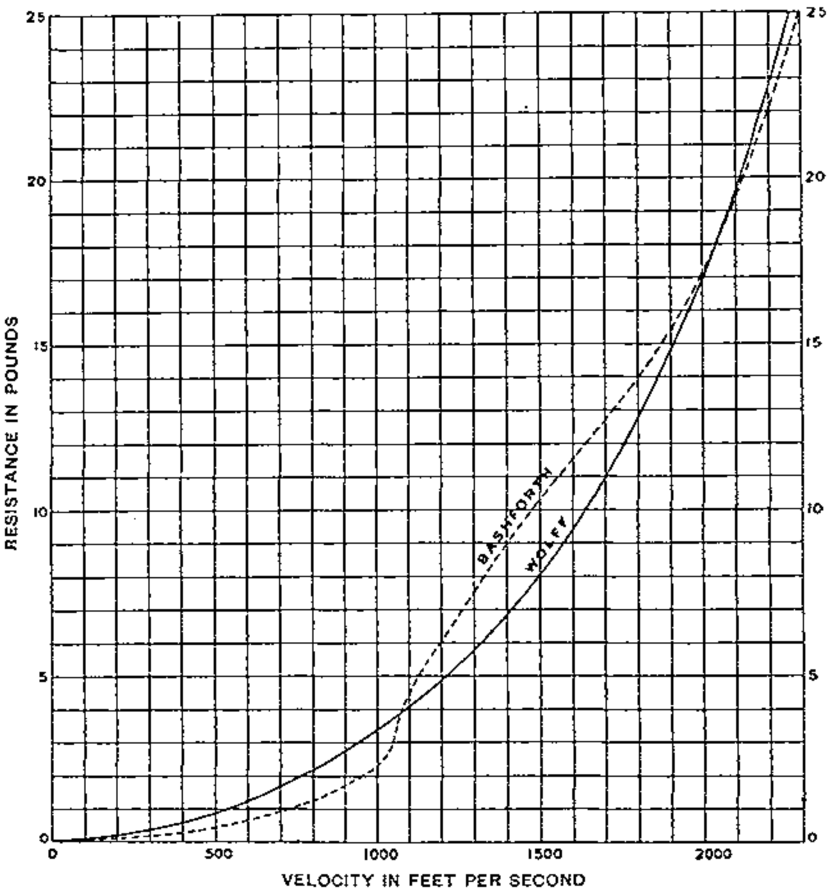


FIG. 2.

which it will be seen that the results of the calculation from these formulæ form a smooth curve, which is a sort of mean of the curve calculated from Bashforth's Tables.

The exponent ρ is that power of the velocity with which the resistance is varying in the immediate neighbourhood of the corresponding value of the velocity. It will be noticed that it is about 2 when the velocity is 1,100 feet per second, and steadily increases as the velocity increases. As it is well known that the resistance varies as the square of the velocity at low speeds, and we have no reason to expect any change in this law until the velocity approaches that of sound, the lower part of the curve in *Fig.* 2 has been filled in as a parabola.

A very interesting point also arises out of these figures for resistance and velocity. This is whether we can find a simple expression for the resistance in terms of the velocity. With this object in view, a formula of the form

$$R = av^4 + bv^3 + cv^2 + dv + e$$

was assumed, and by putting in the corresponding values of v and R eight equations were obtained from which to find the values of the five coefficients. On doing this it was found that a became so small as to be quite negligible, and the remainder simplified into the form

$$R = 3{\cdot}5\,(v - {\cdot}992)^3 + 3{\cdot}36\,v^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3),$$

where v is expressed in *thousands of feet* per second.

The result is interesting as suggesting that the power of the velocity rises rapidly at first from a value of about 2 at the velocity of sound, and continues to rise at a decreasing rate until it approaches asymptotically to the value 3, when the velocity becomes infinitely great.

To return to the exponent ρ of Table I., this is found as follows:—We assume a curve whose equation is of the form $F = \gamma V^\rho$, and for any desired value of the velocity we calculate values of γ and ρ, such that when $V = v$, $F = f$ (the retardation of the bullet), and $\frac{dF}{dV} = \frac{df}{dv}$. Thus at the value of the velocity under consideration the assumed curve passes through the same point as the curve of retardation and velocity, and has a common tangent with it.

For the assumed curve

$$F = \gamma V^\rho$$

$$\therefore \quad \frac{dF}{dV} = \gamma\rho V^{\rho-1} = \rho\frac{F}{V}$$

$$\therefore \quad \rho = \frac{V}{F}\cdot\frac{dF}{dV} = \frac{v}{f}\cdot\frac{df}{dv}$$

$$\text{But} \quad \frac{df}{dv} = \frac{\frac{df}{dr}}{\frac{dv}{dr}} = \frac{\frac{df}{dr}}{\frac{1}{v}\frac{dv}{dt}} = \frac{\frac{df}{dr}}{\frac{f}{v}}$$

$$\therefore \quad \rho = \frac{v}{f}\cdot\frac{df}{dv} = \frac{v^2}{f^2}\cdot\frac{df}{dr}$$

Now from (2) we have

$$f = (\text{Resistance}) \div \frac{w}{g}$$

$$= \frac{g}{2c} \frac{abr^2 - 24acr - 9bc}{(7ar^2 + 5br + 3c)^2}$$

and since $\frac{g}{2c} = v_0^2$ we may write this

$$f = v_0^2 \frac{f(r)}{[\phi(r)]^2}$$

Then $$\frac{df}{dr} = v_0^2 \left\{ \frac{(2abr - 24ac)[\phi(r)]^2 - 2f(r) \cdot \phi(r) \cdot (14ar + 5b)}{[\phi(r)]^4} \right\}$$

And $$\rho = \frac{v^2}{f^2} \frac{df}{dr} = \frac{v^2}{v_0^4} \cdot \frac{[\phi(r)]^4}{[f(r)]^2} \cdot \frac{df}{dr}$$

$$= 2\frac{v^2}{v_0^2} \left\{ (abr - 12ac) \cdot \left[\frac{\phi(r)}{f(r)}\right]^2 - (14ar + 5b \cdot \frac{\phi(r)}{f(r)} \right\} \ldots\ldots (4),$$

which is readily calculated since $f(r)$, $\phi(r)$, v and v_0 are already known.

The Converse Problem.—Having once obtained a curve connecting the velocity with the resistance or retardation, the question next presents itself whether we can obtain the values of a, b, and c in a simple form. If so, we can immediately find the values of the angle of elevation, the angle of descent, and the final velocity, if we know the range and the initial velocity.

This can be done as follows:—

We have already seen that $v_0^2 = \frac{g}{2c}$ and hence we have at once

$$c = \frac{g}{2v_0^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5).$$

Knowing c, we can next obtain the value of b from the expression for the retardation. If we put $r = o$ and $v = v_0$ this becomes

$$f_0 = v_0^2 \cdot \frac{b}{c}$$

or $$b = \frac{cf_0}{v_0^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where f_0 represents the initial value of the retardation.

Finally we have $\rho = \frac{v}{f} \cdot \frac{df}{dv}$ and is, therefore easily calculated.

Also when $r = o$, $\frac{\phi(r)}{f(r)} = -\frac{1}{3b}$, and therefore

$$\rho = 2\left\{ -12\,ac \times \frac{1}{9b^2} + 5b \times \frac{1}{3b} \right\}$$

$$= \frac{2}{3}\left(5 - \frac{4ac}{b^2}\right)$$

whence $$a = \frac{b^2}{4c}\left(5 - \frac{3}{2}\rho\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7).$$

Having thus obtained the values of a, b, and c, we have at once

$$\tan \alpha = (ar^2 + br + c)\, r \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8),$$

and if β is the angle of descent

$$\tan \beta = \frac{dh}{dr} - \tan \alpha$$

$$= (4ar^2 + 3br + 2c)\, r - (ar^2 + br + c)\, r$$

$$= (3ar^2 + 2br + c)\, r \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9).$$

The value of the final velocity is also given at once from Equation (1), and we are thus able to obtain immediately all the most usually required figures.

TABLE I.

Range, yds.	Angle of elevation, minutes.	Velocity, f.s.	Retardation, f.s. per s.	Resistance to standard bullet, lbs.	Exponent ρ
0	0	2038	1386	17·91	2·78
100	4·40	1851	1064	13·75	2·68
200	9·66	1691	839	10·84	2·57
300	15·81	1551	675	8·72	2·46
400	22·90	1428	552	7·13	2·35
500	30·99	1318	460	5·94	2·24
600	40·13	1218	387	5·00	2·13
700	50·36	1127	329	4·25	2·02

TABLE II.

Resistance of Standard Bullet from Formula (3).

Velocity, f.s.	Resistance, lbs.	Velocity, f.s.	Resistance, lbs.	Velocity, f.s.	Resistance, lbs.
0	0	800	2·15	1600	9·39
100	·03	900	2·72	1700	10·96
200	·13	1000	3·36	1800	12·74
300	·30	1100	4·06	1900	14·76
400	·54	1200	4·86	2000	17·04
500	·84	1300	5·77	2100	19·59
600	1·21	1400	6·81	2200	22·43
700	1·65	1500	8·01	2300	25·59

THE KUNGCHULING POSITION OF THE 2ND ARMY.

Epitome of an article by Colonel S. A. Tsabel in the August, 1906, number of *Eenzhenernee Zhurnal.*

THIS position, which was fortified by the Russians towards the close of their campaign in Manchuria, was situated on the railway about 26 miles to the north of their main position at Hsipingai, to which it was intended to serve as a rear, or reserve, position. The section allotted to the 2nd Army, which is shown in the attached plan, is the right, or western, half of the position, the eastern half being occupied by the 1st Army, and the railway forming the dividing line between the sections.

