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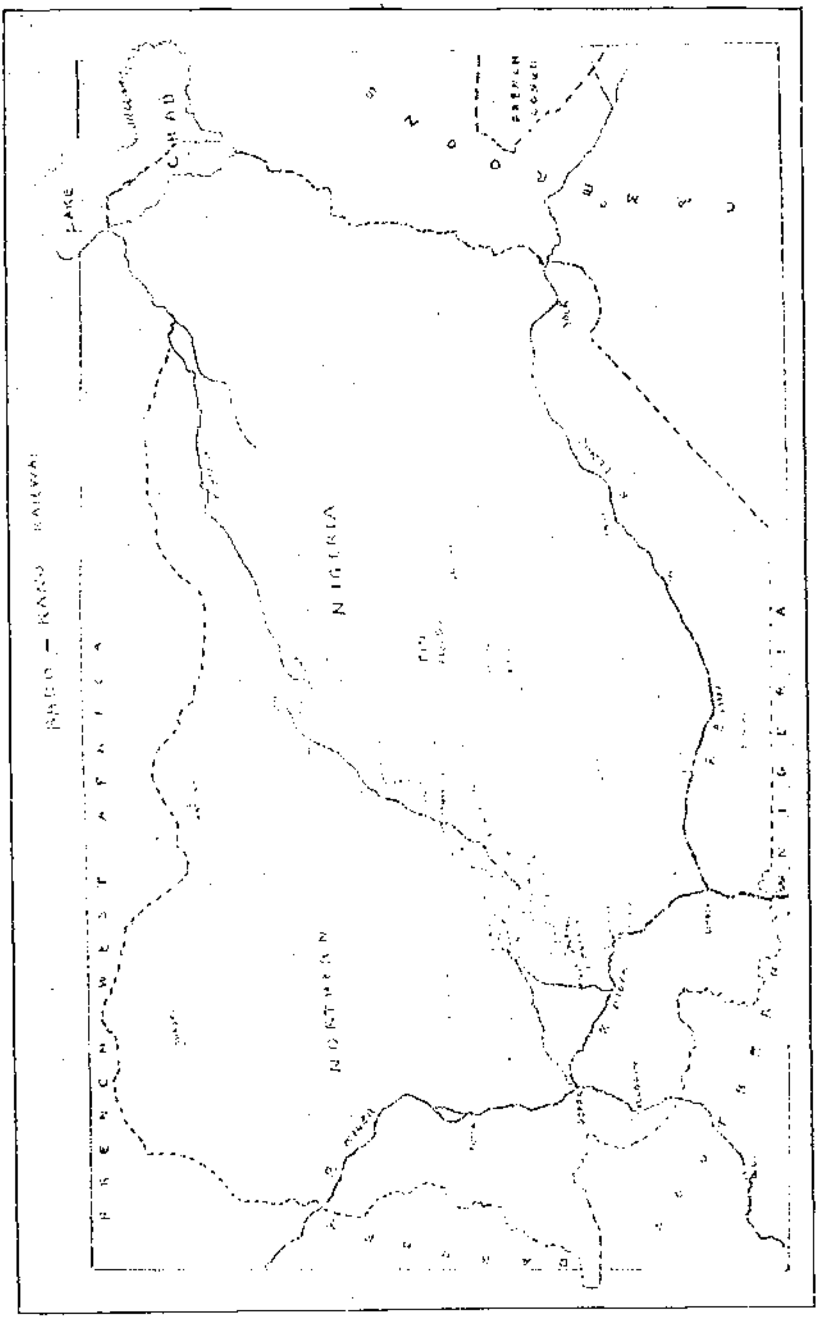
PRIOR to the construction of the Baro-Kano Railway, the sole means of communication over all portions of Northern Nigeria not immediately served by the Niger or navigable portions of its most important tributaries, the Benue and Kaduna, was by native tracks, over which all stores had to be conveyed by head transport. These tracks were for the most part impracticable in the height of the rainy season, and at the best of times 15 miles was considered a good average day's progress. It became evident several years ago that further development of this colony was impossible without improved communications, and the matter came into special prominence, when the investigations of the British Cotton Growing Association brought to light the fact that Northern Nigeria was the most promising field for the production of cotton to meet the expanding requirements of our most important textile industry, now threatened with shortage of raw material owing to the increasing proportion of American-grown cotton required for American mills. In addition to the necessity for a cheap outlet for the products of the country, efficient administration was most difficult and costly, and there always remained the strategic difficulty of coping with any native rising with the small forces available under the existing adverse conditions of transport and personal travel.

To these primary considerations must now be added the discovery of a rich tin field in the region of Bauchi, some 140 miles east of the railway under construction.

A large amount of official correspondence had taken place on the subject of Nigerian Railway Construction, and a survey had been made from Baro to Kano *viâ* Zungeru before 1907. Various schemes were put forward, and after consideration a 3′ 6″ gauge line was recommended over this route with a maximum gradient of 1 in 50. In May, 1907, Sir Percy Girouard, Governor of Northern Nigeria, formulated a railway policy in which he recommended the construction by the Public Works Department of the Protectorate, of a 3′ 6″ gauge railway from Baro to Kano, avoiding Zungeru, the present capital, the site of which ceases to be of importance as soon as a more efficient channel of communication than the Kaduna River becomes available. As the result of a survey, superintended personally by Sir Percy Girouard, it was found possible to adopt a ruling gradient of ·7 per cent., or 1 in 143, for traffic going up country, and

MAP OF NORTHERN NIGERIA SHOWING BARO-KANO RAILWAY.



·6 per cent., or 1 in 166, for traffic coastwards throughout the first section of 111 miles. Construction was authorized in August, 1907, and 10 miles of permanent way material were at once sent out. Thanks to very careful preparation and to the organization of all the resources locally available, a full programme of work was carried out during the dry season 1907–8, thereby probably saving a year in the time required to complete the railway to Kano. An absolutely free hand has been given to the man on the spot as regards all engineering details including the alignment. Without this such cheap and rapid construction would not be possible. It has also been decided to link up the Lagos Railway with the Baro-Kano line by extending the former through Jebba and Zungeru to Minna.

The Niger in Jebba flows in two channels, one of which is now being bridged, and the other will be traversed by train ferry till the traffic justifies the building of a bridge.

The portion from Minna Junction to Zungeru has already been laid, and railhead of the Lagos extension is about half-way from Jebba to Zungeru. The road bridge over the Kaduna at Zungeru is being strengthened and altered to carry the railway, and it is hoped that the systems will be linked up early next year.

Baro, the Niger terminus of the Baro-Kano Railway, is situated about 420 miles from the coast. At high water from the beginning of August to the middle of October, it is accessible by steamers drawing from 9′ to 12′ and containing up to 1,100 tons of cargo. For the rest of the year boats drawing 4′ have no difficulty in reaching Baro, except for the months of April, May and June, when a draught of 2′ is all that can be reckoned upon. It was found, however, that there were only about 2 miles of shallows to be dredged to make the river available for vessels drawing 4′ throughout the year, and that only some 5 miles of shallows stood in the way of a 6′ channel all the year round. A powerful suction dredger has therefore been obtained, by means of which it is hoped to maintain a channel for vessels drawing at least 4′, and it is a hopeful sign that the very small amount of work which was done by this dredger during the recent especially low river, enabled the larger stern wheelers to work regularly up to Baro for the first time. With an available draught of 4′, all traffic likely to pass over the Baro-Kano Railway for some time to come during the low river season can be easily handled by tugs capable of towing two barges each with a capacity of 100 tons.

Delivery of Material at Baro.

In view of the very rapid rate of progress on which the estimates for the construction of the Baro-Kano Railway were based, the serious question arose as to whether it would be possible to deliver at Baro, during the high river, the large quantity of material required for a whole year's programme. Some difficulty had been experienced, owing to an exceptionally low river, in delivering by three large steamers (commonly known as "branch boats"), supplemented by stern wheelers, the 3,000 tons required for the 1907–8 programme, and the estimated tonnage for 1908 high river was 23,000, and for 1909 nearly 30,000. The possible causes of failure were many, and it was freely predicted that the programme would have to be considerably amended for this reason. The unfortunate early experience of the French on the Senegal River under somewhat similar circumstances showed clearly how serious might be the consequences of any miscarriage. Thanks, however, to the careful co-operation of the shipping firms, and to favourable high river seasons in 1908 and 1909, all these fears have proved to be groundless.

The appliances for dealing with railway material on arrival at Baro were of the most primitive nature. All that could be done in the time was to provide sufficient stacking ground—no easy matter on such sloping ground—and to obtain a number of $12'' \times 12''$ timbers about 50′ long for employment as gangways from the branch boats to the shore. When the first steamers arrived the level of the water was such that a steep pull-up was involved, but later on this disadvantage ceased to exist. An unlimited amount of absolutely unskilled labour was made available, and from 22 to 24 European foremen were detailed at Baro for the work of dealing with the first year's shipping. Of these foremen, 9 were Royal Engineers, and 16 in all were quite new to the country. Under the circumstances it was only possible to employ the most rudimentary methods, and for the first day or two progress was decidedly slow. It was found best to employ about 60 to 75 natives at each hatchway, and at first it was necessary to employ a foreman at each hatchway and one on the stacking ground for each ship, but the latter was dispensed with after the first fortnight. Two shifts were worked, the first being 6 to 8.30 and 9.30 to 3 p.m.; and the second 3 p.m. to 7 p.m. and 8 p.m. to midnight. A number of Kitson lights were provided for night work. They were found to be rather delicate and to require a skilled European mechanic in charge of them, but otherwise answered the purpose most excellently except actually during tornadoes. An acetylene flare light, however, has since been tried, and it appears to offer considerable advantages on account of its strength and simplicity. Work was carried out on Sundays, usually one shift only, but it was found necessary to arrange for every European and gang to have one day a week off the works.

Discharging Rails.—The procedure for discharging rails was to slide them in bundles of from three to ten, depending on the slope up to the bank, across a gangway consisting of two of the long timbers mentioned above spaced at about 15′ interval, each of them having rails spiked along their upper surface and kept thoroughly greased. A hauling rope was fastened near each end of the bundles, and, with a little practice, the gangs on shore got in the way of keeping the bundle central with reference to the two timbers, or of adjusting any tendency to move aside or come up skew-ways. On the arrival of each sling at the bank, carrying parties were awaiting in sufficient strength to take the rails to the stack beds at once, as an accumulation of more than a few rails on the bank resulted in impeding the work. The rail stack beds were most carefully prepared, the type usually employed consisting of four rail lengths of track side by side, the whole of the sleepers being carefully packed quite level. Owing to lack of space it was found necessary to have full layers in both directions throughout the stack, which was raised to a height of 13 layers, or about 4′ 6″. Separate stack beds were provided for "special" rails and for the percentage of shorter rails from 18′ upwards, and it is important to separate out all bent rails and stack them separately for subsequent straightening. A simple form of rail hook, made out of $\frac{3}{8}$″ iron and about 2′ long, was found very convenient for handling the rails on the stack beds. Care must be taken that the ends of the rails are not burred by blows from a hammer.

Discharging Sleepers.—Sleepers were carried ashore on gangways and can be stacked on almost any ground. Where space admits it is quicker and more economical to throw them into piles. Time is also saved when re-loading, as sometimes two or three sleepers in a proper stack, jamb together and have to be separated by a bar.

Handling Heavy Cases.—Owing to the lack of facilities, the discharging of cases weighing from 2 to 30 cwt. was a source of much trouble, two or three handlings being sometimes necessary and the cases having occasionally to be broken up on the beach. The best way of dealing with these would be by a quick-acting steam crane direct into trucks. It is well worth building for the purpose, a small jetty capable of receiving a lighter alongside, and to arrange for all such cases to be delivered from the steamers into lighters.

Handling Heavy Locomotives.—The most difficult problem was the discharging of the boilers, frames and tenders of the locomotives. These weighed up to 12½ tons, and the first consignment had to be got ashore from an insecurely moored steamer, over a clear span of 42′, then up an incline of 1 in 2 for 30′, along 40′ of level, and finally lifted on to trucks. The only power available was one of the ship's winches, and less than a foot was available on board to receive the ends of the gangway timbers. The shore was reached by a gangway of four heavy timbers with rails spiked on top, the outer timbers having to be spaced only 9′ apart to fit the gangway of the ship. A cradle with smooth metal under surfaces was constructed to slide on this gangway and provided with flanges at 9′ gauge. The heavy weights were carefully balanced on the centre of the cradle, to which they were lashed with wire rope. Large sheerlegs were erected on shore, 12″ × 12″ timbers over 50′ long being employed, and steel rope lashings and tackle throughout. The sliding track was continued from the gangway up to the sheerlegs, under which a siding was laid. The cradle was pulled from the ship's side to the siding by the main tackle of the sheerlegs, the angle of attachment of the sling which was passed round the cradle, and its weight, being arranged with very great care. As the blocks available for the first weights were much weaker than the rest of the tackle, every precaution had to be taken to avoid hitches which might bring indeterminate strains to bear, and a vital point to bear in mind is the disturbing effect on the ship's moorings, caused by the use of the ship's winch for the main tackle of the sheerlegs. The use of steel rope lashings and tackle for sheerlegs required to lift regularly from 10 to 20 tons, is strongly recommended. The second consignment of heavy weights was dealt with in a similar manner without any difficulty as stronger tackle was available, and owing to the higher river the clear span and steepness of the slope were much reduced. In 1909 the heavy weights were loaded direct into trucks from the steamers at a jetty erected for the purpose.

Wagon frames, which weighed about 2 tons, were transferred from the ships to the tops of lighters and slid off on to carefully prepared stacking beds, from which they were later on slid under a derrick for erection.

General.—In dealing with large quantities of material, as above, the secret of success is to look well ahead in the preparation of sufficient stacking beds, to insist on the economical use of the ground, and to be on the *qui vive* to repress the inevitable tendency of the carriers to get rid of their loads at the earliest possible moment, and, by thus effectually blocking the entrance to the stacking ground, to very seriously retard the operations which may have to be temporarily suspended to put matters right.

Arrangements were made to deal with three branch boats at a time. After the first few days it was found possible to deal with 500 tons a day with ease, and on August 31st a maximum of 870 tons was attained. The quickest boat averaged 355 tons a day for two shifts, or 25 tons per hour of actual work. The total number of natives employed at this time was about 1,200. A dressing tent on the site of the work saved a lot of time in dealing with minor injuries. Almost incredible to relate, in 1908 over 20,000 tons of material were handled with absolutely raw labour, with only one serious accident which necessitated the amputation of a foot.

As regards the cost of handling, it was found impossible to analyze each class of work at the time, but, with foremen costing £1 a day and native labour at 9d., there should be no difficulty in handling rails and sleepers at 1s. 2d. a ton, including the preparation of stack beds, stacking, and the clearing-up operations frequently necessary after the periods of greatest stress.

Discharging Locomotives from Lighters.—After the high river, some locomotives were sent up to Baro in lighters, and proved an awkward task to discharge as the banks were very high at this time, and the barges had to be lightly loaded to reduce the draught. The procedure was to jack the weights high enough above the level of the barge to allow a gangway to be inserted underneath them together with the cradle referred to above. The weights were then pulled up a very steep incline in the same way as before, with the exception that an insufficiently powerful winch had to be employed for the main tackle. As this winch had no capstan drum, three separate lifts had to be taken before the weights were deposited on the trucks. For this purpose, and to guard against accidents, safety ropes were invariably provided and kept tight, a most useful precaution in view of the fact that the cylinder cover of the winch blew off on one occasion. The most serious difficulty in off-loading from lighters is due to their instability, as any deviation of the weight from the centre made them heel over badly. It is well worth while rigidly lashing a second barge alongside.

At a certain level of the river it was found possible to use an existing slipway, and to arrange to traverse the heavy weights by jack direct from the barge to the truck over intervening staging.

Plate-Laying and Ballasting.

The Baro-Kano Railway is being constructed as a pioneer railway, that is to say, the expenses of construction are cut down to a minimum, consistent with obtaining a railway capable of carrying all traffic in connection with the administration of the country, and such trade as is likely to develop during the first years of its existence. This economy has not been allowed to affect the most efficient grading and alignment, so that it will be possible as the amount of traffic justifies it, to gradually strengthen the line and improve the accommodation to meet the requirements. One very considerable source of economy is in the ballasting, which is carried out with sand or any other suitable material available in the immediate vicinity of the line. It is only over a few comparatively short lengths, where the surrounding soil is entirely clay or black cotton ground, that ballast has to be brought by train. This saving in the actual cost of haulage is supplemented by the important reduction in the amount of rolling stock necessary for construction, a point of the highest importance. The extra cost of obtaining better ballast at the expense of a longer lead up to half a mile or even a mile, is well worth incurring, but it may be found in rapid railway construction that shortage of labour may prevent full weight being given to this consideration. Ballasting was placed under the officer in charge of the Plate-Laying District, and was carried out only a few miles in front of railhead.

Procedure.—The procedure of ballasting and plate-laying is as follows:—

The formation is trimmed up by the earthwork parties and the line is re-centred with pickets left standing about 3″ above the surface. At the same time level pegs are given every two hundred feet on the straight, and every one hundred feet or even fifty feet on curves. These pegs are best driven on the edge of the formation flush with the correct formation level, and marked by reference pegs painted white, two such reference pegs being used at each change of grade. This re-centring and levelling is of the greatest importance, as the quality, rapidity and cost of the work, depend on the track being laid absolutely straight and as nearly as possible to correct levels in the first place. Next come the ballasting parties who make a platform of the best material available 8′ wide on the top, with the surface on straight portions of the line 7″ above correct formation level. In this way an accurately graded surface is prepared for track-laying, notwithstanding slight irregularities in the formation. In the centre of this platform there is left a **V**-shaped groove or furrow (to which fact this ballast platform owes its local name of "the furrow") for the purpose of leaving the centre pegs exposed to view, and at the same time guarding against any chance of the centre of the sleeper being packed higher than the ends. Accuracy of the grading and alignment of the furrow is obtained by putting in side pegs every 25′ to mark the outer edges of the furrow, these pegs being levelled to the exact height by boning from the formation pegs. One European with from six to ten locally trained natives has no difficulty in doing from 1½ to 2 miles of this boning in a day. On curves the furrow is correctly super-elevated, the point under the inner rail remaining at the height of 7″. In this way the road is safe for construction traffic immediately after track-laying, a large amount of lifting is saved, and the extra quantity of ballast required is provided for. The section of the furrow is calculated to provide the requisite ballast for a correct lift to formation level, additional ballast being required for very low places or boxing in.

Track-laying is carried out directly from the construction train, which is pushed by the largest engine which it is safe to allow over the line. The material is loaded up in units of two trucks containing one-fifth of a mile of material complete. The bottom layer of rails in the rail truck rests on three or four transverse sleepers, and each layer above on thin strips of packing which is broken up as the truck is off-loaded. It is important that no bent rails or short "specials" are loaded up with the ordinary rails, as these delay the track-laying and are expensive and troublesome to pick up. The sleepers are carried from 100 to 200 yards ahead of the train and thrown down across the furrow. Here they are roughly spaced at an even distance of 2′ 6″ centres, by a few natives provided with gauges. This ensures the correct number being left per rail length. The centre of each sleeper is at once marked ready for the sleeper straightening and spacing party, consisting of about six natives provided with a special 90′ chain, the links of which are exactly the length between the centres of the sleepers. This chain is stretched along the centre pegs and held by a boy at each peg, and the sleepers are accurately spaced, centred and squared to the chain by a trained head boy. It may here be mentioned that the weight of rail is 45 lbs. per yard, and that 12 steel sleepers (weight 72 lbs.) are used for each rail length and spaced 2′ 6½″, except at the joints which are 2′ 0½″.

The natives of Northern Nigeria carry all loads on their heads, and find considerable difficulty in picking up heavy weights from the ground. The work of rail carrying was, therefore, enormously expedited by the expedient of inserting short lengths of rails as cantilevers under the bottom layer of rails on the truck, and sliding the rails on to these cantilevers so that the carriers could take them directly on their heads. This expedient also avoids the tendency of rails being left behind when the construction train moves forward. The rail-carrying gangs vary from 8 to 10 men. For continuous work, especially when laying through deep cuttings or over high banks, it does not pay to cut down the gangs to less than 10. The number of linking-in rail gangs depends on the rate desired. If over ½ mile a day, a special gang lifts the rails and places them on the sleepers as near as possible in position, so that the gangs inserting the rails have less to do. The latter operation is carried out with the assistance of about six thin-pointed crowbars for each gang. The rails are next butted against the expansion irons (these are ⅛″ thick, hot weather midday; ¼″ hot weather morning, cool weather midday; ⅜″ cool weather, morning) and fished with two bolts. After three or four rail lengths the track is straightened to centre pegs, the sleeper spacing checked, and the train signalled forward. The remaining two fish bolts and all the keys are put in later on, sometimes two or three weeks behind railhead, though it would be better to follow close behind. Within 5 miles of railhead should follow the first lift party, and these leave the track accurately packed straightened and graded at the final height of 12″ above formation level. It will be seen that accurate pegging out, ballasting and track-laying will greatly facilitate the work of this party, who should have no difficulty in averaging ½ mile a day, including boxing in, for each party consisting of 1 European and 150 natives. The track is then fit to run over at 30 miles an hour, except over special places such as deviations. A few small maintenance gangs should work on the section immediately behind the construction train to deal with slacks on the newly-made banks, put in points and crossings, and attend to bridge approaches and deviations. During the dry weather it is possible for several weeks to run over the track just as it is left by the construction train, and it is wonderful how the line holds up under these conditions with good sand ballast.

On curves, special rails 29′ 8″ long were used at first to keep the joints square. Owing to a shortage in these, joints on curves were staggered by starting with an 18′ rail on the outer side just before entering on the curve, and finishing with a closer, just after the end of the curve, to bring the joints square again. No time is lost cutting the closer which is fly fished for the time being. Except for the disadvantage of the irregular spacing of sleepers, there is no doubt that the staggered joints resulted in a better running track.

The usual working hours at railhead were from 6 a.m. to 3 p.m. with an interval for breakfast at an hour depending on the progress of the work, but if possible before 10 a.m. In the hot weather in the Bako Valley these hours were slightly curtailed, and work started at 5.30 in the morning. The Europeans of the construction party were accommodated in type camps from 5 to 10 miles apart, the houses being mud or grass, supplemented by tents. It is difficult to get work done on the day of changing camp, and it very often pays to reconcile oneself to losing a day, or to make it fit in with pay-day. It is most important that camps should be kept thoroughly clean, and an expenditure equivalent to £1 10s. per mile was freely incurred with this object.

The *labour question* has hitherto been a most serious one. Some 15,000 natives were employed on the Baro-Kano Railway from January to March, 1910, and in a new country it is not easy to procure this number. Moreover, during the past season work has been carried on through large uncultivated areas, and the question of food supply has added to our difficulties. Markets were established at Railhead Camp, free passes were issued to traders bringing supplies to railhead, and rice was imported and issued at cost price. Weekly payments were found necessary to give confidence to the natives, and the arrangement of this, including the supply of specie from Baro, gave endless trouble.

General.—A covered tool truck is kept at Railhead Camp, and saves a lot of trouble and loss in view of the frequent moves as railhead progresses. A native blacksmith and a few native carpenters are required at railhead. The latter, besides attending to miscellaneous jobs, make from local timber all the pick and hammer handles used at railhead, and also all the wooden beaters used with sand ballast in preference to the ordinary form of steel beater.

When out of touch with the European doctor, a European medical orderly is attached to railhead, and in any case a native dresser to attend to minor injuries and ailments among the labourers which would otherwise throw a lot of extra work on the engineer in charge. A canteen truck is arranged for at railhead, through one of the Baro firms, and is found a very great convenience.

It is most important that railhead should be in good telegraphic or telephonic communication with stations behind and headquarters. With this end in view, the advanced telegraph station was kept pushed forward to the railway station nearest Railhead Camp. A telegraph line was laid by a construction party attached to railhead and had no difficulty in laying 2 miles a day. Great trouble was experienced through breakdowns caused by lightning and by bush fires.

Rate of Progress.

Plate-laying was started on the 22nd October, 1908, railhead at this time being at miles 6¼, the remainder of the 10 miles sent out in 1907 being required for Baro Yard. For the first few days, from 100 to 150 raw natives only were employed, and the whole attention of the Europeans was devoted to instructing the gang in the rudiments of the work. For example, it took three or four weeks before the head man of the sleeper spacing gang could be relied on to leave the sleepers square with the sleeper chain. On December 30th, with 296 labourers, 1 mile was laid for the first time, and it was only because track-laying caught up the earthwork and culvert parties that the maximum of 1¼ miles was not exceeded during the first season. On resuming track-laying in November, 1909, 1 mile a day was done during one of the first weeks. In March, 1910, the main track-laying party laid 22 miles of main line over 15 bad deviations, and 2 miles of sidings with 11 sets of points and crossings. But for various delays not connected with the railhead party, and which checked the work on 11 days, another 7 miles might have been laid. In one week of this month 6·4 miles were laid and camp shifted, the best day being 1⅔ miles over two of the worst deviations on the line. To carry out this work a good deal of night running had to be undertaken on the advance section with the largest engines available. During the early part of this same month a second plate-laying party laid 9 miles on the Zungeru branch line, and afterwards cut out several deviations, bringing the grand total for the month up to 37 miles. On February 25th, with 450 natives, Lieut. Maxwell laid 2⅔ miles by 4.15 p.m., when all the available material was finished, and on the same day just over 1 mile was laid by the party on the Zungeru branch. A table is given showing the monthly rates of progress for the two first plate-laying seasons.

During the second season the grand total of track laid, including sidings and temporary work, was 165 miles, an average of 24·65 miles per month having been maintained for 6½ months. Taking Lieut.

Maxwell's plate-laying party alone, the total laid in 6½ months was 130·4 miles, which works out at 20·1 miles per month. The progress of this party on the main line only, was 123·4 miles, which gives an average of 19 miles per month. The last 17 miles into Zungeru was laid between the 3rd and 19th of May in 17 days; notwithstanding 4 days' complete or almost complete stoppage of work, the average amount laid on the 9 days on which no delays were experienced was 1·44 miles per day.

Causes of Delay.

I will now deal with the principal causes which resulted in delay to the railhead party :—

1. *Lack of Labour.*—As there was a general shortage of labour, the amount available had to be proportioned so as to ensure an equal rate of progress by the earthwork, culvert, plate-laying and bridging parties. A large proportion of the labour was recruited in gangs by arrangement with the native chiefs who changed them at intervals, the result being that the Europeans had to start again the work of instruction. The actual linking-in gangs however were permanently engaged.

2. *Minor culverts* were put in ahead of the track, and it was found advantageous not to put in the deviations too far ahead of the track. During the last season the plate-layers kept on the heels of the preceding parties and experienced several checks. On one occasion, at a deviation, the earthwork ballasting and plate-laying parties were all working within a distance of 200 yards.

3. *Deviations.*—Up to 15 of these were crossed each month. Owing to the impossibility of starting the construction engine on the up grade, each deviation necessitated a long carry for the rails and sleepers. Moreover, newly-made deviations with high banks are a source of great anxiety, and it is frequently necessary to interpolate wood sleepers between the steel ones over the softest places. During the wet season these deviations must be taken slowly, and the only way to do this is by considerably reducing the loads of the trains. On one occasion at a bad sag under the weight of the train, the buffers of eight wagons and one break van became interlocked, but the driver had the presence of mind not to stop the train, and averted a derailment. A more serious matter was the sudden collapse in the middle of the dry season of a newly-made deviation bank, resulting in one of our largest engines turning right over. Luckily nobody was hurt. The breakdown operations occupied less than a fortnight, and the engine was running regularly within five days of being re-railed. The driver, 2nd Corpl. Marriner, R.E., behaved very pluckily.

4. This brings me to the increasing difficulty of track-laying as the wet season approaches. Gradually the heavier engines have to be

taken off the newly-laid track and the maintenance officer, who desires to postpone this cause of delay as long as possible, has an anxious time of it, especially if through shortage of labour the first lift party are several miles behind railhead, in which case also the cost of maintenance is higher. Eventually a few serious settlements of soft banks give a warning which cannot be disregarded, and railhead has to be kept supplied as best possible by the smaller locomotives, which have also to be employed on ballasting the worst places.

5. *Lack of Material at Railhead.*—Once the plate-laying party has been thoroughly organized and a clear run is open to them, the limiting factor in the rate of progress is found to be the supply of material to railhead. On account of the limitations caused by other sources of delay, this particular difficulty has not hitherto come into the prominence which it is expected to reach next season, where the lead starts at 215 miles. This result has been largely due to the splendid work put in by the engine drivers, both civilians and R.E., whom we have been fortunate enough to secure. In the event of material not being forthcoming on any particular day, the delay was frequently averted by taking the weekly day of rest on that day.

6. For the first 20 miles of track-laying the permanent bridge trestles were built in advance, and railhead was held up at each bridge while the stringers were placed in position. This practice was not found conducive to rapid or economical plate-laying, as with cheap labour the cost of deviations is comparatively small and will be saved in the cheaper track-laying and transport of bridge material.

7. In the earlier days, portions of incorrectly levelled formation, due to the rawness of the earthwork parties, caused considerable trouble to the ballasting parties, themselves consisting of untrained gangs, and the plate-laying parties were handicapped by an uneven platform to lay on.

8. Hitches in connection with timekeeping, shifting camp and pay, will occur unless the officer in charge keeps a careful watch on these matters.

9. A new gang at the base may result in several trucks of material being sent out badly loaded to rail head.

10. Temporary water supply for locomotives has to be arranged for, and very often it is found impossible to erect tanks as early as desired. In any case the railhead engine will require a tank truck. In the tropics it is best to use steel piping even for temporary work, though sufficient hose and couplings should be kept at railhead for emergencies. It is important to arrange for interchangeable couplings between the hose and the steel piping.

11. In the wet season work is occasionally entirely interrupted by washaways at deviations, or at unfinished culverts in places where it has been found expedient to fill in the bank temporarily. In this

case all available gangs are concentrated on re-establishing communications.

12. The wet weather again is responsible for bad steaming of locomotives with damp wood fuel, wood being used as much as possible to save the transport of coal.

13. An occasional derailment adds to the variety of the work, which even under the best circumstances can hardly be rated as monotonous.

All these delays were generally counteracted by working overtime.

LABOUR FOR PLATE-LAYING.

The following is a statement of the amount of labour found necessary at railhead and for the first lift, to work at the rate of 25 miles a month.

Ballasting party	350 to 400
Linking in	250 to 350
Keying	45
Points and crossing and maintenance at railhead	70
First lift	300 (in 2 parties).
Woodcutting	35
	1,200

Cost.—The cost of the work at railhead depends on the delays experienced, on an average they work out as follows:—

Boning	£3 to £4 per mile.	
Furrow	£12 " £18 "	
Linking in and keying ...	£22 " £30 "	(generally nearer the lower figure).
Miscellaneous	£8 " £25	(the latter figure includes maintenance for 30 miles behind railhead).
First lift	£16 " £20	

These figures include the salaries of the Europeans with their passages and proportion of pay and leave, pay of boys and all other expenses at railhead, except the cost of rail transport, which is debited to another subhead.

The item "Miscellaneous" includes pay and allowance of officer in charge and clerical staff, pay of mechanics, pay of Europeans while on the sick list, temporary water supply, points and crossings, maintenance in front of first lift, and incidental work done on days when railhead is checked.

1910 TO 1911 PROGRAMME.

In the approaching plate-laying programme the limiting factor will undoubtedly be rail transport. As the quantity of rolling stock required during construction is far in excess of what is necessary for the first year of open line working, the amount purchased for construction should be the minimum which will suffice with careful organization, to carry out the allotted programme.

In view of the fact that work at railhead does not continue throughout the whole year, the off-season is utilized for bringing up rails and sleepers from the base to one or more advanced depôts, thereby reducing the lead and increasing the rate of delivery at rail-head when the plate-laying starts. The cost of the extra handling of the material is quite insignificant compared with the saving effected in the amount of rolling stock necessary.

Owing to a very late river, we shall also be faced with the difficulty of transporting from Lokoja to Baro some 3,000 tons of material which was discharged at Lokoja before the river had risen high enough to allow branch boats to proceed to Baro. Being also the last year of the work, the greatest care will have to be taken to pick up all material lying along the line or in temporary work, and also to straighten a large number of rails bent in transit (this item alone will amount from 10 to 20 miles) in order to make quite sure that the material will be available for the last few miles into Kano.

The last section is a particularly easy one as regards bridging and culverts, and labour and food are very plentiful, so that no difficulty is anticipated in getting the formation ready ahead of the plate-laying party, and the plate-laying and maintenance parties if provided with the labour asked for (1,200 boys gradually increasing to 2,000) should easily cope with all the material that the traffic department can supply. Arrangements are being made to complete 25 miles of culverts and of furrow before the commencement of the next plate-laying season.

There remains the difficulty of water supply, and attention is already being devoted to forestalling this. The ruling gradient which is 1 in 60 compensated in both directions from Minna to Zaria is reduced to 1 in 80 from Zaria to Kano.

On account of lack of space I propose to touch only lightly on the earthworks and bridging of the line.

EARTHWORKS

cost from £200 to £340 per mile, though, in a few places where there was very heavy work, the cost reached £800 per mile. The rate of progress has been from 15 to 26 miles per month. The cost of the work from $3\frac{1}{2}$d. to $4\frac{1}{2}$d. per cubic yard.

Rock cuttings have been carefully avoided, but heavy work has been faced to obtain a better ruling grade with a view to the best ultimate efficiency of the line.

Bridging.

Bridging on the first two sections, namely up to the Kaduna, has had to be very heavy for a pioneer line. The waterways amount to 50 lineal feet per mile on the Baro-Minna Section. The largest bridge will be about 500′ long over the Kaduna. The largest span employed is the South African type of 100′. In the first section practically all the foundations are in sand and consist of wells sunk up to a depth of 20′. The expedient of using concrete well curbs reinforced with a few train rails was found to be most successful. With one exception, where a powerful steam pump was used, the foundations were kept clear of water by diaphram pumps. It is vital to get all the foundations in before the first heavy rains, and towards the end of the dry season the work on the piers and superstructure is practically neglected till all these are secured.

Steel trestle piers are used for spans up to 30′ and can be very quickly erected. The commonest spans are 15′, 20′ and 30′. The bulk of the culverts are thick corrugated iron, 2′, 3′, 4′, 5′ and 6′ diameter, the weight being relieved by dry stone walls with a concrete arch or a platform of rails and stones, in the case of all culverts over 3′ diameter. A number of thick steel culverts 6′ diameter have also been employed.

Locomotives and Railway Stock.

The rolling stock available on the Baro-Kano Railway during the second plate-laying season was as follows :—

5 engines known as the "Emir" class (eight-coupled with leading bogie, and weighing with tender 74 tons loaded).
2 eight-coupled tender engines with leading poney, weighing about 62 tons.
2 six-coupled tender engines with leading poney.
2 six-coupled tender engines with leading and trailing poneys.
3 shunting engines, six-coupled weighing 22 tons.
2 small six-coupled shunting engines weighing 15 tons.
—
16 engines in all.

And 190 bogie trucks with bodies 31′ long and sides 18″ high.

Flat-topped trucks without any sides have been found to be quite good enough for rail carrying.

The erection of the wagons is a very simple matter with the aid of a steam crane or even a derrick with hand tackle. There should be no difficulty in erecting from 5 to 10 wagons a day, once the gang have got into working order, if all the parts are available.

For the erection of a locomotive, a fixed four-legged gantry made of $12' \times 12'$ timbers was erected over a siding and fitted with a 15-ton differential tackle.

Nearly all the engines were erected single handed by Corpl. Gatford, R.E. with very inefficient natives to help him.

The second Emir engine erected by him in 1908, was started on November 26th, the frame wheeled on November 28th, boiler mounted on December 4th, tender mounted on December 7th, and the engine completed for trial run by December 16th, or a period of three weeks. An enormous amount of delay and trouble, and possibly the loss from traffic of one or more locomotives for several weeks, was obviated by the simple expedient of marking all the cases and packages belonging to each locomotive with a distinctive broad band of colour, thus enabling the complete locomotives to be sorted out without any delay from the hundreds of similar cases discharged during the shipping season. Certain cases of locomotive parts had to be opened on the beach in 1908 on account of their weight, and the parts carried up separately. A European and a gang of natives were told off to take special charge of such cases and to see them repacked in the store. It is important that the spare parts for locomotives should be placed in a separate store, preferably in charge of the Locomotive Superintendent. The cases containing the locomotives were arranged by engines on rail beds close to the erecting gantry. The boilers, frames and tender bodies were allowed to remain under load on trucks till erected.

To facilitate running repairs a wheel pit should be constructed without delay, and should be of sufficient width to enable a pair of wheels to be drawn out sideways from under the locomotive and lifted clear without the necessity of moving the engine.

A great deal of trouble was experienced from hot boxes in the case of the wagons, due firstly to a slight defect in their design and also to the necessity for putting them into regular work before the brasses had time to bed down properly. The difficulty was at length got over by temporarily reducing the loads and by increasing the wagon inspection staff.

The engine driver always has a hard time of it on construction, and this more particularly applies to the tropics where continual overtime cannot be worked with impunity. In the early days also there were no firemen, and the driver had to do a great deal of the firing himself until he had trained a raw native. The drivers of all engines are Europeans, except in the case of shunting engines, which are driven by Coast natives.

During construction we have had to content ourselves with the most elementary running statistics. To obtain these and also to train the drivers in readiness for open line working, the same form of Enginemen's Train Bill as is in use on the Lagos Government Railway has been employed from the commencement.