The project of defence, which was drawn up after a brief reconnaissance by two captains, one of Engineers and one of the General Staff, was accompanied by a report which contained the following information:— The ground in front of the position was thickly overgrown with bushes and clumps of trees impeding the field of fire; a good supply of axes would therefore be required. The roads were good, but bridges and "drifts" required repair, and extra ones had to be made. There were no serious obstacles in the rear.

The western section—No. 4—from the village Tafanchen up to and beyond the Mandarin road, was cut in two by a ravine. Its defence should consist of strong works on the heights on either side and trenches in the valley. The work on the western height, with a fine field of fire westwards, would cover the right flank against a turning movement.

Section No. 2, from Tafanchen to Syaochenzi, also rested on two heights divided by a valley. Here again there should be strong works on the heights, while the valley and its branch ravines should be protected by cross-fire from suitably sited trenches.

The 3rd Section, Syaochenzi to Kunduling, the chief features of which were the narrow salient spur on the western side and the water channel running along the front on its eastern side, should have trenches on the narrow spur to enfilade the approaches, and if time allowed a blinded caponier for machine guns, while the channel should be formed into a huge *point d'appui*, by (*a*) adapting it for defence, (*b*) connecting it with the works on its flanks by trenches, (*c*) protecting both channel and trenches with abattis, and (*d*) preparing for defence the native house in rear, to command the whole interior of the space thus enclosed. At the same time trenches should be placed along the crests of the hills in the centre.

The left section should be protected on the right by the strong and extensive *yimpan* (or enclosed farm), which when put in a state of defence would enfilade approaches, connect up with No. 3 Section, and close the valley at the mouth of which it stood. The left flank near the railway should be protected by a strong work, and the intermediate crests by trenches.

The position described in the above report intersected the railway at four miles to north of Kungchuling Station, and rested on the front slopes of a line of small hills lining the northern bank of the river Dalyao-ho. Belonging to the category of "Reserve Strategical-Rear" positions, it stood in the probable line of retirement of the Russian armies from their main position at Hsipingai. The right half-position took the form of a salient right angle, generally facing the probable line of advance of the enemy. Its extent—about 11¼ miles—might not be considered unsuitable for occupation by an army of five army corps, when it is remembered that the latter must previously have fought an unsuccessful battle in the Hsipingai position.

The ground was generally unsuitable for the action of cavalry, except on the extreme western flank, where it was flat and open and convenient for manœuvring large masses of horsemen.

As regards the fields of view and fire to be obtained from the position, there was considerable difference between the various sections. Near the railway the field of view, both near and far, and also the field of fire, were very good, the front-lying ground being level, and the only cover available to the enemy being the river gorge, which ran parallel to the front and about 1,200 yards to south of it. The right flank was drawn back in the project to some distance from the river, and the commanding height at the trigonometrical station, which was left unoccupied and stood at from one to two miles distance from the front, deprived it of both distant view and fire.

As to the flanks, the left was protected by the position of the 1st Army, beyond the railway. The right rested on no natural obstacle, but the country being open and flat, and the view unimpeded by anything except bushes which could be easily cleared, this flank when fortified might be considered sufficiently safe.

Communication within the position, along its front and in its depth, was impeded by many streams with swampy bottoms, which required a large number of small bridges and causeways.

As ready-made cover within the position, the Chinese villages were very suitable, being surrounded with mud walls, very convenient for defence.

There were no serious obstacles to the enemy's advance in front of the position, but as an obstacle to counter-attack from the left flank the river gorge may be mentioned.

The line of retreat was obstructed by a deep ravine which extended parallel to the whole front at between four and five miles in rear of it; this ravine was already crossed by four bridges, but this number was not thought sufficient, and it was decided to make more bridges and to improve existing fords.

The following is a detail of the work which was actually decided on and carried out in the position:—

Between the 26th and 31st May a detailed reconnaissance of the ground was made by the Inspector of Engineers, 2nd Army, and it was then decided to make the following alterations in the design:—

(1). To increase the depth of the position, especially that of the right wing, which seemed the most liable to attack, on account of the constant attempts made by the Japanese at enveloping and turning movements. With this object an advanced line was added in this part of the position, reinforced with fortified *yimpans* and redoubts of trench profile.

(2). To increase the number of *points d'appui* in the main line along the whole position, placing them in two rows, and thus giving each section separately the power of making a resolute defence.

(3). To make a separate front position on the commanding ground near the trigonometrical station, so as to prevent the enemy from approaching unseen to the right half of the position, and thus turning the right flank.

(4). To put some redoubts of strong profile behind the salient as an additional defence to the right flank.

(5). To carefully construct communications both along the front and in the depth of the position, and to add four bridges of piles to those already existing over the ravine in rear.

The troops detailed to carry out the defence works were the 99th Infantry (Ivangorod) Regiment, and the 160th Infantry (Abkhasia) Regiment, each of four battalions, and the 3rd Company, 16th Sapper Battalion. The general superintendence was entrusted to the writer of the article, Colonel Tsabel.

During the reconnaissance already mentioned, in the presence of the regimental and battalion commanders and of all the sapper officers, the sites of all redoubts were finally selected and the lines of rifle trenches laid down. The troops set to work clearing the foreground on the 1st June, and the siting of the trenches was checked and, if necessary, amended as this work proceeded.

The whole position was divided into two regimental sections, and each of the latter into battalion sections, each battalion being encamped within its own section. The sappers were divided between regiments and battalions, and were attached to the infantry for rations in order to relieve them entirely of routine duties.

Work proceeded daily from 7 a.m. to 11 a.m., and from 3 p.m. to 7 p.m. The work in the redoubts was superintended by the battalion commanders and directed by the sappers. The lines of rifle trenches were divided into company sections, in each of which the work was managed by the company commander under direction of a sapper officer. From each company a portion of the men, under a junior officer, was placed at the disposal of the battalion commander for work in the redoubts, while the remainder worked in the company section.

On the 10th June the 3rd Company of the Abkhasia Regiment, with a party of sapper carpenters, was detached to commence the bridges over the ravine in rear.

On the 8th July, in consequence of the heat, the G.O.C. 2nd Army reduced the working day to six hours, work proceeding from 6 a.m. to 10 a.m., and from 4 p.m. to 6 p.m. From this date also the Sunday holiday was introduced, and the bread ration was increased from $2\frac{1}{4}$ to $2\frac{3}{4}$ lbs.

On the 14th July the rainy season commenced; on the 18th July the G.O.C. 2nd Army inspected the position, and sanctioned the preparation of the front position at the trigonometrical station for six battalions and three batteries; on the 19th July occurred a serious storm, by which many trenches were filled up, casemates destroyed, and trestle bridges and causeways washed away.

On the 25th July the working day was further reduced to three hours only in the mornings, the afternoons being allotted to training. The Abkhasia Regiment did a course of musketry, which reduced the working parties by one-half, and the works made little progress, as the men available for work were hardly sufficient to repair the damage caused by the rains, which still continued.

After this there were rumours of peace, and the progress of the work became less and less, until it ceased entirely on the 3rd September.

The following is a more detailed description of the various kinds of work carried out on the position:—

CLEARING THE FOREGROUND.

The foreground was cleared continuously in front of the main line for a distance of 2,000 paces, and in front of the redoubts of the second line for a distance of 800 paces. Shrubs and small trees, up to 3 inches in diameter, were removed, but of the larger trees, only those were cut down which were required for the roofs of splinter proofs in trenches and redoubts.

The many Chinese dwellings which impeded the field of fire were left untouched, to be demolished only when necessary, as the urgency of the case did not warrant the expense and unpopularity which would be incurred by evicting the inhabitants.

RIFLE TRENCHES.

These were sited on suitable ridges in the front slopes of hills, or in level ground wherever they could find the best field of fire. The length of each trench—depending on the ground—varied from 25 to 200 paces. The profile was one which allowed of firing standing from a step. The parapet varied in height from 0 to $4\frac{1}{2}$ feet, depending on the requirements of the field of fire and avoidance of dead ground. The total length of rifle trench made throughout the position was 26,700 paces. Traverses were made in the trenches at intervals of 15 to 20 paces.

Light splinter-proof cover was made under the front parapet, in length equal to one-quarter of the total length of the firing line. This allowed cover for one-half of the garrison, as the men sat in these blindages two deep. Each blindage was built to hold 25 men, a half-section.

In commanding points, possessing a wide field of fire, special blindage-hoods were made, to accommodate 12 men firing from underneath them.

The interior slopes of parapets, and the steps, were revetted with hurdle-work, sods, and kowliang stalks, the last-named form of revetment being especially suitable to low parapets.

COMMUNICATION TRENCHES.

These were dug wherever the approaches to the rifle trenches from the rear were insufficiently concealed, and in some cases the rifle trenches were also connected together along the front in groups, the trenches of each company being as far as possible grouped in this way.

The profile of the communication trenches varied considerably in depth in different places, but in every case 6 feet of cover was provided. In plan the trenches represented either short zigzags, or were similar to siege approaches with traverses at intervals of 15 paces. Wherever a field of fire was obtainable they were provided with steps for riflemen. Their uniform breadth at the bottom was 2·35 feet, and all angles were rounded off to allow the passage of stretchers. At intervals wider crossing places were made in the trenches. The total length of communication trench constructed in the position was 14,245 paces.

POINTS D'APPUI.

These consisted either of Chinese *yimpans* prepared for defence, redoubts of trench profile, and redoubts of stronger profile with outside ditches. The *yimpans* were disturbed as little as possible on account of the inhabitants. The outside walls were loopholed, those which were too thin and those exposed to artillery fire being reinforced with earth. Flanking defence of the walls was prepared either from the towers or by special caponiers. In high walls the loopholes were placed at a height of 6 to 7 feet from the ground, with banquettes on the inside, and in places two tiers of fire were arranged, the platform for the upper tier forming a blindage for the protection of those below. Within the *yimpans* were built *shimoze*-proof blindages, and defensible exits were made in the back walls for communication with the rear.