An expert boilersmith used to locomotive running work has been engaged. I am glad to say that he has not yet reported any ill effects from the use of wood fuel.

Traffic.

The organization of a traffic staff has presented the greatest difficulties owing to the impossibility of obtaining trained natives from other West Coast railways. The first station masters had to be specially trained and the simplest possible working adopted. In February, 1909, an assistant traffic manager was sent out to take charge of the details of organization, and has worked wonders.

On the first section, the grades being very flat, one train a day in each direction met all requirements, and the traffic was worked on the system of a definite time table which could only be modified by the Assistant Traffic Manager at Baro. At the end of the season, Tyers' Electric Tablet instruments were installed up to Minna and have been in use ever since. A great many interruptions were caused by bush fires, but it is hoped this will be avoided in future by maintaining a fire belt.

In the season 1909–10 the section north of Minna had to bear from two to four trains daily in each direction, and pending the installation of electrical staff instruments, the train staff and ticket system was introduced and required a great deal of careful arrangement to ensure the staff always being at the right end. To avoid serious delays the traffic officer in charge of this section was authorized to arrange irregular working, on his authority alone. Construction regulations of which a copy is here for inspection were drawn up in 1908, and include rules for train working and for the guidance of the whole construction staff.

In order to lose no time in accustoming the natives to the advantages of the railway, a simple system was introduced whereby natives can travel at very cheap rates on the top of the construction material, and take with them their country produce to the neighbouring markets. A form of ticket was designed to meet our requirements and is still in use. Few railways can record that they started carrying public traffic before the railhead reached the first station 14 miles from the base. So early as the month of February, 1909, nearly 4,000 passengers travelled on the line.

By December, 1909, the station staff up to Minna was sufficiently trained to justify the adoption of a system of station accounts approximating that on open lines.

It was desired to allocate the cost of rail transport to the various subheads on construction, but it is questionable whether for a pioneer line the value of the information is worth the amount of trouble involved in obtaining it.

On the whole we have been fortunate in being singularly free from accidents of which there have been few fatal ones. This is the more astonishing in view of the fact that the native who passes his village while on the train often thinks it is the correct procedure to jump off. I have seen this happen several times and only once was the native sufficiently stunned to be caught.

An ice and mineral water plant at Baro, adds to the comfort and health of those of the staff who have to live at or near that mosquito-ridden place.

Royal Engineers Detachment.

The first detachment of ten N.C.O.'s under Capt. Mance, arrived at Baro early in August, 1908, in time for the shipping. The second detachment under Lieuts. Hammond and Maxwell arrived early in November in time for the plate-laying. The third detachment, completing the 30 men, arrived in January, 1909. All the men of the detachment were granted the local rank of sergeant.

After the first few months, when some of the men not constitutionally suited for the country were invalided home, the health of the detachment was on the whole well above the average, though I am sorry to say we lost one man, Sapper Guy, from blackwater fever, complicated by heart trouble. The climate of Northern Nigeria is far healthier than that of any of the other West Coast colonies, and the right type of man should have every prospect of keeping fit if he observes certain simple precautions, namely taking his quinine regularly; never sleeping except under a mosquito net, which should be kept in perfect order; wearing mosquito boots instead of shoes in the morning and evening; always wearing a helmet between 8 a.m. and 5 p.m.; wearing a spine pad especially during the hot weather, and not disdaining the use of an umbrella; keeping an extra blanket at the foot of his bed under the mosquito net to draw up the cool of the morning, living temperately and in no case touching intoxicants before sundown, and taking as much exercise as possible. In order to ensure a cheap supply of good provisions some 250 "chop boxes" were taken out from England, and issued to the detachment at cost price as required during their first tour. On subsequent tours the men had the experience and the means to take out provisions for themselves.

The work has been an excellent experience for both officers and men and most valuable training for railway work in war. As regards plate-layers, experience has shown that we can give them sufficient training in the Corps. Young sappers, who had been in training at Longmoor for only one year, were sent out in charge of the construction train, or placed in charge of a maintenance section within six months in Nigeria. To obtain suitable engine drivers, there is no doubt that we should enlist firemen with a few years' experience, as the Corps training and practice is not enough in view of the responsible duties of engine drivers. Nearly all the R.E. drivers in the detachment have had previous civil experience as firemen, and their subsequent R.E. mechanical and general training has given them an all-round knowledge which has led to their doing conspicuously good work in positions of considerable responsibility.

The following are a few figures showing the progress of the work :—

PLATE-LAYING PROGRESS—BARO-KANO RAILWAY.

1907–8	$6\frac{1}{2}$ miles main line only.		
1908–9 :—			
October 22nd–31st	$2\frac{1}{2}$	„	„
November	$5\frac{3}{4}$	„	„
December	9	„	„
January	$17\frac{1}{2}$	„	„
February	17	„	„
March	14	„	„
April	$11\frac{3}{4}$	„	„
May and June	15	„	„
	99	„	„

1909–10 :—

Month.	B.K.R. Main Line Mileage.	Additional Track Laid.	Link Main Line.	Link Sidings.	Cutting Out Deviations.
October ...	4	—	—	—	—
November ...	$15\frac{3}{5}$	$\frac{3}{5}$	$\frac{2}{5}$		—
December ...	$16\frac{2}{5}$	$1\frac{3}{5}$	—		—
January ...	$17\frac{4}{5}$	$\frac{4}{5}$	—		—
February ...	$16\frac{2}{5}$	$1\frac{3}{5}$	8		—
March ...	22	$1\frac{3}{5}$	9	1	$4\frac{2}{5}$
April ...	$18\frac{3}{5}$	$\frac{2}{5}$	$3\frac{2}{5}$		$1\frac{1}{5}$
May ...	2	—	$16\frac{3}{5}$		?
June ...	—	—	$\frac{3}{5}$	$\frac{1}{5}$	?
		$6\frac{3}{5}$			
		$\frac{4}{5}$*			
	$112\frac{4}{5}$	$7\frac{2}{5}$		$1\frac{1}{5}$	$5\frac{3}{5}$

Total main line B.K.R. $211\frac{4}{5}$. Zungeru Link 38 miles. Total 250 miles.

* Third leg of triangle and extra sidings at Minna.

THE "PERFECT" LOOPHOLE.

By CAPT. P. S. GREIG, R.E.

IN an article on loopholes (in the January number of *The R.E. Journal*, 1907) by Capt. Mance, D.S.O., R.E., appeared the following paragraph and sketch :—

"The theoretically perfect loophole, which, however, for various practical reasons is hardly within the range of practical utility even to the keenest Sapper, would be a combination of a pivoted steel plate *a* and a fixed plate *b*.

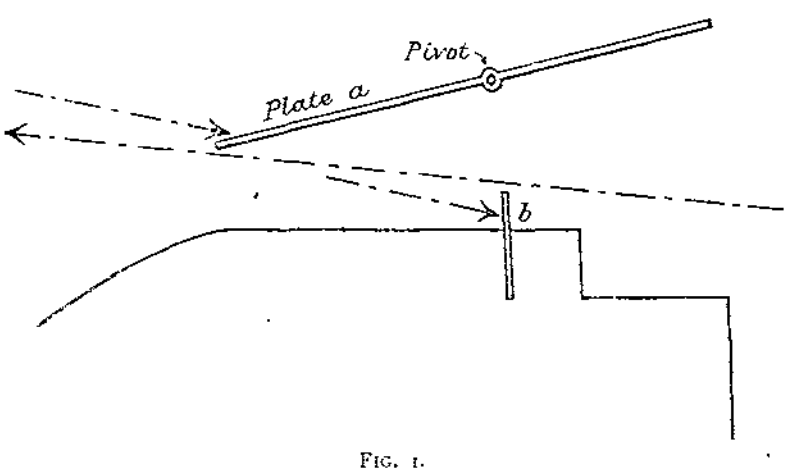


FIG. 1.

"The plate *a* must be canted just enough for the bullet to leave at the required angle of elevation for the enemy's firing line. The angle of descent at any range being greater than the elevation, the defenders would be immune !"

Such a challenge could hardly be allowed to go by unheeded, and without claiming to be on the topmost pinnacle mentioned by the author, the casuals of the 54th Company, R.E., in their recent field-works course endeavoured to test the practical difficulties of the problem. The "Heads I win, tails you lose" loophole is of too alluring a nature to be abandoned to the barren regions of theory without an effort. The accompanying photographs A and B show

Photo A.

front and rear views of such an effort, the loophole being constructed out of iron plates picked at random from store, a short length of water piping (to serve as pivot), two short pieces of timber, some wire (to adjust elevation of plate) and a nail (to be seen on right of helmet in *Photo* B).

The loophole is not very conspicuous from the front; in fact, considering that the photograph (A) was taken at a distance of only 6 yards it will not be found easy to detect the man in the trench behind, and the muzzle of a rifle looking direct at the observer. Further, seeing that the defenders are presumably immune the conspicuity of the head cover is not a matter of much moment!

The practical difficulty seems really confined to the finding of the iron plates which of course do not grow on the veldt or on the open battlefield. They should however be available for any work of a semi-permanent nature. For the rest, some pieces of water piping iron standards, or short lengths of wood to form the pivot, and a little wire are all the stores required.

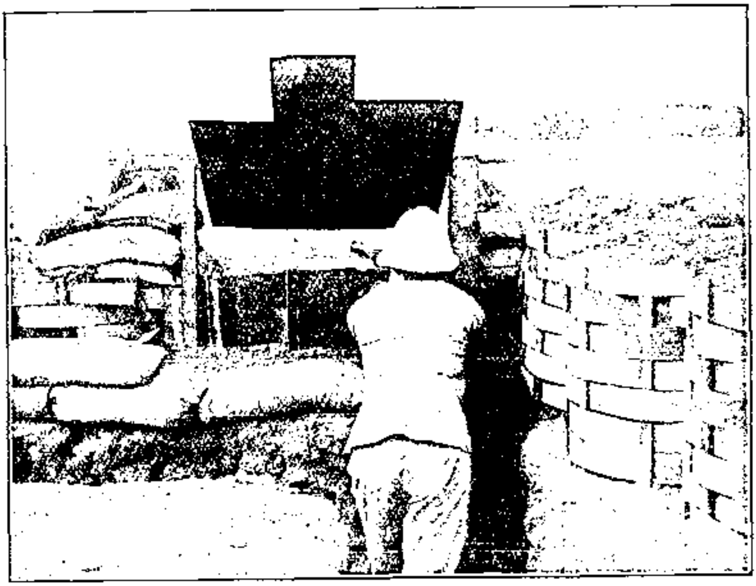


Photo B.

Capt. Mance mentions that at the Siege of Mafeking the defenders employed a very serviceable type of loophole—an iron plate about $3' \times 1' \, 3'' \times \frac{1}{2}''$ thick bent at right angles with a small rectangular hole at the angle (*Fig. 2*).

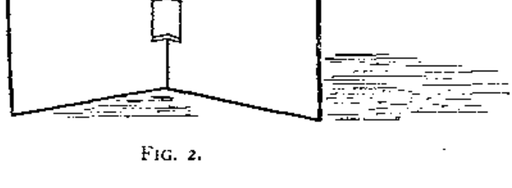


Fig. 2.

One of these plates was struck by 26 bullets ! With this type of loophole, however, the defender, if of a mathematical turn of mind, will be wondering all the time what the chances are of a bullet finding its way through the rectangular hole and thence to its billet. The nervous wear and tear of the survivor of the

26 hits must have been prodigious. No such problem harasses our defender of the "perfect" loophole. The pattering of bullets on the plate will be as music to his soul for he is buoyed by the certain knowledge that in the long run it is a case of "Heads I win, tails you lose," and as he draws his bead for the last time upon the foe he softly murmurs "He laughs best who laughs *last*."

Arruda
Bucellas
Alverca
Quintella
Via Longa
Povoa
S. An. de Tojal

MAP

A REPORT ON TORRES VEDRAS.

THE original manuscripts of the following interesting documents have been kindly presented to the R.E. Institute, for the R.E. Museum, by Sir Lawrence T. Jones, Bart.

The manuscripts are rough drafts of a letter and report sent by Sir J. T. Jones (grandfather of the donor) to Sir Richard Fletcher, C.R.E. in the Peninsula. They refer to the Alhandra position of the lines of Torres Vedras, and were written some two months before the British Army retreated behind the lines. Unfortunately no copy seems to have been made of the hand-sketch which accompanied the report and which is referred to in the letter.

LISBON, *29th August*, 1810.

SIR,

In consequence of your wishes, I have now the honour to enter into some detail respecting the position at Alhandra and of the means to prevent its being turned. I enclose a paper of memoranda which I drew up yesterday when on the spot, it must be read as relating to the state of the work on Saturday next and will I hope prove a satisfactory account of that strong position.

The ground on the opposite side of the valley on the left is a range of strong hills of a much superior elevation to any other ground near them and connected by a regular descent with the Hills in rear of the position—at a point about a mile retired from the front of the Alhandra Position, this ridge terminates to its left with a bluff point which overlooks all the Country to the Ajuda Works at the distance of perhaps in a straight line between them of less than three miles—at this spot it appears to me that a post might be formed for fifteen hundred men extending completely across the ridge one flank of which shall appui on the bluff point and consequently overlook the Country in that direction, the other flank appuiing on the valley which forms the left of the Alhandra position and its fire co-operating with the Alhandra Redoubt preventing the passage of an enemy through the valley. This post would so thoroughly occupy these hills as to prevent the march of Infantry to the rear otherwise than by the space of two or three miles between it and the Aguda works and it would leave the whole Army at liberty to act in that difficult Country whilst the Enemy would have the Garrisons of Pobral and

Alhandra in their rear. I should conceive it too hazardous an enterprise for them to attempt—if that is allowed it follows that it would secure Alhandra from being turned by an Enemy with or without Artillery.

I have one feeling of doubt on my mind which it is my duty to state and that is the possibility of an enemy forcing the valley between the two works. I will here state what has been done to secure it, that, if not judged sufficient orders may be sent for further obstacles being created—at its entrance eight 12 Prs. in inattackable situations can shower down grape shot upon the Enemy and during a passage of half a mile they will always be under the fire of at least six pieces of that nature of ordnance and for some part of the way under ten,—the work now proposed will give an additional cross fire and will prevent an entry into the valley by a collateral branch which exists about midway and which is a most serious disadvantage.

It is however to be recollected that the fire of the Artillery is from a very great height, and that much cover is created in the valley by hollow ways and steep rising grounds, and that in the night time the fire will be often uncertain; when an attack is expected it will be proper to cut down the Trees, and place them as an obstacle across the valley and also to level the houses, walls, etc.

The works I propose to construct are three Redoubts for four hundred men each mutually flanking each other with a smaller work in advance to look down the valley in front which the three forming the Position cannot do,—it is proposed to make them to resist Cannon and they being nearly a mile retired from the front of the Alhandra position I do not think any Enemy dare to bring up Artillery for their reduction without having first forced Alhandra, for as the rear of that post will be open to the Army and hid from him, he can never tell whether there are four or fourteen hundred men it.

1st. I have sent a hasty sketch from memory of the ground but which I trust will be sufficient to point out the situation of the proposed works.

2nd. The soil is very unfavourable for this construction of works it will therefore require nearly two months to complete them from the day of their commencement.

MEMORANDA RELATING TO THE POSITION OF ALHANDRA.

Sent to Lieut.-Colonel Fletcher, Commdg. Royal Engineers.

LISBON, *August 29th*, 1810.

The position of Alhandra as now taken up is formed of an isolated range of heights, its right bounded by the Tagus, its front left and part of the rear by a deep and difficult valley. It may be viewed under the three divisions of its front left flank, and rear.

The front naturally subdivides into two parts:—1st an extent of upwards of 2,000 yards on the left, which has been so cut and blasted as to give it a continued scarp everywhere exceeding 10 feet in height, flanked in its whole length by musketry and Cannon—and the approach to the scarp laying under a fire of grape shot. Large general flanks have been established for that purpose, and *Redoubts have been erected on the summit, for the security of the Guns and Troops should any part of the position be forced.

The second Division of the front is an extent likewise of about seven hundred yards, more than half of it the low flat ground bounding the Tagus, the remainder is the slope of a hill of easy ascent gradually rising from the low ground till it meets the artificial scarp.

This whole length has been intrenched by a continued flanked line of a strong profile, across the low ground an advanced ditch has been added, flanked from the line ascending the hill, and which has likewise been made to answer as a powerful flank to the low ground generally, at the left extremity of this line, and at the point where the nearly inaccessible part of the front ceases a Redoubt has been thrown up.

The left of the Position may be considered as having a front of half a mile, the ground is very high and steep, but not inaccessible. Two Redoubts have been established there, the one on the most commanding point of the whole Position for 400 men, and eight 12 Prs., the other on the left for 350 men, and six 12 Prs.

A species of Redoubt or Flêche has been thrown up where the nearly inaccessible part of the front finishes on the left, for which perhaps 150 men should be apportioned, as in case of necessity they can support the front or flank as either may be pressed.

Scarping and other impediments of that nature have also been attempted with success so that the left flank may be considered only less strong than the front.

The rear of the position is above 2½ miles in extent, it is very open and of easy ascent and one part of it is commanded by a range of Hills, the occupation of which by an Enemy would turn all our defences, and most probably cut off the retreat of the Troops.

There are but three ways by which an Enemy can get in the rear or obtain possession of the above-mentioned ridge of Hills.

1st. By forcing his way through the valley on the left.

2nd. By marching a Column along the opposite heights of Calhandrin, parallel to the left flank.

3rd. By making a detour to his right of several miles.

* Leaving the rear out of the calculation, Alhandra with a proportion of Artillerymen (say 200) for the forty Pieces of Cannon mounted upon it may be considered as almost an inattackable position for Five Thousand Men, and might in case of necessity be safely left to the care of Four Thousand Men.

To guard against the first a height detached in advance of the position on the left has been occupied by a work for 250 men and five 12 Prs., and which from its situation and construction is so strong that it ought never to be forced, the fire from this work, and from the redoubts, with an abattis may perhaps be deemed sufficient to prevent an enemy from passing along the valley.

The second passage might be impeded by the construction of a post for fifteen hundred men upon the Hills parallel to the left flank, at present to carry Artillery by that route it would be previously requisite for the Enemy to force a redoubt above Francoso.

The third method can only be properly opposed by the Manœuvres of the General Commanding the Army, but its bad effects might probably be counteracted by the erection of a strong work on the rear range of Hills where it would be the object of an Enemy to establish himself.

EARLY ROMANO-BRITISH PEACE OR WAR CONSTITUTIONS.

By COLONEL O. E. RUCK, LATE R.E.

IN the *R.E. Journal*, April, 1910, Colonel Hickson, D.S.O., continues the exposition of the constitutional methods initiated by Servius Tullius, and, by the contribution of additional facts, still further strengthens the closeness of the similarity of the Servian politico-military organization to that of Henry II. in this country.

In tracing the evolution of the Comitia Centuriata of Servius from the Curiata of Romulus, as studied and interpreted by Niebuhr and Mommsen, Colonel Hickson is helpful to the student of military history by shedding many an illuminating sidelight on matters of detail on controversial points, some of which the original Roman historians do not themselves, in all cases, appear to absolutely agree upon.

For instance the original Tribal System, tending as it did to create local and intertribal contentious bickering, necessitated a complete reorganization by the strong hand of a strong man. Servius Tullius with far-reaching prevision stepped in, introducing a new system distributing the citizens into tribes, not as before according to racial or family extraction, but dependent upon their local situation.

The first original three tribes consisted of No. 1, named after Romulus and included the Roman citizens of the Palatine; No. 2 which consisted of the Capitolines and Sabines; No. 3, the Tuscans and all foreigners except the Sabines. Tarquinius Priscus soon doubled the number of tribes but in a short time, No. 3 tribe greatly exceeded the rest in number and caused an inconvenient distribution which led to the Servian reconstitution.

Servius divided the city tribes (Tribus Urbanæ) into four, viz., Palatina, Collina, Suburana, and Esquilina as per Niebuhr, and at the same time divided the Roman Territory into 15 (some say 16, and some 17) called (Tribus Rusticæ) or country territorial tribes.

In the year A.U.C. 258, B.C. 495, the number of tribes was made 21;[1] afterwards the number of tribes was increased by the addition of new citizens at various times up to 35 in number,[2] (which number continued to the end of the Republic).[3] After the admission of the Italian states to the freedom of the city, 8 or 10 tribes are said to have been

[1] Livy, II., 21. [2] Livy, XXIII., 13. [3] Livy, I., 43.

temporarily added, but in a short time all the Italians were distributed amongst the 35 old tribes.

In the very early days of Rome, the original three tribes of Romulus were divided into 10 curiæ, the whole territory of Rome—then very small—being also divided into three unequal parts, the largest of the three being again divided into 30 portions to answer to the 30 curiæ.[1]

The people were divided into two ranks (ordines) Patricians and Plebeians, the equites being added by Servius Tullius some 200 years later. From each tribe Romulus chose 1,000 foot soldiers and 100 horse,[2] hence these 3,000 infantry and 300 cavalry formed the original legion for which reason Niebuhr's mention of 30 men to the century of the original legion (for explanation of which Colonel Hickson desired in his footnotes), is correct, at 100 centuries to a legion. But the number of men in a legion was different at different times.[3] In the times of Polybius it was 4,200, at one time there were 60 centuries in a legion,[4] and if there had always been 100 men in each century as its name implies, the legion would have consisted of 6,000 men. But this was not the case.

With regard to the same quotation from Niebuhr's "Von den Comitien, etc.," for which explanation is required by Colonel Hickson—"Levies were made according to the tribes, of which there were 30 (see Dionysius, IV., 14)"—it would appear that differences of opinion between Dionysius and Livy existed as to numbers, writing as they did some 300 to 500 years after the events recorded. For in the year of the city 258 the number of tribes was made by Livy to be 21.[5] Dionysius (IV., 14) states that Servius instituted 30 tribes, but at the trial of Coriolanus, A.U.C. 263, or only five years later, he mentions 21 the same number given by Livy as having voted.[6]

Be that as it may, for a considerable time after the constitution of Servius Tullius, a tribe was nothing else but the inhabitants of a certain region or quarter in the city or country; but afterwards the tribes came to be reckoned parts—not of the city or country—but of the State (non urbis sed civitatis). Whereupon everyone leaving the city tribes wished to be ranked in the rolls of the rustic tribes; such was the fondness of the ancient Roman for a country life aided in some degree by the pressure due to the power of the Censors who could initiate new tribes, and distribute the citizens, both old and new, into whatever tribes they pleased, irrespective of place of habitation or birth.

In the year A.U.C. 449, Q. Fabius separated the meaner sort of people from all the tribes amongst which they had hitherto been distributed by Appius Claudius, thereby relegating them to the four city

[1] Dionys., II., 7. [2] Plutarch in Romulo. [3] Livy, VII., 25; VIII., 8; XXVI., 28; XXIX., 24; XLII., 31; XLIII., 12; Cæs., B. G., III., 106. [4] Gell., XVI., 4. [5] Livy, II., 21. [6] Dionys., VIII., 64.

tribes;[1] amongst these were many of the Proletarii (under 1,500 asses valuation apiece) and the Capite Censi men, Agrarians, and those who were rated at no assets at all!

From this time, and perhaps before, the four city tribes began to be esteemed less honourable than the 31 rustic tribes; and some of the latter appear to have been considered more honourable than others.[2] Hence when the Censors deemed it right and proper to degrade a citizen, they removed him from a more honourable to a less honourable tribe (tribu movebant); and whosoever convicted anyone else of bribery or corruption, upon trial thereof, obtained by law if he chose as a reward, a transfer or exchange into the tribe of the person so convicted or condemned.[3]

These rustic tribes took their names from some territorial place such as Tribus Falerino, Levonia, Cluvia; sometimes from some noble family, *e.g.* Tribus Claudia, Fabia, Julia, Veturia, Horatia; occasionally the name of the tribe is added as a surname, *e.g.* M. F. Terentina, Sex. F. Quirina.[4]

In determining what classes of men came out under the regular annual conscription it is necessary to know the exact period of the 500 years' more or less continuous warfare alluded to, and if for a small war, or whether a case of (in tumulto), *i.e.* a state of panic prevailing; a not unheard-of contingency, even in the case of the great Imperial Roman organization.

Colonel Hickson quoting from Niebuhr with reference to the comparatively insignificant number of engineers and artificers included by Livy in the Classici or First Class of the Servian Comitia, suggests that these useful men may likely have been drawn from the trade guildsmen of ancient Rome.

It is difficult to avoid the thought that Niebuhr,—in stating that these artificers attached to the Classici could not have been plebeians, as no plebeian could engage in any occupation other than that of agriculture,—may have been alluding to a later period of Roman society.

It has been commonly supposed that all the Roman citizens, with the exception of the Patricians and Equites were classified in the times of the Kings and early Republic as Plebs[5] or Populus. But the word Plebs has not infrequently been applied to describe the meanest or lowest class of the then so-called common people, *e.g.*, ad populum, plebemque referre.

Thus Horace speaks of 'unus e plebe, *i.e.* a plebeian not an eques.'[6] Those of the plebeians who lived on and cultivated land in the country were 'Plebs Rustica.'[7] Those who lived in the city 'Plebs Urbana.'[8]

[1] Livy, IX., 46. [2] Cic. pro Balbo, 25; Pliny, XVII., 3. [3] Cic. *ibid.* [4] Cic., Quint., 6. [5] Cic., Fam., VIII., 8; Gell., X., 10. [6] Horat., Ep. I., 1, 59. [7] Livy, XXXV., 1. [8] Cic., Off., I., 42; Sall., Cat., 27.

Of these two classifications, that of the Plebs Rustica was deemed the most honourable.[1]

Many of the Urbana possessed of no trade and being very poor had to be supported by private largesses,[2] whilst in the latter times of the Republic these urban unemployables were, at the public expense, granted a subsistence allowance of 5 bushels of corn per man per month.[3] Cicero alludes to them as 'mercenarii'[4] 'Fex et sordes urbis,' 'urbana et perdita plebs' and often contrasts the plebs or multitudo with the nobility (principes delecti, benesti and locupletes).

But from whatsoever class the Engineer artificers attached to the 1st Class or Classici by Livy came, whether they were plebs rustica, plebs urbana or not of the plebeian order at all, but freedmen or Peregrini[5] (foreigners) as per Niebuhr's suggestion, no authentic records can be traced, so far as can be ascertained to effectually establish their identity. But knowing as we do that foreigners in the times of Tullius were ineligible for the army and that freedmen were just beginning to feel their feet as hired gladiators,[6] and that by the laws during the Tribuneship of C. Papius Celsus, A.U. 688, all foreigners were ordered to quit as undesirable aliens,[7] we cannot but think that the engineers attached to the Classici came from a then more honourable class of the community, in the absence of preponderating evidence to the contrary.

[1] Cic., Rull., II., 31; Pliny, 18, 3. [2] Sall., Cat., 37. [3] Sall., Frag. edit. Cortii, p. 974. [4] Cic., Sext., 17, 27, 48, 68. [5] Cic., Off., I., 12. [6] Horat., Sat., II., 7, 5. [7] Cic., Off., III., 11; Brut., 8.

RECENT INVESTIGATIONS INTO THE THEORY OF DEW-PONDS.

By COLONEL W. PITT (LATE R.E.).

DURING the past two or three years a considerable amount of attention has been paid to the subject of dew-ponds by some of the leading scientific bodies, and important investigations have been carried out. The result of these enquiries appears to be that the time-honoured tradition regarding these ponds must be regarded more or less as a myth. It is possible that the reports of the proceedings may have escaped the notice of some who are interested in the subject, especially as they are published in the journals of different societies; it is therefore proposed in the following notes to give a brief description of what has been done and the conclusions arrived at.

Anyone who is acquainted with the downs in the southern counties of England knows that there are numerous ponds scattered about them, especially at the higher levels, which are used for watering sheep in an otherwise waterless country. All officers who have taken part in manœuvres in these counties know that stringent orders against the use of these ponds by the troops are invariably issued. In the great majority of cases the ponds have no visible source of supply, though sometimes where they are situated near a road or track a channel is cut to lead surface drainage into them, yet they are seldom found to be dry. It is obvious of course that they get the benefit of any rain which falls on their surfaces, but it has been held from time immemorial that they are chiefly replenished by dew or condensation from fogs. For this reason they are known as "dew-ponds" in some parts of the country, or "mist-ponds" in others.

It is claimed by some archæologists that dew-ponds were in use in the Neolithic age, and that the hilltop camps of which there are so many on the chalk downs were dependent on them for their water supply.* It is not proposed to consider this question here.

Extraordinary beliefs have been prevalent, and statements made, as to the quantity of water which might be deposited on the surface of a pond in the form of dew. In his monumental work on ancient

* *Neolithic Dew-Ponds and Cattle-Ways*, Arthur John Hubbard, M.D., and George Hubbard, F.S.A., etc.

earthworks* Mr. Hadrian Allcroft has a chapter on dew-ponds in which he says that "it has been found by actual experiment that a dew-pond may rise as much as 2" in a single foggy night of January, and in five nights rise fully 8". In the early summer the same pond collected 3½" of water upon five nights of heavy dew." No particulars are given as to the pond or details of the experiment. It appears that we are asked to believe that the deposit from dew alone may be equivalent to a rainfall of 2" in about 14 hours which would necessitate a heavy downpour, such as is rarely experienced in England, during the whole of that period! The thing is incredible. There may have been trees overhanging this particular pond and dripping on to its surface but even so the statement is difficult to believe. Although the facts as put forward by Mr. Hadrian Allcroft may have been regarded as an exaggeration, or describing an improperly carried out experiment, or relating to a peculiar case, the popular belief was in the replenishment of the ponds, in the main, by dew. There were however those who doubted.

The matter was taken up by the Royal Society of Arts and on March 3rd, 1909, at a meeting of that society, a paper was read by Mr. George Hubbard which was published in its journal.† Mr. Hubbard described the theory of the deposition of dew and the principle on which dew-ponds are constructed, the most important detail being the laying of a bed of straw under the clay puddle. The object of this was explained to be the interposition of a non-conductor between the earth and the clay, and so prevent the radiation of heat from the former during the night and encourage the deposition of dew on the cold clay sides of the pond as well as on the surface of what water there might already be in it. Reference was made to the way in which ice is, or was, obtained in India from shallow earthenware pans resting on a bed of straw. Mr. Hubbard stated that dew-ponds on hills are more successful than those in valleys and he gave a curious reason for this. His theory is that air carrying aqueous vapour rises and in higher altitudes expands, consequently the temperature falls and condensation ensues; also that hilltops radiate easily and act as condensers. It may be remarked that this explanation hardly seems convincing.

Mr. Hubbard went on to say that dew-ponds are only successful when constructed on a chalk bottom, because "chalk is a sterile soil, and it is owing to the absence of worms that the layer of straw can remain dry." This also seems to be rather what a Hampshire shepherd would describe as "dubersome." I know that when I had a garden on chalk with only 4" or 5" of soil there used to be plenty of worm casts on my lawn. It seems probable that ponds are more numerous on chalk downs than elsewhere because there are no

* *Earthwork of England*, A. Hadrian Allcroft, p. 275.
† *Journal, Royal Society of Arts*, March 5th, 1909.

springs or streams from which water for sheep and cattle can be obtained, also because, as will be shown later, the rainfall is heavier on the hills than in the valleys, and near the coast the hills get more mist and sea fog.

After describing some experiments in condensation on wooden trays standing on sheets of mica, the paper goes on to suggest the adoption of dew-ponds as a means of obtaining water in barren rainless lands such as the Desertas Islands near Madeira, and describes the effect of trees and vegetation in encouraging the deposition of dew.

Mr. Hubbard next refers to the covering of a portion of the rock at Gibraltar with corrugated iron on a wooden backing, on which he says "the warm moisture-laden wind becomes chilled and the dew is deposited, and if I am rightly informed Gibraltar has now a supply of pure water." It was however subsequently pointed out by another writer that this structure was erected with the object of collecting rain and not dew.

The paper concluded with some remarks on the use of various substances as non-conductors and condensing surfaces, and suggestions that by making use of the dew, the arid places of the earth such as the Transvaal, Australia, and parts of India might be made fertile.

An interesting discussion followed the reading of the paper in the course of which Mr. G. Blundell said that many dew-ponds in Wiltshire and Sussex were made with the straw on the top of the clay puddle to keep it from cracking, and with a layer of rubble on the clay. In his reply Mr. Hubbard reiterated his statement that in Sussex the exact opposite was the custom. He also said that the depressions often found in the South Downs were probably ancient dew-ponds. This I believe to be an error. In a paper contributed to the *R.E. Journal* on "Swallow Holes in Chalk" * I explained that these depressions are a natural formation, but even if this theory is incorrect they cannot all have been dew-ponds, there are too many of them, and they vary too much in size. On the chalk hills of Hampshire the fields are riddled with such depressions, you will find six or eight in a single field often close together; some are much too large and deep, others too small and shallow. Moreover there is absolutely no trace of the bank round which must have been formed by the earth thrown out if they had been excavated artificially.

Mr. Hubbard's paper attracted a good deal of attention and was followed by some correspondence in the *Journal of the Royal Society of Arts*, chiefly as regards details of construction. Then an article signed E.A.M. appeared in *Nature*.† The writer of this was no doubt Mr. E. A. Martin whose important investigations will be referred to later. He controverted the theory that the ponds derive their water supply from dew, and pointed out that evidence is wanting that the

* *R.E. Journal*, May, 1909.
† *Nature*, April 22nd, 1909.

temperature of the water in the ponds falls below dew-point during the night: so long as the surface of the water remains warmer than the air, dew cannot be deposited on it. Mr. Arthur Beckett also wrote to *The Field** giving particulars of the method of construction of dew-ponds on the Glynde Estate near Lewes and saying that he had been forced to the conclusion that the ponds depend for their water chiefly upon rain, and in a much smaller degree on mists and hill fogs. These views were controverted by "East Sussex" but reiterated by Mr. Beckett.

E.A.M.'s article in *Nature* was replied to by Mr. Hubbard in the *Journal of the Royal Society of Arts*† in a note in which he admitted that probably dew, *per se*, forms a very inconsiderable factor in the supply of dew-ponds. He went on to quote the following important figures.‡ "On the summit of the South Downs the annual rainfall is from 35" to 40"; the annual evaporation is certainly not more than 20", and so from rain alone a pond should accumulate a depth of 15" to 20" a year, supposing the bottom to be watertight"—and of course that sheep are not watered at it. With reference to E.A.M.'s statement that evidence is lacking that dew-point is reached in the ponds Mr. Hubbard quotes as a proof Mr. Hadrian Allcroft's remarkable figures which have been mentioned earlier in this paper. The experiment described by Mr. Allcroft was, Mr. Hubbard says, carried out by Mr. C. J. Cornish.

Mr. J. B. Cohen wrote to *Nature*§ saying that he had always been sceptical about the dew-pond theory for the reason that "lakes and ponds lose their heat slowly, and that after radiation has set in at night they indicate a much higher temperature than the ground adjoining, or the air above." To this objection Mr. Hubbard replied‖ that "it is not the temperature of the bulk of the water that, in my opinion, regulates the deposition of dew, it is the temperature of the surface film of water which is alone involved, and this is not readable on the scale of an ordinary thermometer." He said that on this account the results obtained by Mr. Cohen and Mr. Martin appeared to him purely negative. With reference to the above it may be remarked that when the water in a pond is cooling at night we should expect it to do so from the top and that it actually does so was conclusively proved by Mr. Martin in his experiments which will be referred to later. Even if he were unable to take the temperature of the surface film, it is difficult to believe that this can be higher than that of the water immediately below, which at night rises regularly to the bottom.

* *The Field*, March 20th, 1909.
† *Journal*, *R.S.A.*, May 14th, 1909.
‡ *Symon's Meteorological Magazine*, April, 1909.
§ *Nature*, May 13th, 1909.
‖ *Journal*, *R.S.A.*, May 21st, 1909.

We must now go back to 1908. In the summer of that year Mr. E. A. Martin with the aid of a Royal Society Government grant began a scientific examination of the subject of dew-ponds, on the Sussex Downs, and continued his observations the following summer. The results of his investigations will be found in two papers read before the Research Department of the Royal Geographical Society on April 22nd, 1909,* and April 21st, 1910,† but in both cases they were not published till some months later. These papers are of great interest and contain a mass of information including several pages of tables of temperatures. It will not be possible here to do more than refer briefly to some of the more important points and give the conclusions arrived at by Mr. Martin. Those who wish to pursue the subject further are referred to the pages of the *Geographical Journal.*

In his first paper Mr. Martin starts with the postulate that "certain high level ponds maintain their supply in the driest, hottest weather, long after those in the plains below have more or less completely dried up." He says that this has been attested by many observers, from Gilbert White onward. He observes that to be useful, ponds must receive dew in summer, in winter they are fed by rain. He constructed a dew-pond for the purpose of carrying out experiments and records that on the night of September 21st, 1909, the temperature on the grass fell from 52° to 30° whilst that of the surface of the water fell from 50° to 42·5°, dew-point being 45·5° on the grass, but it does not follow that the pond received any dew. The depth of water was only 4″. Mr. Martin remarks that evaporation may continue all night, and that he thinks a pond may receive dew while the water in it has not fallen below dew-point. In the subsequent discussion this suggestion was controverted and Mr. Martin has since modified his opinion. It does not seem possible that he can have been right. Further on in his paper Mr. Martin pointed out that if a pond is very shallow the whole body of water will be heated during the day to such an extent that it will continue evaporating throughout the day and night. He next described the various methods of construction and gave sections of ten different ponds all made in different ways and in various localities, including Yorkshire, Leicestershire, Essex, Dorset, Wilts, and Sussex. Of these ponds some had straw over clay, others straw under the clay, alternate layers of straw and clay, and two had no straw. Lime should be mixed with the clay to keep worms out.