The following work was left to be carried out at the last moment by the garrisons of the *yimpans*:—To clear the field of fire by demolishing orchards and outbuildings; to remove inflammable materials and provide means for extinguishing fires; and to barricade the gates and all superfluous openings in the walls. This work was estimated to take about three to four hours.

The *redoubts of trench profile* were placed in the firing line, and consisted of closed trenches, each accommodating two companies, surrounded by rings of obstacles. They are denoted in the plan by the letters A, B, C, D, E, F, G, and H. By order of the Commander-in-Chief all redoubts were provided with whisker-trenches. In each redoubt the whole garrison was provided with blindage cover, of which not less than one-quarter was *shimoze*-proof.

The *redoubts with outside ditches* (Nos. 6 and 7 in front line and Nos. 1, 2, 3, 4, 5, 8, 9, 10, 12, 13, and 14 in second line) were chiefly noticeable for the arrangements for the defence of their ditches. These were either frontal or flanking, the latter being provided by either open trenches or concealed caponiers. In each redoubt the whole garrison was provided with *shimoze*-proof shelter. Wells for drinking water were dug within most of the redoubts, and where this was not possible Chinese earthenware jars were placed in the blindages for storing water.

The inner slopes of parapets were revetted with hurdle-work, crowned with sods. Traverses were revetted with hurdle-work, sods, and *kowliang* stalks, and steps with hurdle-work. For obstructing the passages through obstacles, and approaches through the parapets to the whisker-trenches, *hedgehogs, i.e. chevaux de frise* entangled with barbed wire, were made to fit the openings.

COVER FOR ARTILLERY.

The artillery commander of the 16th Army Corps was specially detailed to select the artillery positions, and during five days, from 10th to 14th June, in company with the officer superintending the works, he selected sites for gun emplacements for eight artillery brigades, assuming that the strength of the army would be four army corps, each containing two artillery brigades.

The positions chosen were concealed either on the reverse slopes of hills, or behind bushes or groves. Besides these, sites were selected in the firing line for some "Georgievsk" sections, intended for immediate action against attacking infantry.

It was decided by the G.O.C. 2nd Army, that the excavation of the gun emplacements should be deferred until the actual occupation of the position, for fear that the sites of the guns should be given away by Chinese spies.

As part of the defences of the front position—which was sanctioned after the inspection of the G.O.C. 2nd Army—emplacements were excavated for 48 guns, connected together in batteries by communication trenches.

OBSTACLES.

All the *points d'appui* were surrounded with obstacles, which consisted chiefly of five rows of *trous-de-loup*, reinforced with wire entanglement. Besides this, in all places peculiarly accessible to the enemy, were placed separate groups of obstacles barring covered approaches to the position. For instance, on the left flank, in the interval between redoubts G and H, and in front of bridge No. 24, the ravine running into the position was blocked with abattis and wire entanglement, and for commanding the obstacle the portion of the ravine immediately above it was cleared and two rifle trenches with blindages were built in it.

The *trous-de-loup* were all made 6 feet deep, and measured 6 feet wide at the top and 3 feet at the bottom. The clayey nature of the ground was very favourable to their use, as with this it was found that very steep excavations preserved their shape for a long period. In consequence of this the *trous-de-loup* were placed at a distance of only 1 foot from one another, or 7 feet from centre to centre, and presented a very serious obstacle to assault. In spite of frequent and abundant rain, they were still in good order when peace was concluded three months later.

In conjunction with the *trous-de-loup*, entanglements of both plain and barbed wire were used, and also pointed stakes, the latter in the Redoubts E and F, as the supply of wire ran out.

Redoubt A was surrounded with a special portable abattis.

BRIDGES AND ROADS.

The communications within the position were carried out simultaneously with its fortification, and included mainly the construction and repair of bridges over the numerous streams and narrow ravines which intersected the position in various directions. Spans up to 17½ feet were bridged by frame bridges, and larger gaps by trestle and pile bridges. The roadway in every case was 14 feet wide.

Across the boggy valley and stream, between Redoubts D and No. 6, there were made, besides the bridges, three causeways with aggregate length of 2,100 paces.

In all 48 bridges of various sizes were made. No. 23 was 77 feet in length, supported on two shore abutments and nine piers, each consisting of two piles. Many small bridges were made over communication trenches, drainage cuts, etc., for the convenience of inspecting officers and others.

Of the four new bridges built over the ravine in rear, No. 3 (35 feet in length) was of trestles; No. 4 (70 feet in length) rested on four piers, each consisting of four piles; No. 5 (77 feet in length) was of piles; and No. 7 (154 feet in length) was also of piles. As a precaution in case of damage to any of these bridges a cross-road was made along the south side of the ravine, with three small bridges crossing branch nullahs.

The bridges, Nos. 3, 4, and 5, built before the storm of the 19th July, were all more or less damaged by it. No. 3 was washed completely away, but the others, although much damaged by the water rushing over them, both themselves and their shore abutments built of gabions anchored back with wire, remained intact.

STORM-WATER DRAINAGE.

Drainage arrangements were made during the construction of all the defences. In redoubts, with outside ditches, the drainage from the interior was led into the ditches, while redoubts of trench profile, trenches and communications, were drained into soak pits, or if the ground was favourable, by drainage channels.

During May and June the works suffered little from the weather, but during July the rainy season began, and the water came down in such quantities that everywhere great destruction was caused to all the works. During the storm of the 19th July all the streams overflowed their banks, and a flood from the hills washed over works and trenches, completely filling many of them with silt.

The works in the water channel in front of Redoubt No. 8 were completely destroyed, and in the redoubts, without side ditches, the caponiers were flooded with water, which ran in through the loopholes. As a result of the flood brushwood revetments soon began to rot and parapets to collapse. After this for some time new work had to be abandoned, and all hands set to work to repair the old works, and to protect them from further damage. Meanwhile the rains continued, and on many days it was not possible to do any work.

It is most important before commencing a work to consider the question of drainage from all points of view, and further, to make ample drainage arrangements during the construction of the work itself.

CONCEALMENT.

The following measures were taken to make the defences as inconspicuous as possible:—The height of parapets was reduced as much as the requirements of a good field of fire without dead angles would allow; all outside angles were rounded; the interior parts of works were not allowed to show above the firing line; obstacles were placed in triangular ditches, and concealed from the front by glacis; and in front of the trenches the nearer bushes and trees were not cut down continuously, but only so far thinned as not to impede the fields of fire and view over the front-lying ground. A rapidly-growing weed was sown over all the works, and quickly rendered them invisible.

CONCLUSION.

In most "Reserve, rear" positions, it is considered sufficient to content oneself with making the redoubts and excavating some of the main approaches, *i.e.*, only such works as would take much time in their construction. To dig the rifle and communication trenches in these positions is inadvisable, partly because—if they have to stand many months before their possible use—they would have to be made unnecessarily solid, and partly because they could always be easily excavated by their future garrisons in the course of a few hours. Where many reserve positions may be necessary, considerations of economy would naturally limit the work done to that alone which is absolutely necessary.

But in the Kungchuling position, it was decided to make both works and trenches, and also to commence both simultaneously. The reason for this was its very insignificant distance in rear of the main Hsipingai position, which, in view of an unsuccessful battle and a retirement of the Russians from that place under pressure from the enemy, might not allow the troops leisure for even hasty entrenchments. That works and trenches were carried out simultaneously, even with the limited amount of labour available, was due to the uncertainty of the conditions as to the time available, as this necessitated the carrying out of the work so as to be in constant readiness for a possible attack. The order of work was consequently arranged as follows:—First of all the Redoubts Nos. 6 and 7, A, B, C, D, E, F, G, and H, and the trenches of the front line were commenced, and only when this work had made good progress, were the redoubts of the second line begun at a distance of 700 to 1,000 paces to the rear. At the same time the first—and main—line of defence was continually improved by putting native houses in a state of defence, constructing obstacles, and excavating a complete system of approaches communicating with the ground in rear.

The writer did not approve of the line taken up for the position. Its form, a salient right-angle, would give the enemy the power of sweeping one or other side with oblique or enfilade fire from guns in his rear. The right half of the position lay in low and very inconvenient ground; in front, at a distance of 2,500 to 3,000 yards, stood commanding ground, and in rear the ground also rose, exposing the communications. If, possibly from the objection to advancing the position too far forward with reference to the adjoining position of the 1st Army, it was decided to abandon the commanding ground at the trigonometrical station, then the right half of the position should have been drawn back, so that the whole position might present a straight line perpendicular to the enemy's probable line of advance, and out of artillery range from the trigonometrical station hill. This arrangement, while not interfering with the good position of the left half, or with its communication with the 1st Army, was additionally desirable, as it would have brought the line nearer to the watershed, and would have considerably improved the field of fire.

The result of this faulty choice of the line of defence was the necessity of the front position, and also of a rear position, in rear of the right flank on the above-mentioned watershed, though the latter, through want of labour and time, was never made.

Frequent errors made in the selection of defensive positions during the war arose from two causes:—(1) That sufficient time was not allowed to those drawing up the project of defence to carry out this important duty thoroughly, and (2) that, owing to the non-existence of a contoured survey of the country, and to the fact that surveyors sent to draw the ground often contented themselves with sketching only the area actually included within the position, those whose duty it was to criticize the projects were unable to form any opinions as to the approaches, flanks, or ground immediately in rear of the proposed position. The hastily-prepared projects were passed practically without criticism, and the works had frequently made considerable progress before defects received official notice and necessary alterations were authorized.