The amount of the annual dewfall was then considered. Mr. Martin stated that this had been estimated at under 1·5″ on surfaces other than water. On a night when there was a heavy dew he collected it on a waterproof sheet and on measuring the quantity

* *Geographical Journal*, August, 1909.
† *Geographical Journal*, October, 1910.

found it to be $\frac{1}{200}''$. If this amount fell every night of the year the total would be 1·8104″, but as it cannot be regarded as a fair average he estimates the annual fall at something over $\frac{3}{4}''$. If the evaporation is deducted from this there will not be much left to feed the pond. Mr. Martin then considered the question of supply from fog or mist apart from ordinary dew. On the South Downs sea fogs cause great quantities of moisture to be deposited, especially at the higher levels, and for this reason hilltops are now chosen for pond construction. Trees overhanging ponds arrest the moisture and cause it to drip into them, reeds also growing in the water increase the deposition. As regards rainfall it has been observed that a gauge in a hollow measures more than one on the ground above. Mr. Martin kept a record of the fall measured in the hollow of his experimental pond and on the top of the bank. During 21 rainy days in August and September, 1908, the gauge in the hollow registered 3·51″ and the other 2·57″. In connection with this I have noticed that roots and cabbages growing in the depressions in chalk soil, previously alluded to, are finer than the rest of the crop. The water from a number of ponds was analyzed and found to contain an unusual quantity of chlorine, probably derived from condensation of sea fogs.

A discussion followed the reading of the paper.

Dr. Mill attributed the lower registration of rainfall on the edge of a pond to the setting up of eddies of wind, from which the gauge at the bottom would be sheltered. Mr. George Hubbard said he did not believe it is possible for a pond to receive condensation if the temperature of the water has not fallen to dew-point. Mr. Sidney Skinner stated that he had marked the level of the water in a pond in St. Boniface Down, Ventnor, and after two days of mist he found less water than before.

Mr. Carle Salter pointed out that whilst the collecting area of a pond as regards rainfall is always greater than the area of the surface of the water, the evaporating area is confined to the latter.

Now with reference to the experiments and investigations carried out by Mr. Martin it may be noted that he gives in his paper no periodical measurements of depths of water in any dew-ponds. When the evaporation and deposition nearly balance one another and the change of level is consequently slight, it may not be easy to ascertain the amount of it, there would however be no difficulty in measuring a rise of 2″, such as Mr. Allcroft claims to have been recorded, or one very much smaller.

Mr. Martin's second paper contains the record of his much more complete observations made in 1909. He began by repairing the experimental pond he had constructed during the previous year. This had filled up during the winter but developed leaks after frosts. In July he excavated the pond to a greater depth. By the 20th there was enough water in it—presumably derived from rain—for him to commence his observations. There was heavy dew on the night of July 19th which made no appreciable alteration in the depth of water, and similarly on subsequent dewy nights the depth was always unaffected. On July 27th and 28th there was a heavy fall of rain measuring 1·21" in 24 hours. A gauge in the pond registered 1·41", but at Ditchling at the foot of the hill only 0·88" fell. This brought the depth of water in the centre of the pond to $4\frac{1}{2}$". There was no rain from July 31st to August 15th on which date the water had nearly all gone. On August 11th there was a thick fog. On August 12th there was an inch of water remaining in the pond. All that the fog on the 11th did was to arrest evaporation.

Between August 4th and September 8th, at ten different points Mr. Martin took a series of temperatures at intervals during nearly every night, usually two or three before, and at midnight, and again at 7 or 8 a.m. The results are given in his paper in tables which it is not necessary to reproduce here. The important temperatures are those of the air immediately over the water, and of the water close to the surface. The bottom water temperature was taken, wet and dry bulbs in air, and dew-point recorded. The net result is that out of 101 records of the temperature of surface air and water they were equal on one occasion, on 16 occasions the water was lower than the air, and higher on 84. The lower water temperatures occurred in the early morning with two exceptions; once the water is recorded as 5° below the air at midnight, and again 0·5° lower. The first of these lower temperatures is probably incorrectly printed in the tables, it is shown as 63° at 10 p.m. and 52° at midnight the respective air temperatures being 59° and 57°. Probably 62° should be read for 52°. At night the temperature at the bottom was always higher than at the surface.

On August 14th and 15th, Mr. Martin recorded temperatures at a dew-pond at Upper Standean every hour for 24 hours, and states that "during the hours of possible dewfall the temperature of the surface air was, with but one exception (12.30 a.m.) always lower than that of the surface water, and on no occasion did that of the water approach dew-point."

Mr. Martin tried to collect dew in trays floating on the surface of his experimental pond. On the evening of August 26th he placed a measured quantity of water in a shallow glass dish. The night was dewy but the quantity of water next morning was the same as at first. On the night of September 7th a quantity of water was measured into a tea tray. There was heavy dew and thick fog and next morning the water was found to have increased its volume by three hundredths. This experiment was repeated in the daytime to ascertain the evaporation. On September 9th, a sunny day, two measured quantities of water were similarly exposed from 9 a.m. to

6 p.m.; of these one lost ten and the other twelve hundredths of its volume.

Mr. Martin described some experiments carried out at Croydon by Mr. Baldwin Latham as to evaporation and condensation from which the annual average evaporation was found to be 18·14″, and condensation 0·36″, giving a net loss of 17·78″. This amount deducted from a rainfall of 35″ leaves 17·22″ available for filling a dew-pond, or 34·44″ if the area is multiplied by two to allow for the collection of rain on the banks. This should suffice to keep a pond full and allow for sheep drinking, but unfortunately the statement is misleading because the evaporation occurs mostly in summer whilst the greater part of the rain falls in winter. Yet ponds free from leakage seldom do dry up entirely and Mr. Martin thinks that mist or fog must come to the rescue.

A suggestion was made that the electrical condition of the atmosphere may have something to do with the deposit of aqueous vapour.

The conclusion finally arrived at by Mr. Martin after two years' investigations, and very much against his will is that dew very rarely forms on the surface of ponds or on their puddled margins, but that rain is the all-important replenisher of the so-called dew-ponds. The mystery of the dew-pond is no longer a mystery.

Those who took part in the discussion following the reading of the paper considered the result of the investigation to be conclusive, no one had a word to say in defence of the time-honoured tradition. Mr. S. Skinner said that Down labourers always told him that the ponds were filled by rain. He suggested that endeavours should be made to measure the deposits of dew and mist separately. Dr. Strahan thought there was room for further precise observations on the fluctuations in the water level.

It is a dangerous thing to abandon an ancient tradition until it has been thoroughly investigated, especially one so widely held as that relating to dew-ponds. The results of the scientific observations so ably and thoroughly carried out by Mr. Hubbard, Mr. Martin and others, however, leave us no option but to consign this belief, little as we may like doing so, to the limbo of popular delusions.

TRANSCRIPTS.

NOTES ON THE THEORY AND PRACTICE OF FIELD FORTIFICATION.—MODIFICATIONS DRAWN FROM THE EXPERIENCE OF THE RUSSO-JAPANESE WAR.

By F. Golenkin, Military Engineer, Lecturer on Fortification in the Nicholas Engineer Academy (St. Petersburg, 1907).

This pamphlet contains a series of lectures on the modifications in field fortification which were suggested

(i.). By the experience of those who took part in the Russo-Japanese War.

(ii.). By articles published recently in Russian and foreign periodicals, and

(iii.). By the proceedings of a special committee, which was assembled under the orders of the Inspector-General of Engineers.

The following is a summarized translation of a few points in the book:—

Developments of Firearms, etc.

Recent changes in weapons and equipment must materially affect the question of field defences. Among modern developments in *weapons* there may be mentioned:—

(*a*). The 6·5-m.m. and 7·6-m.m. improved quick-firing rifles, and their increased range and penetration due to the introduction of the sharp-nosed bullet.

(*b*). Machine guns of the same and of larger calibres.

(*c*). Q.F. artillery: light (guns) of calibres up to 8 cm., and heavier (howitzers) up to 10·5 c.m. and 12 c.m. (4·2″ and 4·8″), all without recoil and almost all shielded.

(*d*). Heavy artillery (guns, howitzers and mortars), which may now be considered to belong to the normal armament of provisionally fortified positions. Medium calibres, such as 6″ and 8″ artillery, were found to be considerably more effective than heavy, such as 11″ howitzers, owing to their far greater accuracy.

(*e*). Hand, and mechanically-thrown bombs and grenades, and land mines.

Recent introductions in the form of *equipment* include balloons and kites; field telegraphs (electric and optical) and telephones; field photography; shields, searchlights and automobiles. The dirigible balloon and its opponent the automobile equipped with a light gun or machine gun, the combination of aerial kites with photography for the survey of hostile positions, and the proposal of shields for infantry (which has probably been settled by the introduction of the sharp-nosed bullet) have also to be taken into consideration.

General Principles.

Little alteration is to be noticed in the general principle of the fortification of field positions. There are still the *skirmishing line*—the trenches of the front line; the *local reserves*—the closed works of the second line and their attendant batteries; the *general reserve*—the rear position; and sometimes *reconnoitring parties*—advanced posts.

The centre of gravity of the defence has now moved forward from the line of works to the front trench line, this is due to the improvement in weapons, which require, for full development of fire effect, the wide extent of trenches, rather than the limited faces of works. The defenders of the trenches must now feel that everything depends on them, and must no longer glance back and think of their own retirement, as they used to do when they felt that the decisive battle would be fought out somewhere in their rear. The line must be reinforced with small works as nucli of resistance in order to give solidity to the trenches. These works will be little more than rings of trench work, surrounded by obstacles, which must not in any way differ in appearance from the rest of the trenches, and must be so sited that they can bring heavy fire to their front, and strong, concentrated, flanking fire over the intervals between them.

The line of works of stronger profile in rear must not be abandoned. If the front line is penetrated by the enemy, this forms a strong retrenchment, from which artillery and rifle fire and counter-attacks can be brought to bear on the front and flanks of the advancing enemy, in order to cause their earlier success to end in their complete destruction.

The ring trenches of the front line must not be replaced by open works or lunettes, which are vulnerable from the rear and easily turned. There is no reason why the closed works should not be quite unrecognizable from the front, when one takes into consideration the numerous subsidiary works, such as communication trenches, blindages, latrines, etc., which lie in rear of a modern defensive line of trenches.

The advantage of *advanced posts* was confirmed at Nanshan, Port Arthur, Liao-Yang and elsewhere. They may fulfil purely reconnaissance duties, and are then most conveniently placed in advance of the flanks, as being more easy to retire from, and tending to increase the circuit of a hostile turning movement. They should be fortified with open works, and their defenders, though making an obstinate resistance until the enemy arrives within 400 paces or even later, should not await a bayonet fight.

Advanced posts may also be intended to act as *caponiers* to the main line, to bring flanking fire along its front or to facilitate counter-attacks.

In this case they must be very strongly fortified and obstinately held. It is in rear of such posts and under the concealment of the hills, villages or woods which are included in them, that so-called "dagger" or "stabbing" batteries of field or machine guns may be placed to enfilade the approaches to the works of the first line.

Flank reserve positions are prepared in rear of one or both flanks as a protection against turning movements. It is important that these should be in echelon, and not placed obliquely to the main line, for the latter does not in any way increase the circuit of a turning movement. With large forces several such positions may be prepared.

Rear positions, intended to cover a retirement, used to consist of lines of strong points. The general opinion of those who took part in the war is that they should now be considerably strengthened and reinforced with rifle trenches and gun pits. Their object is, with a comparatively small garrison, to develop to the utmost the surest means of defence—the strongest possible rifle and artillery fire.

Subsidiary and reserve positions should be occupied by guards, in order to prevent them from being forgotten, as happened at Mukden. In this connection great importance attaches to notice boards, finger posts and lamp-posts, to keep the troops from losing their way.

Technical Requirements of Works.

Passing now to the technical requirements of various works, the experience of the war has shown :—

i. That the thickness of earth cover, both in parapets and roofs, must be increased.

ii. That the command of all works must be reduced, even down to nothing, if the field of fire permits.

iii. The relief of works (*i.e.* the distance from top of parapet to bottom of trench) must be increased.

iv. Careful measures should be taken to protect the men against the very destructive, *indirect*, hits of shrapnel and splinters.

v. Concealment from view, and consequently from fire, must be arranged, the enemy's observatories and balloons not being forgotten.

vi. Obstacles of all kinds should be used as much as possible.

vii. Accuracy of fire at long and short ranges must be provided for, by measuring ranges, setting up distance marks, preparing range tables, and carefully organizing observation stations. The latter may be outside the sections of the position to which they belong and should be provided with observatories and signalling appliances.

viii. Lastly, facilities for working at night must be provided, searchlights, star shell, automatically-lighted flares, especially near obstacles, rifles and guns laid in special directions, communications for the reserves, marked by arrangement, easily recognizable in the dark, telephonic and telegraphic communication between sections, etc.

Night attack arrangements include the counter-illumination of the defensive position to paralyze the action of the defence lights; a most careful technical reconnaissance of the ground; the preparation of the most direct approaches and their careful marking, even to the posting of men along them; the provision of means for crossing artificial and natural obstacles, and telephonic communication as in the defence.

It may be taken as a rough rule that, with large forces engaged and provisionally prepared works, the normal thickness of parapets should be calculated to give protection against the shells of 10·5-c.m. and 12-c.m. field howitzers. With small positions and hasty defences parapets should be proof against field guns. If it is probable that a position of the latter type is likely to be converted into one of the former, the fact should not be lost sight of in designing the works.

FUNDAMENTAL REQUIREMENTS OF WORKS.

The fundamental requirements of various works are as follows:—

i. *Rifle Trenches.*—Fields of view and fire as large as possible, allowing no dead ground within 600 to 850 paces. This must be arranged by siting, as clearing the foreground is laborious and unsatisfactory. Choice of profile to suit the comfort of the riflemen. The two service types which allow of "firing standing from a step" and "standing in bottom of trench" are preferable. Some people recommend arm-rests, but they are inconvenient for "behind cover" firing, when the rifle rests on the parapet and is held by the left hand under the butt. Secure protection from shrapnel bullets, splinters and rifle bullets in frontal, reverse and enfilade fire, and also from side flight of splinters from shells which burst in the trench. The normal interval between men in the trench must be 1½ to 3 paces, and they must be protected with loopholes, overhead cover, *bonnets* (mounds between loopholes), light lean-to roofs, and mined shelters. All kinds of traverses are necessary, recesses for the riflemen are not enough by themselves, as the gangway along the trench must be protected at intervals from enfilade fire. The trenches must be made as invisible as possible, by adapting them skilfully to the contour of the ground, masking every part of them, and, in provisional fortification, by the use of dummy parapets. All sharp edges and turns are to be avoided, and no subsidiary works should show above the front parapet. Uninterrupted *communication* along the trench, without interfering with the men firing is a necessity, and men passing along this gangway must be defiladed from the view of hostile observers. Communication with flanks and rear is necessary, and if there is no time to dig a communication trench all the way, the safest line should be marked by signposts. If there is time to add a few obstacles in front of the trench, so much the better.

ii. "Strong points" or works. Conditions similar to trenches, with addition of an obligatory obstacle, swept by frontal, or better by flanking fire. But parapets must be thicker, blindages stronger and trenches deeper and wider. Safe observation posts for sentries are obligatory. Men spaced at 2-pace intervals. "Refuges," *i.e.* trenches placed in rear and to the flanks, connected with the work, for accommodating three-quarters of its garrison during a bombardment, are obligatory. A work should contain living rooms for officers and men, dressing station, telephone office, store room for military stores, and latrine. There should be a supply of water and provisions, also repairing materials, sacks, poles, planks, etc. The drainage is important, and masking more important than with trenches.

Strong points (ring trenches) of the front line and rifle trenches must naturally support each other, the former being thrown slightly forward. If works of stronger profile are required in the front line, they must be open works—lunettes. Even on the flanks they should not be closed works, but should have closed works supporting them in rear. All the works of the second line should be closed works. Trenches between works may be somewhat concave in trace when viewed from the front.

iii. Machine-gun emplacements require the same conditions as rifle trenches, and especially an accurate knowledge of ranges. Owing to their mobility, machine guns should be provided with many spare emplacements.

iv. Artillery entrenchments require a distant field of fire up to 4,400 or 5,500 yards, and a near field of fire up to the guns themselves in exposed siting. There should be no dead ground. There should be protection for the detachments from all kinds of fire, masking, dummy screens, communications, and obstacles on three sides of the battery. Also in concealed siting the preparation of the foreground, observation stations, referring objects, etc.

v. Cover for reserves requires concealed siting, simplicity of design, convenience of communication with front and rear.

vi. Obstacles must be:—

(i.). Large enough in width, height and extent to form a real impediment.

(ii.). Round closed works they must be continuous;

(iii.). Their distance from the work (40 to 50 paces, and not more than 75 to 100) must not be too great to allow them to be conveniently observed and swept with frontal, and better still with flanking fire; but should be sufficient to safeguard the work from hand grenades thrown from beyond the obstacle.

(iv.). They must be of rapid construction, available materials and simple design.

(v.). Passages through them must be protected by traverses of the same obstacle.

(vi.). They should be especially designed against the means the enemy is likely to adopt for crossing them.

(vii.). They should be masked either by making them match their surroundings, or by the use of dummy screens.

(viii.). Portable obstacles should be simple, light and cheap; convenient for packing, fairly reliable for stopping the enemy, and capable of being set up quickly, and even in the immediate presence of the enemy.

FORTIFIED POSITIONS.

The author exemplifies these requirements by producing examples of:—

(i.). The provisional and

(ii.). The hasty defence of an imaginary piece of ground for a small force, consisting of 1 regiment (4 battalions) of infantry, 8 guns, 8 machine guns and 100 cavalry. The extent of front and the depth are each about 2,300 yards, which is about double those of former days, before the improvement in firearms required wider spacing.

In spite of the war experience that fortified positions are turned and are not attacked in front, the study of a position of this small extent is useful training. The position is suitable for the occupation of an advance or a rear guard, and as such it may be first met with by the enemy's advance guard. If it is strong enough to stop this, no turning movement on the part of the enemy will, probably, be possible until his main body begins to arrive. The delay thus caused will give time to the defenders to bring up their main body and to form on this convenient *point d'appui*, or to retire under its protection.

As regards the entrenching of large forces extending for several miles, the great fault of the Russian positions in the war, from first to last, was their continuity—they were uninterrupted, continuous lines of works. The correct method of entrenching a large force, and that long since adopted in Germany, is the line of so-called "tactical or strategic fortified groups," or "rayons."

These rayons are of greater or less extent according to circumstances, approximating to those shown in the examples. They are sited within supporting distance of one another. They require comparatively little labour in their construction, and do not impede the freedom of manœuvres of the army which rests on their support. The resistance which they offer to an advancing enemy will give the rest of their side time to form on them for defence, or to retire under their protection. But they must be held obstinately, and their defenders must pay no attention to local successes of the enemy in their vicinity. The defence of Sandepu against Grippenburg's attack, in January, 1905, is a good example of the value of such a *point d'appui*.

Occasions may occur when a second and even a third line of groups may be necessary; this is when both sides become involved in a war of positions, as occurred at Mukden, and which a commander should avoid by every means in his power.

Part II. deals with details of the construction and siting of the various elements of a fortified position.

Artillery Positions.

Chapter I. studies the tactical conditions of artillery positions. The Russians used exposed artillery positions in all the battles down to Telissu, and also at Port Arthur. In the fighting on 16th May, 1904, near Nanshan, a Russian battery had hardly appeared in an exposed position when it was struck by such a storm of shell fire from Japanese concealed batteries that in a quarter of an hour it lost all its officers and a half of its men, without firing a round.

The tactical considerations required in artillery positions are :—

(i.). The greatest possible field of fire both in width and depth; and

(ii.). The fullest co-operation of the fire of artillery with that of infantry, with a view to leaving no dead ground in front of the position.

Artillery positions may be "free," from which fire may be directed through a wide angle of front, or "restricted" to some definite object, such as the enfilading of an approach or the command of some river or ravine.

Concealed positions are only admissible when they satisfy these conditions. Otherwise the guns must be placed close behind the natural crest, for the abuse of concealed positions leads to an enormous expenditure of ammunition with little fire effect. Positions may be :—(i.). Open. (ii.). Masked. (iii.). Concealed.

In "*open*" positions, where the guns stand not more than $3\frac{1}{2}'$ below the crest, there is a large field of fire; direct laying; no necessity for special observers; no cover from the enemy's view and fire; difficulty and danger in occupying and evacuating the position.

"*Masked*" positions may defilade :—(*a*). A man standing ($5\frac{1}{2}'$). (*b*). A man on horseback ($8\frac{1}{2}'$). (*c*). The flash of a gun ($14'$ vertically below crest). In (*a*) the guns must be rolled up by hand, in (*b*) and (*c*) they can be drawn by horses. In (*a*) and (*b*) the flash is visible, in (*c*) only dust, and the smoke of bursts at the muzzle, which in Manchuria averaged from 2 to 3 per cent. In (*a*) the goniometer is not necessary, in (*b*) it is necessary, but the commander can watch the firing from a platform, and no special point to lay on is required, while (*c*) requires a specially prepared observing station. In all these positions the guns are discovered as soon as they open fire, and can be destroyed by the system of searching rectangles. This is avoided in "*concealed*" positions where the guns stand at a distance of 400 yards or more in rear of the crest.

Guns may be masked by woods, villages, buildings, bushes, crops, and hayricks, etc., and thus concealed positions may be found on level ground and even on the front slopes of hills. A succession of crests, or of other masks, is extremely favourable. Even concealed emplacements must be thoroughly entrenched, and every form of cover provided for the detachment. Shields only reinforce earth cover. Concealed positions require well-organized observation of fire, accurate passing of orders, and some technical preparation of the position and the ground in front.

There must be two observation stations for each battery or brigade, one to the front for the observers and the other near the battery for the commander. They may be placed on hills, in which case they require solid and well-masked, splinterproof cover, or in trees but not in isolated ones. Trees which just show over a crest or high buildings, preferably in the middle or back positions of villages, are also suitable. Artificially constructed observatories should be sited so as to admit of observation just over the crest line.

For communication, telephones should always be replaceable by visual signalling. Special signals are better than spelt-out words, being more rapid and less likely to be read by the enemy.

It is also necessary to select subsidiary points to lay on, and to prepare an accurate plan of the whole position. This is the duty of the artillery officers.

The war showed that batteries should be scattered as much as possible, and should be provided with spare emplacements to which the guns may be moved if the enemy discovers the original ones. On the flanks batteries should stand in echelon, to enable them to be swung round if necessary. This may also be necessary in front, where a wide field of fire is desirable.

The difficulty of sweeping with fire the dead ground in front of the guns, caused by the screen over which they are firing, may be met in various ways:—

(*a*). By selecting a position commanded by the enemy (the more the ground rises to the front the less dead ground there will be).

(*b*). By drawing back the battery, at a distance behind the crest of the screen.

(*c*). By posting infantry in the dead ground.

(*d*). By combining the positions of batteries in order to sweep one another's dead ground.

(*e*). By placing some of the guns in caponier positions to sweep the dead ground.

(*f*). By combining the posting of guns and infantry to allow of no dead ground. The last two methods are the most practicable.

Infantry standing 700 yards in front of artillery are safe from the effects of premature bursts of shrapnel. In this case the battery must be so sited that, at the least necessary elevation, its shells will clear the crest of the obstacle by twice a man's height. At this same least elevation they should strike the enemy not more than 1,600 yards in front of the defending infantry, *i.e.* the extreme effective range of the latter. Thus the site of the battery may be found experimentally, but the line of sight from it to the enemy's position should always pass 10′ to 14′ below the crest of the obstacle, to give the battery concealment from the enemy's balloons.

Experience showed that guns in concealed positions must cease firing on advancing infantry when it arrives within 600 yards of the defending infantry. It is then intended that two guns out of each 8-gun battery shall be rolled up to a direct position. It is doubtful whether this would be possible, as they would be overwhelmed by the enemy's artillery fire. It is suggested that it would be better to detach some guns from the first for this object, and to put them in carefully concealed positions, where they would lie hidden until required for this special object.

The infantry escorts, at the rate of half a (double) company per battery, should be placed under the orders of the artillery commander, and can be used by him if necessary for replacing casualties among the ammunition numbers, etc. The escorts must entrench themselves where they can best protect the battery; in the case of concealed positions this will probably be on the covering crest, in front of the flanks, and in front-line batteries, to right and left of the emplacements.

The use of dummy batteries, and the careful disguising of actual ones, were fully emphasized during the war on numerous occasions.

The use of "scouting sections" of artillery, *i.e.* the detachment of a few guns into false positions in advance of the flanks, is advised. These positions should be carefully concealed and arrangements should be made for the rapid transference of the guns from one place to another.

Guns of heavier calibres are best sited on the flanks. They require good roads of approach and firm ground, and all the other conditions of ordinary gun positions. In every group of heavy guns it is advisable to add a few machine or field guns for use at close ranges.

Cover for Guns.

The next chapter deals with modern designs for artillery entrenchments. On all occasions entrenching, if not for guns, at any rate for the detachments, is obligatory. The best type is that which provides a separate emplacement for each gun, at intervals of not less than 30 paces. The posting of guns in pairs is not so good, and in battery behind a single bank, worst of all. In these latter cases intervals between guns should be from 13 to 17 paces.

Emplacements may be made for:—(i.). Gun, detachment and wagon, or (ii.). Gun and detachment only, with recesses to take the removable trays containing ammunition. The first should be the normal type, the second only being suitable to the advanced emplacements, with a view to not sacrificing the wagon as well as the gun in case of accident.

When guns are posted at wide intervals it may be necessary, with a view to their concealment from balloon observers, to connect them with a dummy parapet of brushwood or sods, which horses can push their way through if necessary.

The interval between guns in echelon depends on the distance (front to rear) and on the required angle of training, to which must be added half the cone of dispersion of shrapnel bursting at the muzzle. If the required angle is 60° then :—

With distance		15	paces,	interval must be		60	paces	These figures are approximate and each includes 12 paces as half the width of emplacements.
,,	,,	30	,,	,,	,,	90	,,	
,,	,,	45	,,	,,	,,	120	,,	
,,	,,	60	,,	,,	,,	150	,,	

With an angle of 45° the intervals would be 35, 55, 75, 95 paces.
,, ,, 30° ,, ,, 30, 50, 70, 90 ,,

Howitzers require especially large gun platforms—a circle of 8 paces diameter, or a rectangle 8 paces by 4 paces. With mélinite charges they require cover for those making up the charges. Whereas artillery detachment trenches require overhead cover and blindages like rifle trenches, it is not generally advisable to attempt to protect the guns themselves in this way.

It should not be necessary to entrench the wagons of the reserve artillery park or any limbers, natural cover should be available for them in rear of the position.

RIFLE TRENCHES.

Trenches sited at the foot of a slope get the advantage of the full range of point-blank fire, but are difficult to connect with the rear. They are allowable when they can make full use of point-blank range, when communication is possible with the rear by means of folds in the ground, diagonally to the front, and when they are not commanded by the enemy. The parapets should be kept low, unless it is necessary to see over bushes or crops in front, or the soil is hard, clayey, rocky or full of roots.

Great lengths of trench are not advised ; they are difficult to apply to the ground and difficult to conceal ; if the range of one part is found, the whole is under fire ; if the enemy gets into one length anywhere, he spreads along the whole. A half-company trench, 150 to 200 paces in length, is about the limit.

There should be communication trenches to the rear, and in provisional fortification a communication trench parallel to the front behind a reverse slope, which would serve as cover and might be fitted with blindages. The garrisons of the front trenches could use it as a "refuge" during artillery bombardment. The sentries left in the front trenches should have specially strengthened, roofed, lookouts.

Boer rifle pits are not recommended. Supervision is lost, the men are separated and the position only thinly held.

There should be three to four sentry lookouts in each company trench. There must be lookouts at the ends to watch the flanks. The angle of a traverse is a good place for the recess, which must be strongly roofed, with a wide-angle observing slot (60° to 90°), and splinterproof shield at the back. The top of roof must not rise above the parapet. A stool for the observer is a convenience.

Cartridge recesses are easily made by knocking the bottom out of a cartridge box, and using the sides for revetting the recess. Allowance for 300 cartridges for each rifleman should be made. By pulling out a sod or two from the revetment of the interior slope, expense recesses for a few cartridges, or food, may be made.

When concealing trenches, it should be remembered that observers in balloons may attain the angle of 1 in 4, though more generally they are at 1 in 7, or 1 in 8. The back slopes of trenches facing the front must be disguised accordingly, while trenches at an angle to the front may require to be completely prepared for concealment.

Communication trenches should have the greatest possible relief, and should be as narrow as possible—2½′—provided a wounded man can be carried along them. A narrow trench is more quickly made than a wide one, and affords those passing along it better cover. At intervals of 10 to 15 paces, lengths of 4 paces should be widened to double width, to allow stretchers to pass one another. In the intervals between them there should be occasional niches, to allow men to pass.

There should be a large allowance of reserve trenches, and in these all forms of head cover may be omitted, as they will only be occupied in the later stages of the action.

Cover for Machine Guns.

The Russians had carriage mountings with shields, as well as pack mountings for their machine guns. Neither of these was quite satisfactory, and a low sledge mounting, which was improvised, was used with success. Sledge mountings are inconspicuous, light, very mobile, can be carried, or pulled, or mounted on pack animals or in carts, as desired.

Redoubts.

The thickness of parapets in Manchuria amounted to as much as 14′, 16′ and even 18′. The height should not exceed 2·9′ to 3·5′. The interior trench may be deepened to 7′, and the spare earth may be used as a rear traverse to protect against splinters. Outside ditches are the simplest of obstacles.

Sometimes the ditch is replaced by a belt of entanglement, sometimes the latter is added at a distance of 40 to 60 paces from the ditch as a protection against hand grenades. The Japanese attacks on redoubts in Manchuria were always preceded by a storm of hand grenades.

The most suitable shape of a redoubt is that which conforms best to the shape of the ground, in irregular curves, or broken lines with rounded angles, as flat as possible as a protection against the enemy's artillery fire. A broken gorge can be used for flanking the interval between one redoubt and the next.

Redoubts are nowadays so choked with traverses, blindages, etc., that the bayonet fight cannot take place within them. The front parapet is the place for this and steps must be arranged for the defenders to climb out to meet the attack. For this purpose stakes are driven in to act as steps, or stakes with wire, or poles, stretched between them. There is no use in preparing the gorge traverse to bring fire to bear on the interior of the work; it must however be made high enough to cover the defenders of the gorge from reverse fire.

Communication trenches across the rear of open works should have the rear side sloped off, so as to give no cover to the enemy if occupied.

"Whiskers," or *wing* trenches, gained a certain amount of popularity, partly because they gave some protection to the defenders of the work during a bombardment, and partly because they increased the development of frontal fire. They should not cut through the obstacle zone, and are better placed outside it with no connection with the redoubt except by the rear.

Large traverses must be placed at 12 to 15-pace intervals, and light splinterproof ones at an interval of 6 to 12-pace.

Some authorities say that rear traverses, as a defence against back blast, are as necessary in front faces as in the gorge, but they encumber the work and would give good cover to the enemy in a successful assault.

Observation posts for sentries must be supplied at the rate of not less that one in each face and flank, and possibly in the gorge also.

Blindage roofs, proof against high explosive shells, were made with a double layer of $8\frac{3}{4}''$ beams, and not less than $3\frac{1}{2}'$ of earth. Those proof against the shells of light field howitzers, were of two rows of $14''$ beams and $4{\cdot}7'$ to $5{\cdot}9'$ of earth. In order to burst the enemy's shells on the surface, they were generally covered with a layer of broken stones or iron plates, the latter being fastened down with pickets.

In works of this description communication trenches should be rather larger than usual, to allow of the more rapid transference of men from the "refuges" into the firing line.

The necessity of having in the work a small store of repairing materials is strongly urged. A supply of hand grenades, and niches for storing them in, are also required.

Searchlights should not be placed in works, but in the intervals between them. Telephone communication with the rear and with neighbouring works should be arranged if possible.

OBSTACLES.

In Manchuria obstacles of wire and explosives were most used. Those of timber and earth were more rarely met with, the first because of the scarcity of timber, and the latter because of the hardness of the frozen ground, and also from their weakness as independent obstacles. Stakes placed chequerwise, palisades, dams with inundations, and shallow military pits were never used.

Passages, of 7 to 25 yards in width, left through continuous lines of obstacles, may be covered by a traverse of the same obstacle placed in rear of the gap, or by letting the two ends overlap for some 12 to 24 yards.

Deep military pits, by themselves, are easily passed and may be used by the enemy to form a "storming parallel," as happened at Liao-Yang. They take very long to make, especially in hard ground, and their one advantage is that material for their construction is always available. Combined with even a weak wire entanglement they form a more useful obstacle. They should be made in not less than four rows, with steep sides and narrow intervals, and if they can be flooded with rain water, with stakes standing in them, they make quite a formidable obstacle.

Wire entanglements are better obstacles, especially with barbed wire. They have the advantage of being very little damaged by artillery fire, even when they are standing fully exposed in the open. The only effective means of making passages through them is by sending up men with wire cutters. If the entanglement is combined with pits, the men can find cover in the latter, but otherwise the Japanese used shields.

The Japanese wire cutters had handles about $4\frac{2}{3}'$ long. Capt. Modrakh has invented a simple cutter, which fitted on the end of a rifle, like a bayonet, can cut both loose and tight wires simply by stabbing at them. This invention has the advantage that the man using it is not disarmed, as he must be when using both hands with cutting pliers. The conclusion of peace before the invention was perfected, prevented it from being extensively tested.

The idea of cutting down wire entanglements by machine-gun fire, or covering them with bridges or such like, is impracticable.

A belt of obstacle is better 28′, than 21′, in thickness. It is better not to put the obstacle in a shallow trench with a glacis. But a concealed obstacle, which comes as surprise to the enemy, is of great value. Some concealment is obtained by coating light-coloured stakes with mud, or grass, or brushwood. They are best placed behind such cover as bushes or crops, which must not however conceal them from the defenders. If the bushes are themselves entangled with wire they form an obstacle very difficult to discover. In less important localities, and against cavalry, this obstacle may be quite low. When material is scarce, two or three rows of wire fence, with the wires not more than 7″ apart, form a good obstacle.

If the supply of barbed wire is limited, the front row or the top and bottom horizontal lines should be made of it. Even cord has been used in entanglements on emergency.

The Japanese made some use of abattis. Its chief fault is the difficulty of concealment.

Electrically fired land mines and fougasses were extensively used and were very effective against attacks. Solitary mines do not stop an attack, there must be several rows, placed chequerwise, with 12 to 24 yards between rows.

Automatic mines were also used. "Shrapnel" mines threw bodies like shrapnel shells into the air, where they exploded on reaching the extent of some 10′ to 20′ of wire, by which they were attached to the ground. "Repeating" mines were arranged to fire three charges, the second 3′ below the first, and so on at intervals of 10 minutes. These were intended to destroy men who took shelter in the craters.

The following portable obstacles were extensively used :—

Chevaux-de-frise entwined with barbed wire.

Crow's feet chevaux-de-frise, made of three 6′ stakes, pointed at both ends, and fastened together at the middle, at right angles to one another.

Planks, studded with nails on both sides, either straight or in crosses.

Snares of thick wire, used in connection with the studded planks.

The chevaux-de-frise and crow's feet are useful for making obstacles on ice or frozen ground, or for erecting an obstacle in front of a ditch, in the presence of the enemy. When placed, they must be anchored to pickets and entangled. The nail planks are suitable for exterior slopes of parapets or for the banks of rivers, under thin ice. They were used at Port Arthur.

The Russian hand grenades had wooden handles, and the charge vessel was surrounded by two heavy lead rings. Their range was about 60 paces, while the broken fragments of the rings flew as far as 400 paces. The grenades were fitted with safety catches for convenience of transport.

Entrenching Tools.

Tools must be of the best quality, heads of the best steel and helves of strong wood (beech or oak) or hollow steel. The helve should not be too short.

Infantry should carry—besides picks and shovels—axes, saws and wedges, chiefly for use with firewood, augers for use with trenails, tracing-tapes and compasses. Every officer and man should carry something.

Full-sized entrenching tools should be carried in light carts, or on pack animals, immediately in rear of the regiment.

Share of Engineers in the Construction of Defences.

The want of an authoritative statement as to the share required of engineer troops in the fortification of positions has led to many unfortunate misunderstandings, infantry has waited for engineer troops to make cover for them instead of setting to work themselves, with the result of quite unnecessary losses.

The experience of the war has shown how technical troops and appliances should be utilized, and whose duty it is to arrange for their use under various conditions.

In the case of hasty fortification, especially with a small force, the work must be done by the infantry themselves, from their own designs and under their own officers. The commandant of the force, with commanders of units, and artillery and engineer officers (if any), will carry out the reconnaissance of the position, and decide on the spot the general scheme of defence viz. :—artillery positions, sites of strong points on flanks and centre, general position of main defensive line, reserve and echeloned flank positions, advance posts, rear positions, specially important items in each section and what sections are most important to the scheme of operations.

The decision as to smaller details is the right and the duty of the section commanders. All officers should understand nowadays therefore the details of fortification of positions. Only theoretical and practical training on manœuvres can teach the army the peculiar faculty and aptitude for entrenching which was so lacking in the war. Eye-witnesses said that the troops dug well enough, but could not combine their work with tactical operations, the knowledge not only of *digging* but also of *fortifying a position* being possessed by few.