F. E. G. SKEY.

REVIEW.

A FRENCH MANUAL OF FIELD FORTIFICATION.

Instruction Pratique sur les Travaux de Campagne à l'Usage des Troupes d'Infanterie, 1907, is a slim volume of 70 pages, about 7″ × 3″ in size, easy to slip into the pocket.

The preface contains the significant warning to soldiers that although recent wars have shown the necessity for the frequent use of fortifications on the field of battle, yet "it must not be lost sight of that the protection to be sought against projectiles must in no case be allowed to diminish the offensive spirit of our infantry, nor to interfere with its aptitude for movement." . . . "The fact that works have been executed must never keep troops at a particular spot, if the situation at the moment requires their presence elsewhere."

The first chapter deals with general principles; field fortification is divided into hasty (*legère*) and strengthened (*renforcée*); "the former only is of interest to the infantry," and includes utilization of cover and obstacles, formation of parapets, trenches, organization of a position, construction of communications, and demolitions. Field fortification is said to be of special use to advanced guards, and when breaking off a combat. Trenches on the field of battle must generally be excavated lying down.

Differing altogether from the German manual, which lays down as a principle that on the defence one line only is to be prepared, the French instructions direct that successive lines of resistance shall be constructed, although they do not go so far as to label them, *à la Russe*, "advanced," "intermediate," "main," and "rear" positions. They also lay great stress on the use of obstacles, and direct their use at all points which the defender must retain *à tout prix*. Finally they recommend the construction of entrenchments to cover the troops detailed to make the counter-attack, unless natural cover is available.

Chapter II. shows how existing cover—ditches, banks, hedges, walls, etc.—can be utilized, and describes by diagram how to dig lying down. The soldier lies at full length on his stomach, with his head on his left arm, and scoops an ellipse-shaped hole, length about the distance of his head to the middle of his thigh, under his right side. As soon as he can, he gets his chest into the hole; no trench is made for the legs.

In carrying out the organization of an extended line it is stated:—"In principle, the different infantry units, either with their portable tools or tools obtained from the engineer park, will construct the entrenchments of weak profile which they are charged to defend, and will organize the cover or obstacles which they are called on to occupy.

The engineer troops attached to them will, in principle, execute the entrenchments of strong profile, will construct shelters, establish accessory defences, organize redoubts, create points of passage through obstacles, improve communications, carry out important demolitions, and, in general, all the works which require special technical knowledge." As regards the choice of a position and the design of the trenches, the manual lays down:—"The details of the works will be decided on during the reconnaissance made by the commander of the infantry which is charged with the defence." . . . "He alone is responsible for the choice of the line to be occupied and the distribution of the defenders."

Chapter III. deals with practical instruction which is divided into individual instruction, squad instruction, and cadre instruction. It is laid down that:—"It is necessary to train the soldier by constant practice in the handling and use of tools." Individual instruction is limited to the value and use of cover, improvement of cover, formation of parapets. Squad instruction deals with the combination of the work of several soldiers, clearing a field of fire, light bridging, making abattis, making passages through woods, improving the cover of walls, palings, etc.

Cadre instruction is given to officers and N.C.O.'s, and includes putting a position into a state of defence, tracing, arrangement of working parties, reconnaissance of routes, use of explosives, simple demolitions, passage of ditches and water courses.

The instruction of officers is completed at the "schools of field fortification," when all infantry subalterns are attached to engineer battalions for six weeks.

The last 30 pages of the manual contain annexes.

Annex I. gives the portable tools carried by an infantry company:—

112 spades (which have rounded, not tee, heads), 32 picks, 12 hatchets, 4 axes, 16 billhooks (*serpes*), 4 chisels, 1 jointed saw.

Annex II. gives examples of the profiles of fire trenches—for "sitting," kneeling, and standing. In the "sitting" position (which is peculiar) the front part of the trench is 20 c.m. (7·8 inches) deep and 40 c.m. (15·7 inches) wide, and the rear portion is of the same width, but 60 c.m. (23·6 inches) deep; the left knee rests on the step thus formed, while the right leg is extended into the deeper part of the trench. The parapet is 60 c.m. (23·6 inches) high.

In the kneeling position the soldier kneels on both knees in a trench, improved from the "sitting" pattern by deepening the trench to 60 c.m. (23·6 inches) all over. The parapet is lowered to 40 c.m. (15·7 inches) and proportionately thickened.

The kneeling trench is improved for standing (1) by deepening it 20 c.m. (7·8 inches), and (2) by widening it 30 c.m. (11·8 inches). By deepening this new width 40 c.m. (15·7 inches) a man can sit comfortably, sheltered by the parapet. Elbow rests are not provided in these patterns, but are exhibited in a separate drawing; grooves for the rifle to rest in are always made.

The French troops work in parties (*ateliers*) of four or five men, furnished with three or four spades and one pick; each party is expected to execute 75 c.m. (2·46 feet) of trench per man.

Short paragraphs only are devoted to concealment of parapet and overhead cover; head cover is not referred to.

Annex III., Part I., deals with demolitions. The French demolition charge (*pétard de mélinite*) is 135 grammes (4·73 oz.) of melinite contained in a brass case, about 4″ × 1″ × ⅜″, the whole weighing 200 grammes (7 oz.). The cover is secured by a soldered band; when this is removed a socket in the head of the charge is exposed; into this a cap, containing fulminate of mercury, can be placed. Instantaneous fuze (*cordeau détonant*) and safety fuze (*cordeau Bickford*) are provided.

Simple instructions for the demolition of walls, trees, railways, abattis, wire entanglement, railway lines, telegraph lines, and ice are given. It is stated that a charge made up three petards thick, and of a length equal to the depth of the obstacle, will clear a gap in wire entanglement from 3 mètres to 6 mètres wide (9·8 feet to 19·6 feet), according to the character of the entanglement. Each infantry regiment, or independent battalion, carries 108 petards.

Annex III., Part II., gives some short directions for the passage of streams by extemporized means, boats, fording, and on ice.

Annex III., Part III., deals with very elementary camping conveniences:—A kitchen "is formed of two or four stones, on which the pots rest. In the absence of stones, dig a simple trench." The latrine is a long trench with "the earth from it thrown right and left, so that the man can place his feet on each side of the excavation," and thus squats astride of it.

The very short and simple instructions given in this volume, taken in conjunction with those contained in the *Règlement sur les Manœuvres* and the *Règlement sur l'Instruction du Tir*, of which they are the complement, seem to indicate that the French military authorities have not been carried away by the experiences made in the special circumstances of the Russo-Japanese War in Manchuria, and do not intend to break the *élan* of the French infantry by over-indulgence in spade-work.

'E.'

NOTICES OF MAGAZINES.

Building News.

The number of June 12th, has a report on Dry Rot, from which the following notes are extracted :—

1. *Definition.*—Dry rot is a state of decomposition in wood caused by dry-rot fungi—the commonest of which is *Merulius Lachrymans.*

2. *Favourable Conditions to the Generation of Dry Rot.*—The spores of *Merulius Lachrymans* require the presence of an alkali such as ammonia, and it is found in cellars, stables, and outhouses where ammoniacal or alkaline emanations can reach the timber.

It has been popularly supposed that timber felled in summer was more prone to dry rot than timber felled in winter. This has been proved to be incorrect; dry rot will attack timber independently of its quality.

3. The dark stagnant air in cellars and under boarded floors of the ground storey is very congenial to fungus growth.

4. The principal parts of buildings in which it is found are :—

Warm cellars, unventilated floors, basements; particularly in kitchens or rooms where there are constant fires.

The ends of timbers built into walls are nearly sure to be affected by dry rot unless they are protected by iron shoes, lead, or zinc. The same result is produced by fixing joinery and other woodwork to walls before they are dry. Linoleum, kamptulicon, and other floor cloths, by preventing access of air and retaining dampness, cause decay to the boards they cover.

5. *Prevention of Dry Rot.*—All brickwork and concrete floors must be thoroughly dry before timber is placed in contact with them.

6. Any substance or device which imprisons moisture within wood, or prevents free evaporation from its surface, or maintains a damp atmosphere in its neighbourhood will develop dry rot.

Unventilated floors must not be covered with an impervious covering.

Damp or ill-seasoned wood must not be painted, tarred, or covered with plaster of paris; ordinary plaster is sufficiently porous to be safe.

7. Cellars and floors must be properly ventilated.

8. Any specification for the construction of a wooden floor should provide for the removal of all chips, shavings, etc., as these are a fruitful source of dry rot.

9. The ends of beams and joists if built into the wall must have an air space round them, or if this is impossible, should be protected with iron shoes, lead, zinc, or creosote.

10. *Methods of Eradicating Dry Rot.*—Every trace of the fungus should be scraped from the timber, brickwork, or wherever it is found, and the surface of the soil, if exposed, should be removed; the whole must then be burnt. If timber is too far gone for this treatment it should be cut out and burnt.

11. If this cannot be done the beams should be soaked with corrosive sublimate dissolved in methyl alcohol. Methyl alcohol has great penetrating power, and acts as a vehicle to carry the corrosive sublimate into the texture of the wood. The inflammable nature of methyl alcohol must not be forgotten.

12. Carbolic acid or a strong solution of copper sulphate (blue vitriol) in boiling water may be substituted.

13. The walls and concrete floor, if any, should be washed with carbolic or sulphuric acid or Condy's fluid, and the air should be disinfected by burning sulphur.

14. In a slight attack the wood may be covered by a hot limewash.

15. These remedies, however, do not penetrate very far, and as only those parts of the fungus are killed which are in contact with the poison, the deeper-seated hyphæ may remain as active as ever. The rot is not stayed, but its ravages are hidden from view.

R. N. HARVEY.

MEMORIAL DE INGENIEROS.

On the occasion of the hundredth anniversary of the outbreak of the War of Independence, known in England as the Peninsular War, the editor of the *Memorial de Ingenieros* has produced an exceedingly handsome volume of 200 pages, profusely illustrated, dealing with the organization and services of the Corps of Engineers during those campaigns. The various chapters have been written by distinguished officers of the Corps, and the work is a mine of information, specially interesting to British officers.

The Spanish engineer troops date back from the commencement of the last century—the Royal Regiment of Sappers and Miners having been created by a decree dated 5th September, 1802, whilst the Engineer Academy was inaugurated on the 1st September, 1803.

In 1808 there were 196 officers belonging to the corps, of whom 60 were doing duty with engineer units, and the remainder were employed on division work. The regiment of sappers and miners consisted of 2 battalions, each containing 5 companies—1 of miners and 4 of sappers. Each company was commanded by a 1st captain with 4 other officers, 5 sergeants, 16 corporals, 2 drummers, 104 sappers and miners. The staff of the 1st Battalion consisted of 1 colonel, 1 second in command, 2 adjutants, 1 ensign, 1 chaplain, 1 surgeon, 1 armourer, 1 drum-major, and 2 fifes. The staff of the 2nd Battalion was similar, except that the commanding officer was a lieut.-colonel. The total strength of the regiment was 1,215 of all ranks.

At the opening of hostilities the headquarters of the regiment were at Alcalá de Henares, near Madrid, and companies were stationed besides in Portugal, in Minorca, Badajoz, Cadiz, Ceuta, and the Campo de Gibraltar. Steps were at once taken to raise fresh battalions and companies, and by 1811 there were 6 battalions, with an establishment of 3,018 men.

The war commenced by the revolt of the troops in Madrid on the 2nd May, 1808. This revolt was put down by Murat with great severity, but on the 24th of the same month the two sapper companies stationed in Alcalá, marched out of that town, in order to escape from being compelled to take the oath of allegiance to the French Government, and reached Valencia on the 7th June, where they joined the National Government, proclaimed a few days earlier by the Count de Castellon. The engineers took a leading part in the second siege of Zaragoza, the third siege of Gerona, at Ciudad Rodrigo, Badajoz, Burgos, Monzón, etc.

The work contains chapters on fortification and siege works at the time of the war, and on bridges. It also has a list of the services of the principal engineer officers, and of the losses sustained during the campaigns.

'M.'

NATURE.

January to May, 1908.

LIFE ON MARS (p. 442).—One of the most telling arguments which have been used against the possibility of the planet Mars being habitable, has been that spectroscopists have failed to detect the presence of water vapour in the planet's atmosphere; but in March, 1908 (p. 606), Mr. Slipher—in Arizona—succeeded in photographing the lines due to water vapour in its atmosphere. The detection was rendered possible by the use of plates specially prepared by him for the purpose, which enabled the spectrum to be photographed somewhat beyond the "A" band. Comparative spectrograms were made of the moon at approximately the same altitude on the same plates, and with exposures to give a like density for both. Repeated plates of this sort were taken, and their concensus shows unmistakably the "A" band stronger in the spectra of the planet, than in those of the moon. In the case of the moon we are looking through our own atmosphere only; in the case of Mars, through its atmosphere as well. The great dryness of Arizona was a factor in the result. So dry was the air at times during the investigation, that on more than one plate the "A" band is hardly to be made out in the lunar spectra, while in the Martian it is unmistakable. The presence of water vapour in the spectrum of Mars is strong presumptive evidence that free oxygen exists in its atmosphere as well, since it is the heavier of the two.

On the series of photographs (p. 182) obtained on 25th July, are to be seen delicate canaliform markings, which entirely refute the suggestions that such markings, previously recorded visually, are merely subjective phenomena. Professor Lowell thinks that these are really canals made by sentient beings, while Professor Pickering suggests that they are—like the rifts and streaks on the moon (p. 338)—caused by volcanic action, due to internal stresses set up by the cooling of the planet's heated interior. The melting polar caps, and their reforming, affirm the presence of water vapour in the atmosphere, and Professor Lowell has observed blue borders on the edges of the polar caps as they melted. Dr. Wallace disagrees with this interpretation of the caps being frozen water, pointing out that for water to be blue it must be deep, and this cannot be so on Mars, because its surface is so level, probably not more than 2 feet. Dr. Stoney has stated that aqueous vapour cannot exist permanently on Mars, or on any planet, unless its mass is at least a quarter of the earth. As the mass of Mars is only one-ninth that of our earth, the planet must have parted with its vapour ages ago, because the velocity of the molecules would be too great for the attraction of the planet to retain them. Dr. Stoney does not state the temperature he has assumed in this calculation, but a dozen miles above the surface of the planet the temperature of its atmosphere must approach absolute zero—a condition of things in which even hydrogen (p. 302) would not have the necessary velocity to escape.

In certain seasons a blue-green colour on Mars has been noticed, and this Professor Lowell attributes to vegetation, and its change to chocolate-brown, to the fading of verdure with the change of the season.

It is now a commonplace (p. 413) of geology, that a variation of the small percentage of carbonic acid in the earth's atmosphere will have an important effect on the temperature of the latter. A relatively large amount of carbonic acid will cause a correspondingly greater proportion of the heat received to be retained, and the temperature will be higher. Such conditions will be marked by luxuriant vegetation. If now we make the very reasonable assumption that the crust of Mars is composed of the same minerals as those with which we are familiar, and its atmosphere of the same gases as ours, and that accessions of carbonic acid are received from the interior of the planet, we may expect a similar automatic adjustment of the temperature, so that it is never too cold for vegetation, such as that believed by Professor Lowell to maintain itself somewhere on the surface of the planet. Whether Professor Lowell can be considered to have established his views is doubtful, but the arguments against them are not convincing, and remind us of those of the engineers who satisfied themselves that a locomotive could not draw a train of trucks on smooth rails, and were not persuaded to the contrary until they saw that it did so!

W. E. WARRAND.

REVISTA DE ENGENHERIA MILITAR.

May, 1908.

THE CENTENARY OF THE PENINSULAR WAR.—The *Revista Militar* proposes to commemorate the centenary of the Peninsular War by publishing during the years 1908—1914 articles relative to the events that occurred during its campaigns, and the editor is consequently asking for the assistance of all those who may possess documents or information bearing on the subject.

This centenary is being celebrated with much enthusiasm in Spain and Portugal, and as the Peninsular War equally secured our national independence, this display of patriotism might well appeal to Englishmen.

The particular subjects on which the editor of the *Revista Militar* is seeking for information are:—

1. Military psychological study of the Portuguese Army at the commencement of 1807 (discipline, military justice, education; dominant ideas regarding strategy and tactics; respect for tradition, etc., etc.).

2. Ditto after the war.

3. Comparative study of the Portuguese Army from the point of view of its worth as an organ of defence in 1807 and 1814.

4. Portuguese generals; their influence on the campaign.

5. Portuguese officers; their recruitment and degree of general and professional training in each of the arms of the service.

6. Foreign officers; their influence on the reorganization of the Portuguese Army; their relations with Portuguese officers.

7. Biographical studies of distinguished officers both foreign and Portuguese.

8. Proofs of resistance given by the Portuguese soldiers during the war (age, physical vigour of the men, districts traversed by them, seasons of the year, etc., etc.).

9. Parallel between Beresford and Lippe from the point of view of the influence which each of them exercised on the Portuguese Army.

10. Criticism of the plan of campaign which the Portuguese generals proposed to follow before the English generals took over the conduct of the war.

11. Plan of campaign of the English generals and its justification.

12. Appreciation of the two plans above referred to.

13. Recruitment and means employed for completing the effectives of the Portuguese Army during the war.

14. Training of the recruits during the war; means employed of effecting it.

15. The Portuguese infantry; its organization and services rendered by it during the war.

16. The Portuguese cavalry; its organization and services rendered by it during the war.

17. Portuguese cavalry remounts during the war; quality of the horses proved by examples drawn from the history of the war.

18. The Portuguese field artillery; its creation and organization; armament; part played by it in the war.

19. The Portuguese siege and garrison artillery; ditto; ditto.

20. The Portuguese military engineers; services rendered by them in the war.

21. Militia; legal organization and real value at the commencement of the war.

22. Militia; services rendered by these troops during the war.

23. Militia trained bands (*ordenanças*); legal organization and real value at the commencement of the war.

24. Militia trained bands; services rendered by them during the war.

25. Is there anything in the organization of the militia and militia trained bands that would be advantageously applied at the present time?

26. Intrinsic value of the various works of permanent fortification of the country at the commencement of the Peninsular War.

27. Lines of Torres Vedras; their actual value.

28. Employment of field fortification by the allied forces during the war.

29. Sanitary services.

30. Supply of food to the allied troops during the war, more particularly within the frontiers of Portugal.

31. Method of supplying boots and equipment to the allied armies during the war, especially whilst in Portugal.

32. Supply of forage.

33. Supply of ammunition.

34. The arsenal of the army; its services during the war.

35. Lines of communication, both by land and river, made use of for the transport of ammunition and supplies, especially the Tagus and Douro.

36. Nature of the arms used during the war, and ranges at which they were effective.

37. Comparative study between the tactical value at the present time and at the time of the war of the positions occupied by the belligerents within the Portuguese frontiers, keeping in view the changes in armament.

38. Constitution of the English units which took part in the campaign with the Portuguese troops.

39. Expenses incurred by the Portuguese Army during the war.

40. State of the Portuguese Navy in 1807.

41. Units of the navy and their distribution at the outbreak of the war.

42. Services rendered by the Portuguese Navy during the war.

43. Bibliographical notice of unedited manuscripts on the war, and impressions of recognized rarity, not registered in the various dictionaries.