If there are engineers in the force, their *rôle* is that of skilled assistants, to assist those in charge in their calculations and instructions, in checking the accuracy of the work, and in avoiding mistakes. Engineer officers, if available, will be placed at the disposal of, and be subordinate to the commanders of sections; they cannot interfere with the responsibility of the commandant and the sectional commanders. Their men will be employed as the commandant may decide. They may deal with approaches or communications, or with rear or reserve positions, or with the defences of specially important strong points.

In the case of provisionally fortified positions, the engineers will draw out the project of defence in all its details and apply it to the ground, laying out all the work, (except the rifle trenches, which will be traced by the company commanders) and carrying out much of it themselves. The troops in this case provide working parties, and their commanders are only responsible for the accurate carrying out of the work allotted them by the engineers.

Special Occasions for the Use of Fortifications.

In an appendix the author enumerates some special occasions for fortifying field positions.

Positions for the Defence of Defiles.—Defiles may be open (river crossings), or concealed (mountain passes). These positions are required either to allow advancing troops to deploy from the march into battle order, or to allow retiring troops to close. In order to protect the mouth of the defile from the enemy's shrapnel fire, the position should be 3 versts (3,600 yards) in front of it.

When the enemy can advance up both banks of a river, the position covering the defile becomes a double *tête du pont*.

A position in rear of an open defile is intended to prevent the enemy from using it. The position should then be within the range of effective rifle and artillery fire from the defile. It is more effective if the obstacle (stream or marsh) takes a curve concave to the direction of the attack.

Positions in rear of concealed defiles are intended to prevent the enemy from debouching from them. The works should be protected against plunging fire.

A position within a defile is intended to obstruct the enemy's advance. It should be placed where the defile widens out or where two or more defiles join. A good réduit, or keep, is necessary to cover retirement, which is difficult.

Points of Disembarkation.—These positions are taken up and entrenched by the first troops who get ashore. The flanks may be protected by the guns of the fleet. With large forces there should be several lines, with a strong réduit to facilitate re-embarkation. A position to oppose a landing is fortified like one in rear of an open defile.

Posts on Lines of Communication.—These include the base or "initial" station, the "head" station, "intermediate" stations, and sometimes also "concentration" stations, at railhead or where field operations begin. They must be protected from all sides, usually by girdles of detached strong points. A strong réduit, so sited that it will command the interior of all the other works is very important.

Positions covering railway stations, tunnels, and railway bridges, are similar to small posts on the lines of communication, blockhouses taking the place of strong points. Communication by telegraph or signal with the neighbouring points on the same railway line is important.

Fieldworks in the Attack of Fortified Positions.—Now that an attack lasts several days, the attacking troops must entrench in front of the defensive position, especially if their line of advance is obstructed, for instance by a defile. Such entrenchment will be used by the holding attack during a turning movement, which may last several days.

Parties of troops who have seized on some important tactical point in the enemy's position will entrench themselves while waiting for reinforcements.

The attacking troops should also prepare a rear position for use against a counter-attack, in the line of their first artillery position. From this they would work forward to the second artillery position, the whole operation being similar to the siege of a fortress.

ENGINEER TROOPS IN THE ATTACK.

Engineer troops in the attack will:—

(i.). Arrange for the passage of natural and artificial obstacles.
(ii.) Prepare approaches to artillery and rifle positions.
(iii.). Put in a state of defence important points captured from the enemy.

The reconnaissance of obstacles, and of the ground nearest to the enemy's works, is the duty of engineer officers. It is carried out by night by special reconnoitring parties, or by day, possibly, from observatories and balloons.

THE NEW GERMAN INSTRUCTIONS FOR FORTRESS (SIEGE) OPERATIONS.

(A *précis* of a notice appearing in the *Militär-Wochenblatt*, No. 132, of the 22nd October, 1910).

The publication of these *Instructions* fulfils a long-felt want. As the greater part of any force, put into the field in any future war, will have to deal more or less with fortresses, the issue of such regulations was absolutely essential. The training of all ranks and all arms in this important branch of military operations should be at least equal to that given with regard to other forms of military work.

It is interesting to compare these regulations with those issued in France, which were discussed in previous numbers of this paper.* The main principles are the same, and it is therefore scarcely surprising that the views expressed should, in most cases, be very similar in both countries. Both condemn a purely passive defence, and both consider that the closest possible co-operation of all arms alone holds out prospects of success.

The new German *Instructions* deal fully with the latest developments (*e.g.* wireless telegraphy, airships, aeroplanes, motors, etc.) likely to be of special importance in fortress warfare. It is pointed out that the attack of a fortress must as a rule depend upon purely military considerations. The fall of a fortress can only have a decisive effect upon a campaign, if the enemy's field army is seriously compromised thereby. It is also pointed out, in the introduction, that though the use of heavier armament may modify the outward and visible forms of tactics, the general principles of attack and defence remain essentially the same.

The first part deals with the attack. As a rule a formal siege can alone promise a successful issue. The enhanced importance of heavy artillery, engineers, and communication troops, is also alluded to.

The disposition of the besieging force must be as simple as possible. Various "sections" will be allotted to army corps, divisions, or brigades as the case may be. Those in which the decisive attack is to be made will be strongly occupied, while the others will be reduced by their comparative weakness to more exclusively defensive operations.

Great emphasis is laid upon the necessity for simplicity and method in organization, and upon unity of command. There are to be no semi-independent commanders of special arms (*e.g.* of heavy artillery or engineers) such as are contemplated in the French regulations. Such specialized arms will be represented on the staff of the officer commanding a "section," but he alone remains responsible for their employment.

* *Vide Militär-Wochenblatt*, Nos. 6, 7, 9 and 10, of 1910.

The work and responsibility of a divisional commander are thus greatly increased (and with them, the necessity for previous tactical training), but such unity of command will ensure the close co-operation of all concerned.

It is pointed out that in some respects the choice of direction and method of attack is more restricted than in the case of ordinary field operations. In addition to considerations as to the general situation and the necessity for attacking a decisive point, the question of communications becomes a ruling factor. The colossal traffic, involved in modern siege armament, can only be successfully coped with by full-gauge permanent railways, which therefore largely decide the direction of the attack. It is essential that the operations should be correctly planned from the outset; hence the importance of full and accurate preliminary reconnaissance, in which full use will be made of airships, aeroplanes, etc.

An energetic advance to within the closest possible distance of the fortress will tend to facilitate and expedite subsequent operations. On the other hand the defender will probably have the advantage during this early phase, and the attacker may be thrown on the defensive—in which case he must select the best available line beyond the range of the artillery in the enemy's main position. These two principles are contradictory, but the *Instructions* leave it to the General Officer Commanding to do the best he can—*i.e.* to push forward as far as possible, without incurring useless losses.

As soon as it has been decided to attack a fortress, all arrangements must be made in the most methodical manner possible. Precise and suitable organization of troops, ground, transport, supplies, etc., and, above all, good communications of all kinds are essential. Accurate arrangements and clear orders can alone ensure smooth and expeditious handling of the enormous transport connected with a modern siege.

The duties to be carried out by the leaders and by the troops during the battle are then described in the German *Instructions*.

They point out once again that the difficulties of the attack are so great that they can only be overcome by the combined action of all arms working together for a common purpose, that infantry, though the chief factor in forcing a decision, is powerless to gain ground unless effectively supported by the other arms.

In the attack, the method of progression of the infantry is different to what it is in field operations. In field operations infantry move forward by sudden rushes from one position to another; in the attack on a fortress the infantry advance is most deliberate, and needs the assistance of both spade and rifle, and, while this advance is taking place, a number of guns, rifles and machine-guns superior to that of the defence must strive their utmost to keep down the fire of the enemy. As it is essential for all arms to work together in battle, the German *Instructions* point out how necessary it is for each arm to have a clear comprehension of the conditions under which the other arms fight, and a knowledge of the effect to be obtained from their fire. All arms must therefore be trained to work in combination in peace, so as to be ready for what occurs in war.

The duties assigned by the German *Instructions* to the leaders are by no means easy to carry out. The leaders are responsible that the attack never flags. The difficulty of their task becomes apparent when it is realized that the battle will be of long duration, and that the increased effect of fire will compel the attacking infantry to advance by night and to resort to the laborious process of digging its way to the front.

The increased fire effect of modern weapons will also enable the defender to maintain himself in his advanced positions for a greater length of time than before, and will prevent the artillery of the attack from approaching to within effective range of the defender's main position. Consequently the attempt to capture the advanced positions will entail a fiercer struggle than hitherto, and it may be necessary to bring into action some of the heavy artillery of the field army in order to support the attack. As ammunition would also be required for this heavy artillery, such a procedure would occasion, at the very least, a loss of time and strength.

The German *Instructions* likewise state that the fight for the advanced positions will be particularly strenuous when those positions are situated so close to the defender's main position that his batteries in that position can join in the fight. So it may be necessary, even in these preliminary stages of the battle, to bring some of the siege guns of the attack into action.

The deployment of the artillery for the attack of the defender's main position forms, according to the German *Instructions*, the first phase of the final contest. For the advance of the infantry is of course quite out of the question until the guns are ready to open fire. But before the guns are in a position to commence firing much time must necessarily elapse, owing chiefly to the vast amount of ammunition which has to be collected. To open fire with single batteries as they become ready for action would involve defeat in detail, as the batteries would be overwhelmed by the concentrated fire of a superior number of guns. The artillery of the attack should not then come into action until it has sufficient ammunition and sufficient guns of sufficient calibre to engage the enemy, or until such time as the remainder of the artillery is ready to take part in the fight.

The opening of fire by the artillery is the signal for the infantry to advance at once and to push forward boldly. But not for long; a slower rate of progression will soon have to be adopted to avoid heavy losses, and this same reason will necessitate supports being moved forward only under cover of darkness.

To ensure all forward movements taking place simultaneously, all orders for the advance on the battlefield will be issued by the Commander-in-Chief, but the method of advance is of course left to section or other subordinate commanders. Should the enemy's fire render the usual method of advance impracticable, then recourse must be had to the wearisome method of advancing by sap. Such a course would be rendered necessary if the heavy artillery, together with the advanced field batteries of the attack, had failed to cope with the heavy armament of the defence. Such a case would be particularly likely to occur if the defender kept some of his batteries in rear of his main position, and so far back as to be out of range of the artillery of the attack. Under these conditions it would again be necessary to push forward some of the heavy batteries of the attack to enable the attacking infantry to continue its advance. Thus, in opposition to former ideas, the artillery of the attack will in future come into action at various stages of the battle, viz. (1) against the enemy's advanced positions, (2) against his main position and (3) against the batteries in rear of his position.

The German *Instructions* then deal with the support to be rendered by the engineers. The closer the attack approaches to the enemy's works, the greater will be the resistance met with. These works will probably be so powerfully constructed that artillery at a distance will be unable to destroy them. The infantry will find it impossible to force its way into the enemy's position unaided, and assaults by infantry at a distance of 150 or 200 yards are no longer feasible. Now is the time for the engineers to take an active share in the struggle. Under cover of infantry and machine-gun fire they will have to work their way right up to the enemy's positions.

Even then it is almost impossible to carry by assault a work which has not been destroyed. This work of destruction cannot be accomplished by the artillery for fear of hitting one's own side. It rests then with the infantry and the engineers to provide themselves with, and to bring into use the necessary engines of destruction.

It will thus be seen that the co-operation of all arms is necessary even in the final stages of the battle to overcome the defender's last efforts of resistance.

Part II. of the German *Instructions* deals with the defence of a fortress.

The greater fire effect of modern weapons enables the defender to hold on to his advanced positions for a greater length of time than before, provided these positions are within effective range of the guns in his main position. Heavy artillery should not as a rule be placed in the advanced positions, but mobile batteries of the field artillery reserve might, with advantage, be pushed forward in front of the main position, and without incurring great danger. They would be protected by the guns of the heavy artillery.

The German *Instructions* point out that advanced positions are of great value for enabling the defender to discover his adversary's line of attack, and for preventing the enemy from seizing advantageous ground on which he could deploy his artillery within decisive range of the defender's position.

Should the defender compel the enemy to take up his line of investment at a considerable distance from the position to be attacked, to bring his heavy artillery into action against the advanced positions, and to fight a prolonged action to gain a favourable position for his artillery, he will not only have gained time but will have compelled a force, probably superior in numbers to his own, to be so tied down by the attack of the fortress that the plans of the chief commander of the enemy's main army in the field must be adversely affected thereby. Though the defender must offer a stubborn resistance, it is of great importance, both from a moral and a material point of view, that he should constantly adopt the offensive. The proper time to do this is when the assailants are still at a sufficient distance from the defender's mobile artillery, to enable this artillery to be brought into action against them without fear of its being cut off from the fortress.

The German *Instructions* state that the final decision should be sought for in the main position. Here they differ from the French *Instructions* which lay down that, when the governor of a fortress has come to the conclusion that the enemy is about to assault his *centre de résistance*, he orders that position to be evacuated and a fresh position to be taken up in the *position de soutien*. There is much to be said in favour of the French method. Its drawbacks are the following:—The danger of retiring too soon from the main position; the dividing up of forces (for some of the artillery must be kept in the rear position), and the consequent risk of the batteries in front being overwhelmed by superior artillery fire.

Finally the German *Instructions* deal with the methods of meeting the final assault. A successful result is only to be obtained by the most intimate co-operation of all arms in addition to the assistance to be rendered by neighbouring sections and by the general reserve. Works which have been captured must be recaptured, and every effort must be made to save the main position from falling into the enemy's hands. Even should this occur, the fight must not be considered at an end. Intermediate positions in rear must be occupied, and the flanks made to rest on works in the front line which are still holding out.

USE OF SAP ROLLERS IN THE RUSSO-JAPANESE WAR.

Précis of an article in the *Injenerni Jurnal*, No. 11, 1910.

THE following is the description of a method of constructing sandbag breastworks, when in close proximity to the enemy, with the aid of sap rollers.

This device was used successfully with the 3rd Infantry Division of the Russian Army on the Sha Ho in November, 1904. The opposing forces were so close to each other (250—300 yards) that the operations were carried out almost under siege conditions. The ground was frozen to a depth of 3′ 6″, and attempts to construct flying saps had proved futile. The sap rollers described below were then resorted to. The rollers were made of iron or steel plate. (Thickness not stated). Each roller was 7′ long and 6′ in diameter. Two men could propel the roller easily over level ground. The method of employment is shown in the *Plate*. Briefly stated, the procedure was as follows:—

Three rollers were pushed out during the dark to the relative positions indicated on the *Plate*, and the following detachments were posted:—

8 men to No. 1 roller.
4 men to No. 2 roller.
2 men to No. 3 roller.

Three trucks, A, B, and C, were also placed in position.

The detachment of No. 1 roller took with them the ends of three ropes destined for use with trucks A, B, and C respectively; and, the detachment of No. 2 roller took the end of a rope for use also with truck A.

The ropes were marked at regular intervals so as to ensure that the correct distances were observed in the dark. When the rollers were in position, detachment No. 1 drew out truck A, which was loaded with sandbags. Under cover of the roller, the truck was turned so as to be able to travel towards No. 2 roller, and pulled by No. 2 detachment, until just clear of No. 1 roller. Further supplies of sandbags were packed on trucks B and C and drawn out alternately to roller A, where they were off-loaded, and built into a breastwork by men working behind cover of truck A. As soon as the breastwork was completed behind truck A, detachment No. 2 would be signalled to draw this truck forward for its own length, and the process of building the breastwork was continued.

Casualties were replaced, and wounded men withdrawn by means of trucks B and C, which were only half loaded in such a case.

NOTICES OF MAGAZINES.

Neue Militärische Blätter.

The Panama Canal and its Military Importance.—The construction of this canal has been so arduously pushed forward since 1907, that its opening is to take place in 1913, instead of on the 1st January, 1915, as the American Congress had announced.

Colonel Goethalz, of the American Military Engineering Department, who was entrusted with the undertaking in 1907, has freed from mosquitoes the strip of territory 10 k.m. wide which the U.S.A. possess on either side of the canal, built small townships all along the canal for the 44,000 labourers—of whom about 8,000 are whites and the remainder half castes, natives, Chinese and Japanese—constructed bakeries, washing establishments and other such necessary public establishments for them, and last but not least, has arranged for food and clothing to be supplied to them at cost price.

It was a moot point at first whether the canal was to be constructed at the same level throughout, or whether locks were to be employed. The former plan had been tried by the original Panama Company of 1881, which failed, and as it entailed an expenditure of time and money almost double that required by the second plan, it was abandoned. The canal will cost when finished 375,000,000 dollars, or £75,000,000, Its length will be 75 k.m., *i.e.*, 12 k.m. from Colon on the Atlantic Ocean to Gatun (this stretch is already navigable), then 15 k.m. in the Chagres Valley to Bohio Soldado, where the first lock is 20 k.m. further; at Obispo is the second lock, and the third, fourth and fifth in a stretch 13 k.m. long between Culebra, Pedro Miguel and Miraflores. The canal enters the Pacific Ocean at La Boca, 7 k.m. below Miraflores and flows for a length of 6 k.m. between two retaining walls into the deep water.

The question of the fortification of the canal has been the subject of heated debates in the American Parliament. Effective fortification will cost 14,000,000 dollars, and the proposal to make the canal neutral finds many partisans. The obvious disadvantage of this scheme is that it deprives the U.S.A. of all the strategical advantages which the construction of the canal would otherwise give them. Warships emerging from it are entirely at the mercy of the enemy whilst so doing, if they are not protected by land batteries. When protected, on the other hand, it is possible for the American fleet to pass from one ocean to the other and form up in battle array under the cover of the guns on the mainland, to oppose any enemy attempting to capture this vital artery. The canal will also allow the Americans of the eastern provinces to compete seriously with the English and Germans on the west coast of South America. Owing to the time (four months) taken and the risks incurred by ships in going round Cape Horn, the two countries mentioned above possess almost all the trade in western South America.

The proposed works consist of three batteries on the heights behind Colon, and of three batteries on the mainland on the Pacific side, and of the fortification of three islands near the heads of the retaining walls.

MILITARY NEWS FROM DIVERS FOREIGN COUNTRIES.—(1). *France.*—It is proposed to create an Inspector-General of Military Aeronautics who will have under his command all the aerial means of locomotion in use in the French Army, and the troops allotted to them. It is proposed to slightly diminish the number of officers who pass through the Staff College, and at the same time to increase the number of officers attached to the General Staff. The attached officers will be employed solely for office work, and by this means it is proposed to liberate from office work a large number of qualified staff officers, who will devote themselves solely to work in the field, and to the preparation for war.

A school for the higher professional education of field officers has been instituted, and on the 15th January, 1911, the first course begins. The class is composed of 20 colonels and majors, who are under the direction of the Commandant of the Staff College, and will be instructed by staff officers.