The editor also asks for sketches, portraits, caricatures, views of battles, itineraries, plans of fortifications, etc., bearing on the war.

HARMONIC SYNTHESIS OF THE TIDES (*continued from the April number*).—Determination of the levels of high and low water conjointly with the respective hours of their occurrence.

PRESENT-DAY DIRIGIBLE BALLOONS AND FIELD AEROSTATIC PARKS (*continued from the January number*).—This article contains a description of the Nulli Secundus and the Italia, and a comparison of the systems employed in these two dirigibles and in the Parseval and Patrie. There is also an account of the Gordon-Bennett race from St. Louis and of the experiments of the brothers Wright.

Other countries, besides the owners of the balloons named in the preceding paragraph, are making experiments in aerial navigation. In Russia a committee has been assembled under General Kirvichiev to study the problem. In Austria-Hungary three airships are under trial, but details are not forthcoming. In Spain one is being built after the designs of Capt. Kindelan. It is to be 35 m. long by 6 m. in diameter, there will be screw propellers at each end of the car, and a movable weight is provided to correct longitudinal instability. When completed it will serve as a model for the construction of a larger machine.

SOME PROJECTS AND WORKS EXECUTED IN THE PROVINCE OF MOÇAMBIQUE IN THE LAST NINE YEARS (*continued from the April number*).—An interesting paper showing designs of works—some of them executed and some only projected. English and German practice in Africa is quoted with approval. Notes are given on the provision of lightning conductors, disposal of sewage, construction of kitchens, best system of construction to resist white ants, etc., etc. For the latter purpose the author recommends concrete walls in preference to brick, double channel iron floor girders, concrete or armoured concrete floors, roofing of papier maché or fibre-cement, door and window frames of mucurusse wood, which is abundant in Moçambique, and is not touched by white ants.

'M.'

RIVISTA DI ARTIGLIERIA E GENIO.

April, 1908.

REVIEW OF BOOKS AND PERIODICALS.—*Historical Sources of Military Architecture.*—Henry Rocchi (Major-General).—Under the above title General Rocchi has lately published a new work which is worthy of the highest admiration, because it seems scarcely possible to have comprised in so small a bulk so much learning and information.

In 500 pages, General Rocchi has recounted the entire history of fortification up to the last Russian and Japanese War. He had already published several works; among which may be mentioned a copiously annotated translation of Leithner's *Permanent Fortification and Fortress Warfare*—a work on the study of field fortification and another on the study of permanent fortification (three editions)—both of which are complete treatises on these branches of fortification; and finally numerous articles in the *Rivista di Artiglieria e Genio*, and in the *Rivista Militare*

Italiana, which together form a library of military science, archæology, and art.

The author commences by a study of the conditions under which primitive men sought to defend themselves from the attacks of other men, caused either by envy, or by a desire to obtain possession of their wives and property. Taking refuge in caves, naturally difficult of access, they rendered the approach more difficult by obstacles at the entrances, or by erecting their dwellings on piles near the banks of lakes and rivers; they communicated with them by bridges, which they were able to dismantle or destroy, and thus became the originators of primitive fortification.

Passing from single individuals to the community, then to the tribe, and then to the State, these in their turn had recourse to similar artifices to those above stated, but of a more extended and important nature. They constructed fortifications of a simple and rugged kind, but which were sufficient for the exigencies of the time.

After referring to the art of fortification of early times, the author studies the art of Egypt, of Assyria, of the Greeks and Romans—as it can now be traced in the remains of the beautiful walls of Babylon—of Nineveh, Carthage, Thebes, Rome, and Pompeii.

The Greeks and Romans were well skilled in adapting the fortifications to the ground, and though this principle has been imposed upon all ages, it was, in a measure, forgotten by the scholars of the XVIIIth and XIXth centuries. Now of course its great importance is fully recognized by military engineers.

General Rocchi gives an excellent account of the first examples of active defences, where he speaks of the sieges of Rodi, Avaricum, Alessia, Syracuse, and Rome, and most interesting researches on the first use of the mine and countermine, on the first employment of explosives, Greek fire, and ballistic artillery.

The author examines with brilliant criticism the accounts of the arms that were employed for the attack of ancient works, and of those used for the defence, and reasons on the form of fortifications that should be adopted owing to modifications in the arms. He describes the many details of fortified works; the platforms, towers for observation, flanking towers, the ditches, ravelins, etc., and he deduces that the one great principle of the art of fortification is to know how to adapt and modify it, in accordance with the progress and modifications in the weapons of war.

In the middle ages of feudalism the art of fortification underwent a great change, owing to the breaking up of the States, and the great works of Greece and Rome gave way to mediæval castles in enormous quantities; in France in the XIth and XIIth centuries the numbers are stated to have been not less than 60,000. But in the XIVth and XVth centuries an event occurred of great importance in the history of military art, and not only was this importance limited to the military art, but also it played a great part in the constitution of States and their policy. This was the invention of firearms, which at first from modest beginnings increased step by step, abolishing entirely the ancient ballistic artillery, and substituting muskets, pistols, or other kinds of firearms, for the weapons of other days.

The art of fortification was greatly influenced by this new invention, and sought to adapt itself to the new order of things, by radical changes in the form and tracing of the earthworks. There was then the transition stage with an increased thickness of walls, a lowering of the towers, and abolition of small defences which became targets to the attackers and sources of danger to the defenders; then came the later epoch of fortification which led to the bastion tracing—the glory of the Italian engineers.

In Rocchi's work the appearance of firearms, their development and the results to the art of fortification, are fully explained, with dates and extensive notes. Interesting descriptions are given of the walls of Gradara, of Pesaro, Brescia, Forli, Como, and Viterbo; and also of those of Bologna, Camerino, and Alba, which combined ancient with modern methods.

The author describes, with learned analysis, the natural derivation of the modern bastion from the ancient tower by the slow influence of firearms, and he enumerates the names of many distinguished Italian engineers. Nor does he forget to mention the names of many illustrious foreign engineers, among whom may be enumerated the names of Vauban, Cormontaigne, Chasseloup, Dufour, Coëhorn, and many others.

The XIXth century presents a new era in the employment and construction of artillery with curved fire, breech-loading cannon, and powerful explosives. Again fortification has had to transform its methods of trace and profile, and to pass to the methods of casemates and armoured works. The changes are slow, methodical, and progressive, because the adoption of new forms is always confronted by the watchful upholders of tradition; and, it may be added, because alterations are always confronted by great technical and financial difficulties.

A great writer (De Christoforis) observes, speaking of fortification, that it is liable to become a slave to geometry and to system, and that one cannot say that it is completely free from the impediment of scholastic doctrine.

General Rocchi has said that to write a general history of fortification the author should be an archæologist, an architect, and a military engineer at the same time, and it may be added that he should also be an artist. The author possesses these qualities in a great measure, and has written an excellent work, with illustrations interspersed through the pages, forming a useful, indispensable, and delightful volume.

A STABILITY-INDICATOR FOR SMOKELESS POWDER.—At the sitting of the French Senate, held on the 30th of November last, to discuss the conclusions arrived at by the Commission of Inquiry into the causes which produced the disaster to the cruiser *Jena*, the Senator Monis—reporter to the said Commission—quoted in support of his subject an article published in the *Rivista Marittima* of January, 1908, viz., a letter of E. Bravatta, captain of frigate, on the stability of nitric cellulose and of smokeless powder. The writer especially insisted on the absolute necessity of introducing a *stability-indicator* for smokeless powder, that is, a substance which, whilst having the effect of preventing or at least of retarding the decomposition of the powder, changes its colour. By this means a simple ocular inspection may show whether the powder is in good condition or not, and whether it should be kept or destroyed.

Such a substance, which is made by a primitive formula from aniline, is said to have been studied and adopted in Germany, and by this means it would seem to have avoided the accidents and mishaps which other countries have had to lament.

During his discourse Monsieur Monis stated that about nine years ago the French Metropolitan Artillery proposed the employment of the German stability-indicator, but that the "Service for explosives" obstinately refused its adoption, and only desisted from its tenacious refusal after the *Jena* disaster. In fact in June, 1907, the stability-indicator was adopted unanimously.

The stability-indicator used in Germany, and now adopted in France, is the difenilamina, which is a secondary base of ammonia in the formula $C_{12} H_{11} N$. By distillation, azure of rosaniline is obtained, and it is produced by heating up to 250°, chloride of aniline and aniline. The difenilamina shows under the form of white crystals, which melt at 45°; boil at 310°, emitting an odour like that of roses, which is poisonous and of an acrid taste, and with vapour producing coughing. It is insoluble in water, and dissolves easily in alcohol, ether, petroleum, and benzine.

The salt acid, in contact with the air, is of blue colour. A solution of defenilamina in sulphuric acid, assumes an intense blue colour in the presence of even small traces of nitric acid, and consequently difenilamina constitutes a very sensible reagent to nitrous vapour.

Difenilamina is used in commerce for colouring matter, to obtain blue difenilamina, orange difenilamina, etc.; other colouring groups have a great affinity for difenilamina, and are therefore comprised under the name of difenilamina colours.

It thus appears that the stability-indicator used in Germany—and now adopted in France—is a substance which is used in commerce, and which is prepared without difficulty. The question of the stability and security of smokeless powder is of grave importance, although possibly it can be solved by a simple and modest method.

May, 1908.

REVIEW OF BOOKS AND PERIODICALS.—Ermano Albasini Scrosati, Member of Parliament.—*The National Defences.*—I. Our Naval Problem.—Commencing with a preface in which he states the motives which have induced him to write this book, the author examines the data on which the naval estimates were framed, and also the reasons for the continued increase of the same, and for a further increased allotment of 13 millions of lire. Contrasting our naval forces with those of other nations from data given in Lord Brassey's *Naval Annual*, the author arrives at the conclusion that the Italian fleet is inferior to all the other principal fleets, with the exception of Austro-Hungary; and considering the prevailing tendency of other states, he thinks that—notwithstanding the increase of 10 millions now demanded from the Government for the ordinary expenses of the navy—such inferiority is not destined to disappear. He next passes to an examination of the dangers of naval attacks, such as disembarkations, bombardments, blockades, etc. With regard to the first of these, the author, after an exhaustive discussion, is convinced that a landing on our coasts of more than 50,000 enemy's troops need not be feared; that the operation of disembarking on a beach is always dangerous, and that in Italy such an operation could only be attempted in a few localities which are perfectly known.

Secondly, with regard to bombardments, it is beyond discussion that with the powerful new guns the battleships are able to bombard maritime places at distances exceeding 10 kilomètres. The writer asserts that such bombardments would not have grave consequences and ought not to induce excessive alarm; that the latest war confirms this opinion. A bombardment may be confronted with tolerable serenity, but it is necessary to prepare for it beforehand by endeavouring to quiet the inhabitants, and by taking every precaution for reducing the losses to the least proportions, and for the ready extinction of fires.

The author shows the impossibility of extending a blockade to the whole of the Italian coasts, and points out that, in a country like Italy with three land frontiers, although there might be losses from the enemy's cruisers, the sufferings of famine and the danger to the internal industries of the country would not be encompassed by a naval blockade.

Signor Scrosati next considers what measures both defensive and offensive should be carried out for the navy. The submarine mine, the torpedo, and the submarine flotilla are the weapons of defence. The Russo-Japanese war has shown the terribly destructive nature of the first; and considering its surprising efficacy, all the navy, and especially the weaker units, should be prepared for a greater use of it in future wars. Not only would it be used for defensive measures, such as impeding the enemy's ships on our own coasts, but also offensively, by making it impossible or most hazardous for a hostile fleet to leave the ports of its own country.

The submarines, although their construction has not as yet been perfected, are peculiarly adapted for a nation which has not the means of creating a great navy, and which has to defend a long coast line accessible to the enemy's enterprises. This of course applies to Italy, and it is evident that in the organization of naval forces the submarines would be of the first importance.

The principal strategic value of these is that they assist the fleet by limiting the enemy's coast enterprises. The blockading of ports, and the bombardment of fortified places are operations not likely to be successful when submarines form part of the defences. The Italian submarines in the manœuvres of 1906 gave excellent results.

In conclusion, writes the author, the submarine mine, the torpedo, and the submarine constitute the most efficacious defence for a coast like that of Italy.

The views of the Hon. Albasini Scrosati, however, are not in accordance with those of the editor of the *Rivista*, who, while acknowledging the lucid theories of the author's important work, is of opinion that an eminently naval nation like Italy has a far higher mission than that of being assigned to a mere passive defence.

MILITARY AUTOMOBILE PLOUGH.—The *Revue d'Infanterie* of the 15th April reports that an engineer has lately constructed an apparatus called a *military automobile plough*, designed for rapidly excavating trenches for infantry.

The automobile plough consists of a wagon with two parts, (1) a front limber, similar to that used for field artillery, in which the box contains only the tools required for repairs, and changeable pieces; and (2) a back portion, which carries the excavator and its motor; the box contains the oil and other accessories such as files. The excavator is formed of fuzed steel of great resisting power, and carries four blades of different lengths distributed before and behind.

The thickness of the clods of earth cut by each blade is 3 c.m. After the earth has been thrown up by the excavator, a leveller mounted on a rapidly revolving drum throws it against a kind of shield, which distributes it and regulates the profile of the parapet.

A special mechanism, by means of a hand lever, allows the excavator to be raised and placed in position for travelling on the road without being in action. The motor is located behind, and is arranged in the same manner as the motors of ordinary automobiles.

To be able to obtain the rotational velocity necessary for excavating all kinds of soils, a 150 to 200 horse-power motor is required. The wheels of the vehicle are similar to those of automobiles for heavy traction wagons, and the whole vehicle weighs about 2,500 k.g.

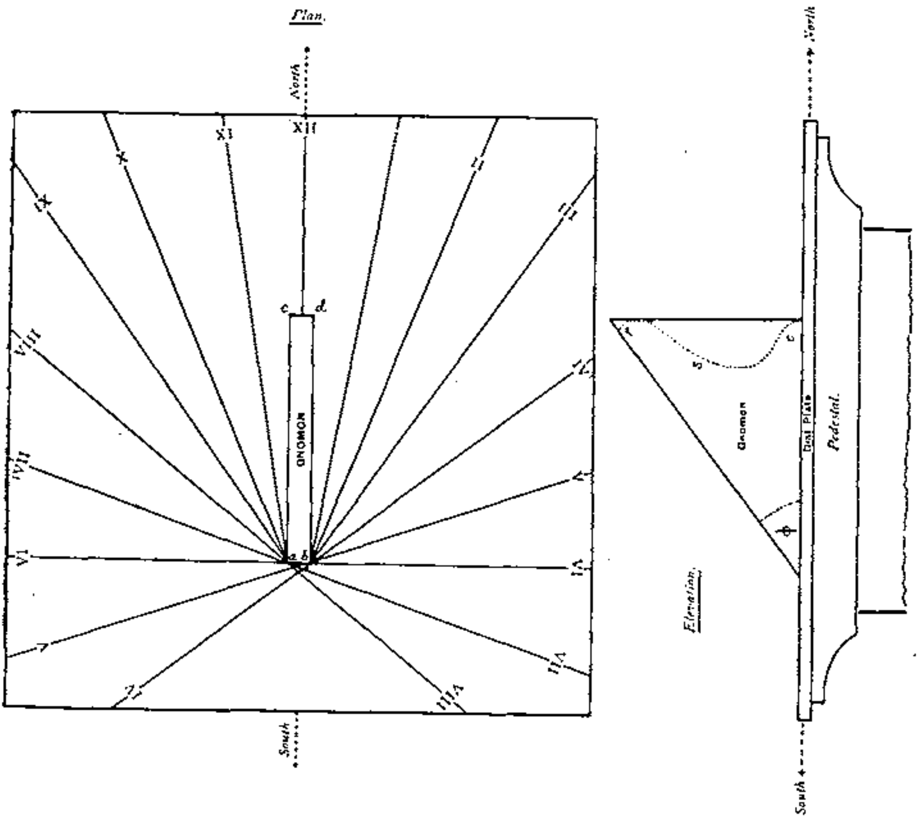
Detailed drawings of the plough with its excavator, and of the profile of the trenches, are shown at pp. 278, 279 of the *Revue*.

It is not understood how this plough could be used for excavating trenches during a battle, unless used at night, as its slow progress and somewhat cumbrous shape would render it an easy mark either for artillery or infantry fire.

EDWARD T. THACKERAY.

CORRESPONDENCE.

A SIMPLE FORM OF HORIZONTAL SUNDIAL TO GIVE LOCAL APPARENT TIME.



Dear Sir,—In the April number of the *R.E. Journal* a description was given of the helio-chronometer. This led to a question being asked by an officer as to the method of constructing a simple form of sundial. The data for doing so are not easily available, and the following notes may therefore prove of interest.

The above plan and elevation represent a sundial for a North Latitude. For a South Latitude it is similar, but the markings are reversed, *e.g.*, II. o'clock = X. o'clock, and the Gnomon would point South instead of North as shown.

INSTRUCTIONS FOR CONSTRUCTION.

The Gnomon makes an angle ϕ with the horizontal plane, where ϕ = latitude of place.

The Gnomon and XII. noon line must be accurately set in the plane of the meridian.

The graduations are made as under:—

For $\left\{\begin{array}{c}\text{I.}\\ \text{XI.}\end{array}\right\}$ o'clock lay off an angle $x^{\text{I.}}$, such that

$$\tan x^{\text{I.}} = \tan 15^\circ \sin\phi \text{ (where } \phi = \text{latitude of place)}$$

For $\left\{\begin{array}{c}\text{II.}\\ \text{X.}\end{array}\right\}$ o'clock lay off an angle $x^{\text{II.}}$, where

$$\tan x^{\text{II.}} = \tan 30^\circ \sin\phi.$$

For $\left\{\begin{array}{c}\text{III.}\\ \text{IX.}\end{array}\right\}$ o'clock

$$\tan x^{\text{III.}} = \tan 45^\circ \sin\phi.$$

For $\left\{\begin{array}{c}\text{IV.}\\ \text{VIII.}\end{array}\right\}$ o'clock

$$\tan x^{\text{IIII.}} = \tan 60^\circ \sin\phi.$$

For $\left\{\begin{array}{c}\text{V.}\\ \text{VII.}\end{array}\right\}$ o'clock

$$\tan x^{\text{V.}} = \tan 75^\circ \sin\phi.$$

For VI. o'clock the lines are due East and West.

The lines are laid off as shown in diagram from XII. to VI. p.m., with centre of protractor at *b* and edge of protractor on *bd*.

Similarly, those for VI. to XII. are laid off with centre of protractor at *a* and edge along *ac*.

The markings IV. a.m. and V. a.m. are those of IV. p.m. and V. p.m., produced, *i.e.*, through *b*, not through *a*.

Similarly for VII. p.m. and VIII. p.m.

The above sundial will give Local apparent time.

PRACTICAL POINTS.

The Gnomon should be from $\frac{1}{4}$ inch to $\frac{1}{2}$ inch in thickness, and must be set up vertical to the dial and accurately placed in the plane of the meridian. The front side need not be perpendicular, but may be shaped to any curve desired, as shown in dotted line *r*, *s*, *t*, so long as the sloping edges, which cast the shadow, are clean and true and parallel to each other.

The Sundial is placed on a pillar some 4 feet high, which may be of any design required.

It is essential that the top should be horizontal, so that when the plate is bedded it will be horizontal too. If the top is square the edges should be located North and South and East and West respectively, so that the dial will not be on the skew, as the Gnomon must be due North and South.

Size of Gnomon and Plate.—This will vary with latitude. A trial could be made with a wood dummy to see what dimensions would be suitable.

Yours faithfully,

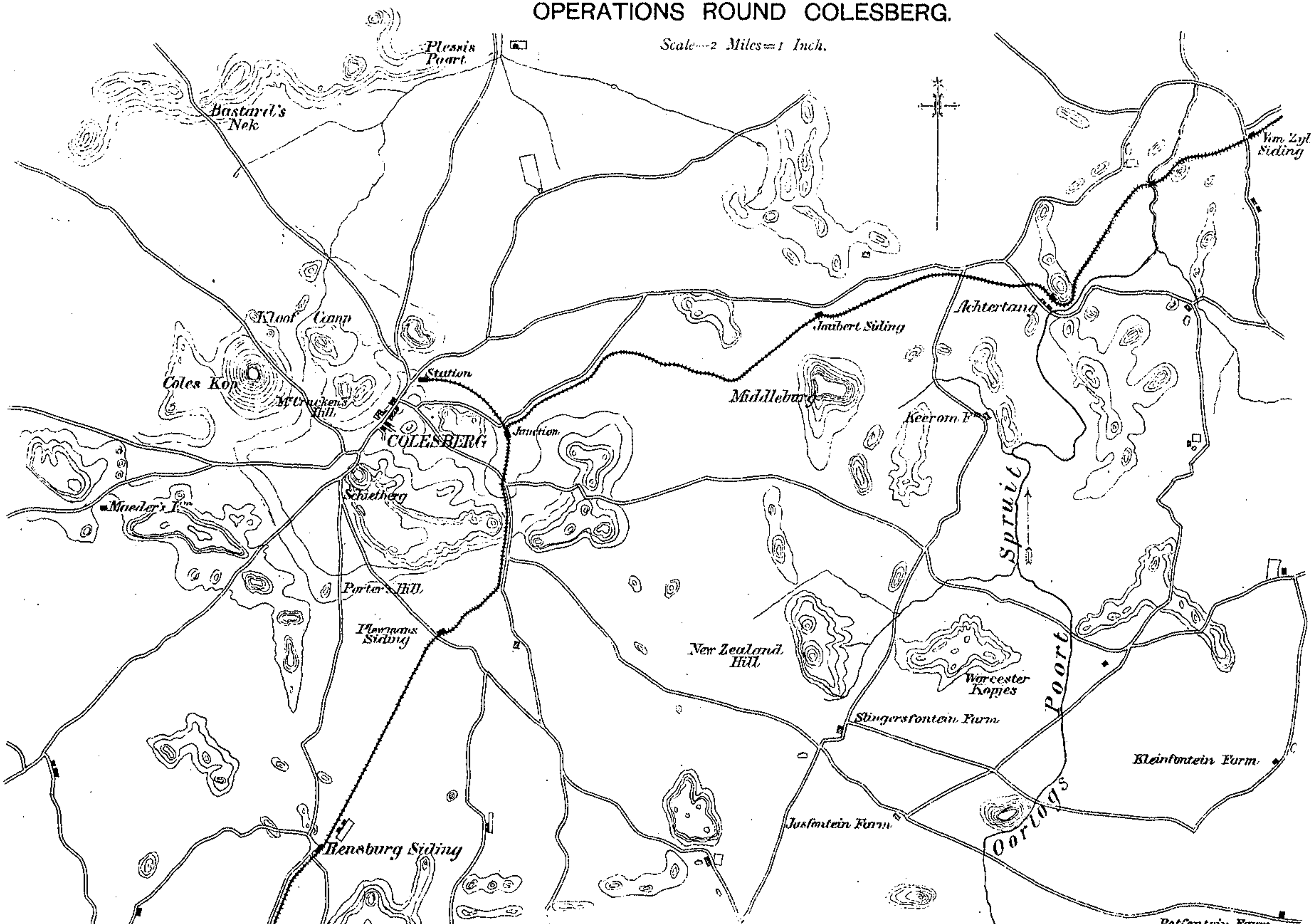
T. N. DUNMAN,

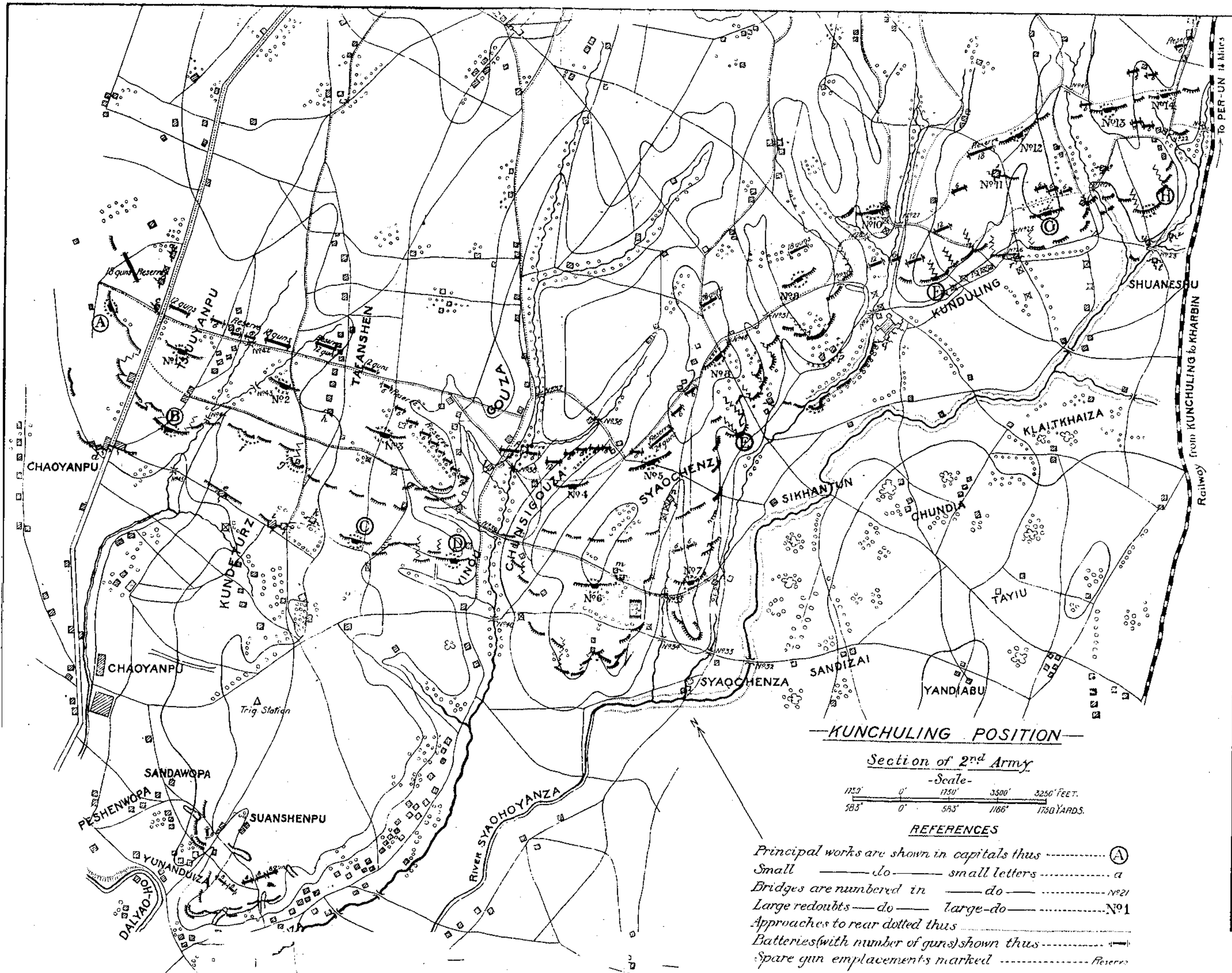
Lieut., R.E.

The Editor, *R.E. Journal.*

OPERATIONS ROUND COLESBERG.

Scale—2 Miles = 1 Inch.




KUNCHULING POSITION
Section of 2nd Army
-Scale-
1750' 0' 1750' 3500' 5250' FEET.
583' 0' 583' 1166' 1750 YARDS.
REFERENCES
Principal works are shown in capitals thus ---------- A
Small ---do--- small letters ---------- a
Bridges are numbered in ---do--- ---------- No21
Large redoubts ---do--- large-do--- ---------- No1
Approaches to rear dotted thus
Batteries (with number of guns) shown thus
Spare gun emplacements marked ---------- Reserve
N
Railway from KUNCHULING to KHARBIN
to PER-UN 14 Miles
SHUANESHU
KUNDULING
KLAITKHAIZA
SIKHANTUN
CHUNDIA
TAYIU
SANDIZAI
YANDIABU
SYAOCHENZA
SYAOCHENZ
CHENSIGOUZA
GOUZA
TAFANSHEN
TSUUYANPU
CHAOYANPU
KUNDEFURZ
VINDU
Trig Station
SANDAWOPA
PESHENWOPA
SUANSHENPU
YUNANDUIZA
DALYAO-HO
River SYAOHOYANZA
No1
No2
No3
No4
No5
No6
No7
No8
No9
No10
No11
No12
No13
No14
A
B
C
D
E
F
G
H
I
18 guns Reserve
12 guns
18 guns
24 guns