Norway.—Reorganization of the Army.—Before its separation, Norway relied almost entirely on Sweden to provide the defensive forces of the realm, and consequently has recently found itself under the necessity of drawing up a reorganization scheme for its army. This is to become law on the 1st January, 1911, and is very much on the following lines.

The army remains a militia force, with only weak "cadres" of professional soldiers. The levies pass through recruits' schools, are then dismissed, and later on undergo refresher courses. (Universal military service exists in Norway).

The army consists of the 1st Line, in which the time of service is 12 years; the 2nd Line (Landwehr), which cannot be employed outside Norway without the consent of the Storthing and of which the time service is 8 years, and the Landsturm in which all Norwegians between 18 and 50 are incorporated unless they belong to either of the above categories, and which would in case of need serve to replace casualties.

The permanent "cadres" consist of 1,700 officers, 2,700 N.C.O.'s and 2,100 men; the average number of recruits trained in a year is 11,000 or 0·44 per cent. of the population; when the Landwehr is also called out for refresher exercises, the strength of the army amounts to about 25,000 or 35,000 men, *i.e.* 1·12 per cent. to 1·5 per cent. of the population. The periods of training for recruits of the different arms are as follows:—Infantry, 72 days; cavalry, 126 days; field artillery, 114 days; fortress artillery, 72 days; engineers, 84 days; cyclists, 72 days. The refresher courses last 24 days. The times are very short.

Officers are trained in the Military College, which has two classes. The first class is followed by both professional and reserve officers, and lasts one year; the second lasts two years, and is solely for professional officers. Before entering the Military College, officers must go through the recruits' training in the ranks.

N.C.O.'s are selected from the ranks, and are trained in N.C.O.'s schools for four years. There is a higher military school with two subdivisions, one or the other of which is visited for 18 months—to train officers for the General Staff or for the Artillery and Engineer Staffs.

Up to now, the highest unit in the Norwegian Army has been the battalion; regiments of 3 battalions are now instituted. The land is divided into 6 brigade recruiting districts, which are further subdivided into regimental, battalion and company districts. There are to be 16 regiments, each consisting of 3 Line and 1 Landwehr battalions. The cavalry consists of 3 dragoon regiments (16 squadrons), and the field artillery of 3 brigades, or 27 batteries of 6 guns. The foot artillery consists of 4 companies armed with the 10·5-c.m. gun and the 12-c.m. howitzer, the mountain artillery of 3 batteries of 8 guns, the fortress artillery of 6 batteries, 1 independent company, 1 detachment, 5 signal and 5 mining detachments; the engineers of 1 sapper battalion of 5 companies, 1 telegraph battalion of 5 companies, and 2 bridging companies.

There are six machine-gun infantry sections of 4 guns each, and three cavalry ones of which two have 8 and one 4 guns. The cyclist companies become ski companies in the winter, are five in number, and are allotted to the cavalry.

The strength of units is as follows:—Infantry battalion, 986; squadron, 129; cyclist company, 126; field battery, 135; mountain battery, 158.

The field artillery is armed with the 1901 7·5-Q.F. gun (with long recoil); rate of fire, 20 shots per minute.

The present war strength of a brigade is laid down at:—2 or 3 infantry regiments; 1 cyclist or ski company; 1 machine company (dismounted); 3 or 4 squadrons cavalry with a mounted M.G. section; 4 or 5 batteries field artillery; 1 sapper company; 1 telegraph company; 1 company medical troops (bearer company); 4 or 5 field hospital detachments.

Russia.—A permanent airship committee of engineer officers is to be created.

£15,000 have been voted by the Russian Ministry of the Interior for the preparatory works of a railway through the Caucasus. Hitherto this project has not been carried out, owing to the insufficient knowledge of Russian engineers in the geology of the Caucasus and to their lack of skill in constructing tunnels. This scheme involves the construction of a tunnel 23·5 k.m. long. The railway would shorten the journey to Tiflis by 800 k.m. and thus, in case of trouble in Persia, troops could be brought up in a considerably shorter time than at present.

Football in the German Army and Navy.—The importance of sports is being more and more recognized daily in the German Army and Navy. Up to the present the great fear has apparently been that the mingling of N.C.O.'s and men on the football field would lessen the authority of the former over the latter, and thus be subversive to discipline. The captain of a company of the 116th Infantry Regiment at Mulheim on the Rhein has tried the system of encouraging his men to play football, and describes the results of his three years' experiences at great length. He is perfectly satisfied, finds that not only are his men more active on field days, but also that the ill-temper and lack of patience of the N.C.O.'s has disappeared, now that they are able to take healthy exercise after their long hours of wearisome drilling of recruits on the barrack square. The sense of discipline, far from being lessened, is increased. In the navy, football has for some time past played an important part, and every ship has, since 1908, its football team, whilst the game itself is looked upon as being of as great importance as gymnastics or physical drill. A league exists in the navy, the ships are played off against one another by squadrons, and the squadron teams compete for the Deutschland Shield, which was founded by Prince Henry. The marines also play football with great regularity.

New Terms in Aeronautics.—To comply with the modern spirit in Germany, *i.e.* to avoid as much as possible the use of foreign words, the Airship Association has invented a list of new words, for aeronauts, which are to replace the hitherto employed words of French extraction. These new expressions are as follows:—Aerial navigation (*Luftfahrt*) which can be divided into ballooning (*Luftschiffahrt*) and flight (*Flugwesen*, or *Flug*). The latter expression includes all branches of flight, *i.e.* the technics of flight (*Flugtechnic*), actual traffic in the air (*Flugverkehr*) and flight as a sport (*Flugsport*). The means of locomotion in air (*Luftfahrzeug*) comprise:—Balloons (*Ballon*), airships (*Luftschiff*) and flying machines (*Flugzeug*): the word balloon (*Ballon*) imparts only the idea of the old spherical balloon, the newer cigar-shaped types, provided with means of propulsion are designated by the terms:—Dirigible balloon (*Lenkballon, Motorballon*); the use of these terms is however to be avoided, and the term "*Luftschiff*" alone to be applied to these newer types.

Airships are divided into:—*Starrschiffe* (*i.e.* those without a ballonet or air bag, but with a framework) and *Prallschiffe* (those with an air bag). The ballonet or air bag is called "*Luftsack*."

Flying machines are divided into mechanically-propelled aeroplanes (*Kraftflugzeuge*) and gliders (*Gleitflugzeug*). The former are further divided into *Flugdrachen* (aeroplanes) helicopters (*Schraubenflugzeuge*) and machines with movable wings, like birds (*Schwingenflugzeuge*). According to the number of its planes (*Tragdeck*) an aeroplane is a monoplane (*Eindecker*), biplane (*Zweidecker*), or triplane (*Dreidecker*). Each plane (*Tragdeck*) consists of two wings (*Flügel*).

Aerial navigators (*Luftfahrer*) are aeronauts (*Luftschiffer*) or fliers (*Flieger*). Certificated aeroplane drivers (*Flugzeugfahrer*) will when they have mastered all the difficulties of their profession and undergone two examinations receive the certificate of master flier (*Flugmeister*). The ascent is called with balloons, etc., *Aufstieg* and with aeroplanes *Abflug*.

Italy.—Four wireless stations of extra high potential are to be built at Milan, Turin, Bologna and Florence. They are on the system of a member of the University of Parma, Dr. Jacodello, which is based on the use of Volta's arc; the voltage is 40,000 to 70,000. The work on land is to be constructed by the wireless detachment of the engineers. The fleet is also to be provided with these instruments.

Austria.—Two ski-patrols of three men each are allotted to each mountain battery, and one or two officers are allotted to each field artillery brigade or mountain artillery regiment as instructors in ski-ing. The military textbook: *Introduction to the Use and Military Employment of Skis*, which is used at the ski-courses is to be the textbook for these scouts till a further one is brought out.

A. H. Scott.

Revue Militaire des Armées Étrangères.

November, 1910.

The Career of the German Staff Officer.—The object of this article is to show the probable career of a German staff officer and the nature of his duties, and to bring out the great variety of these same duties owing to the perpetual peregrinations of the officers concerned between the Great General Staff at Berlin, the staff of army corps or divisions, and regimental duties. Since 1909, the number of officers annually admitted to the War Academy at Berlin is 160. The candidates must have at least three years' service, and specially good recommendations from their C.O.'s before they are even allowed to compete in the examination. As a rule about 700 officers compete at each examination.

The lucky 160, who pass the examination, spend three years at the War Academy at Berlin, and at the end of that time return to their units till the 1st April of the following year. They are then, according to the confidential reports rendered on them whilst they were at the War Academy, either "Kommandiert" (attached on probation) to the Great General Staff at Berlin, or recommended for employment as higher adjutants (corresponding to D.A.A. and Q.M.G. in the British Army) or merely left in their units. The latter fact emphasizes the real object of the War Academy: not merely to be a "Staff College" for the preparation of staff officers, but to be an instrument for the higher military education of the army in general. The latter class of officers, those who remain in their units, form according to the writer of an article in the *Überall* of May, 1910, a set of bitter and envenomed men who feel that they have been wronged, know better than everybody else, and are the terror of their comrades in arms. If such is indeed the case, it would seem as if the War Academy rather defeated its own purpose, and, instead of sowing higher education and good feeling in the army, planted the seeds of discontent.

To return to the staff officer proper:—Of the class of 160 who leave the War Academy, 55 or 60 are sent back to Berlin as staff officers on probation. They remain in this capacity one, two, or three years, and finally after a careful process of elimination, about 20 of them are appointed to the General Staff and promoted to the rank of captain, which generally means a gain in seniority on their contemporaries of one or two years. The officers on probation are attached to one or the other of the nine sections of the General Staff; the 2nd section (in charge of mobilization) is especially sought after, other sections on the other hand, such as the topographical and railway sections, are not much appreciated.

The General Staff of the German Army consists of 312 officers and is divided into two large sections:—

(1). The Great General Staff at Berlin, composed of a head office, nine sections, and the historical and geographical departments.

(2). The staffs of the various larger units.

The staff officers are divided equally between these two branches.

The *rôle* of the Great General Staff is:—(1), To prepare for war; (2), to teach the army in general how to do this; (3), to ensure the uniformity of training throughout the whole army.

As regards its first *rôle*, the Great General Staft concerns itself with "German military affairs" (mobilization, concentration, plans of campaign against all possible enemies of the German Empire), the transports of troops by rail to the scene of operations (the details are worked out by technical officers, who do not belong to the General Staff), military organization and foreign theories on the conduct of warfare.

Its second *rôle* comprises the details of staff tours and the winter work of officers, and its third the education and training of the staff officers on probation, and the execution of staff tours—directed by the Chief of the Great General Staff—by the staff officers of the various commands, so that they do not get away from the central influence.

The organization of the staffs of the commands is as follows:—The staff of an army corps consists of a "chief of staff" (colonel or lieut.-colonel) and two or three staff officers, of which the senior is a major, and who are denominated as *1a*, *1b*, *1c*, respectively.

The business of the army corps is classified under four headings:—

(1), General Staff; (2). Adjutantur, *i.e.* D.A.A. and Q.M.G.'s department; (3), military law department; (4), supply, transport, medical, veterinary, and chaplains' services.

As in the case of the Great General Staff at Berlin, the staff officers of the commands are purely occupied with things military and the training of the officers. All technical details are carried out by administrative officers, who do not belong to the General Staff. Thus their duties comprise:—marches, cantonments, tactical schemes and manœuvres, staff tours, mobilization, political matters, preparation of amendments to the training regulations, maps, reconnaissances, military organization questions, the armament of fortresses, winter essays of the officers and the supervision of proper tactical instruction of the men.

The Adjutantur on the other hand is responsible for the issue of daily orders, garrison duties, the discipline of the troops, decorations, recruiting, supply of men, horses, arms and ammunition.

On his definite appointment to the General Staff, an officer is generally sent to an army corps as *1b* or *1c* staff officer, and at the same time he is the personal assistant of the chief of staff; thus he early acquires the necessary experience.

In an army corps, the General Staff officers take precedence of the Adjutantur officers of the same rank, independent of the seniority of the officers concerned; in a division on the other hand, where there is only one staff officer (a captain) and one Adjutantur officer the senior takes precedence.

The post of staff officer in a division is one much coveted by staff officers, as it is one of the greatest independence. It is generally given to staff officers, who after their three years' tour as 1*b*, have gone back to regimental duty, and spent three years as company, squadron, or battery commanders, and have then returned to the staff. It is generally when he is a divisional staff officer, that the staff captain gets round the "major's corner" the point in their career where so many German officers fail.

There is a special captains' promotion roster for the General Staff and thus these officers reach the rank of major very much earlier than regimental officers.

The positions now open, are either 1*a* in an army corps staff, staff officer of a division, or a post on the Great General Staff. These do not, however, last for ever, and the return to regimental duty becomes necessary. This generally means the end of the staff career of the officers concerned, unless they are lucky enough to become chiefs of staff of divisions, or heads of sections of the Great General Staff. Even a chief of staff of a division has before promotion to major-general to revert to regimental duty and command a unit, and then—unless he becomes one of the five assistant chiefs of the Great General Staff—he no longer hopes for continual employment purely as a staff officer.

Theoretically the fact of having been a staff officer has no influence in the German Army on the selection of an officer for the rank of general, it is however needless to point out that an ex-staff officer has innumerable advantages over regimental officers, or even those who have been employed in the "Adjutantur," the accelerated promotion alone being one of the chief of these.

This was by no means forgotten at the recent celebration of the centenary of the foundation of the War Academy, an occasion on which several newspapers reminded their readers that the successes of Germany in 1864, 1866, 1870—1871 were due to the excellence of her military leaders, most of whom had studied at the War Academy and had been subsequently employed on the General Staff.

FOREIGN NEWS OF VARIOUS COUNTRIES.—*Austria.*—The corps of engineers (Militär-baubehörden) in charge of the construction, maintenance, etc., of all military buildings, except fortifications, has been granted military rank. Its *personnel* of officers is fixed in peace at:—1 field marshal—as head of the corps—2 brigadiers, 14 colonels, 16 lieut.-colonels, 22 majors, 75 captains, and 23 attached lieutenants.

The duties of this corps are in peace time to direct and carry out the construction, care and maintenance of all buildings other than fortifications, and in wartime to carry out, besides the above, the construction of fortifications under the direction of the Engineer Staff of the Army.

The peace duties given in more detail include:—(1), The planning, erection and maintenance of military buildings; (2), the purchase of lands intended for the sites of military buildings, rifle ranges, drill or manœuvre grounds; (3), the adapting of modern science to the building services. The officers are recruited from those who have successfully passed the engineers' course, for which all officers who have more than four years' service, or are less than 30 years old can be nominated.

The Engineer Staff is, in Austria, in charge of the fortified works as opposed to those looked after by the "Militär-baubehörden" mentioned above. To relieve this staff from the immense stress of work an auxiliary fortification *personnel* (Fortificationshilfspersonal) has been attached to it, composed of (1) reserve officers or ensigns; (2), foremen of works. The first class is to supplement the staff in time of war, and must have been through the engineering course for officers previously mentioned. It consists of reserve officers. The second class are taken from the foremen of works of the Militär-baubehörden, are specially trained at Vienna and are then granted exceptionally favourable conditions of pay and promotion.

Belgium.—The following are the details of the latest Belgian airships:—(1). "Belgium 3." The balloon is of the non-rigid type, the car is triangular in shape and 22 metres long; capacity 4,000 metres; there are two motors, which can be used singly or together, H.P. 110. (2). The "Brussels":—Capacity 8,200 metres, length 78 metres, two motors, each of 100 H.P.; three independent propellers. (3). A third dirigible is being built by the military authorities on the plans of the commander of the Air Company.

Holland.—The army at present possesses two machine-gun detachments each of eight guns. In September, 1909, the section stationed at the Hague made experiments on the adaptability of machine guns on motor cars in order to repulse landings. The result was most satisfactory.

Russia.—The following details are given on the new aeronautical school created in July, 1910:—The object of the school is to train officers for the air corps to carry out experiments in flying, and to keep the mobilization stores of the air units. It is composed of the officers' class, a permanent staff and a battalion, besides workshops, stores, and a museum. It is commanded by a major-general or lieut.-general, with an assistant field officer to look after the work of the school itself, and of the experimental sections. A field officer and four captains are also employed on the permanent staff.

The officers' class consists of 30 engineer officers, who have at least one year's service. They undergo a course of one year. Officers of other arms can also be nominated, but must subsequently spend two years in an aerial unit. If at the end of that time they are not qualified to be transferred to the corps of engineers, they are sent back to their units.

Turkey.—The staff college at Yildiz, is very much on the lines of the German one, previously described in this review. Special attention is paid to the study of foreign languages, notably French, Russian and German.

A. H. SCOTT.

RIVISTA DI ARTIGLIERIA E GENIO.

November, 1910.

FORTIFICATION AND THE OFFENSIVE.—The authorized German periodical *Vierteljahrhefte für Truppenführung und Heereskunde*, published at Berlin, contains an interesting article under the title "Ingenieurkunst und Offensive," by General von Beseler.

The article in question does not contain new matter, but affirms principles which, thanks to the perseverance of military technical writers of all countries, are making rapid progress. These principles are treated in a very intelligent manner, and are of interest to the engineers not only of our own army but also to those of the great military Powers.

It would not seem inopportune to reproduce a portion of the writings of this brilliant German general, who, not belonging to the engineer corps and having no greater predilection for one arm of the Service than for another, shows a strict impartiality in his views.

"The German soldier has the 'offensive' in his nature. It promises to him fortune and victory. 'The lot of the assailants is always favourable,' exclaimed Frederick the Great in *The Art of War*. Who would wish to see this spirit of the offensive grow less in our army? Victorious defence is only a preparation for victory, not the complete victory itself. The latter is only accomplished by the blow which carries with it annihilation, beats the enemy, and places him in the power of the conquerors.

> Attaquez donc toujours, Bellone vous annonce
> Des destins fortunés, des exploits éclatants
> Tandis que vos guerriers seront les assaillants.

'War promises great things to those who know how to strike bravely,' proclaims the philosopher of Sans Souci to the conquerors of Mollwitz and of Hohenfrieberg, and this advice leads later to the laurels of Rossbach and Leuthen. It is not surprising that, in an army animated with such a spirit, methods of fighting which tend directly to the attack are viewed with the greatest favour."

The qualifications of the engineer, derived from an old Italian word signifying engines of war, lead to quite different conclusions. Originally the engineer was he who constructed and made use of engines of war for the destruction of the adversary's apparatus, and at the same time supplied the means of protecting or repairing the same engines; afterwards he became the constructor of fortresses.

With the invention of gunpowder and the perfection of artillery, there came a change, inasmuch as that all that related to destruction passed to the artillery, whilst the engineer devoted all his activity to the preparation of defensive dispositions, and finally to fortresses. Naturally, modern firearms influenced greatly these works. The author next gives some brief observations on the object and scope of fortresses in modern warfare.

A modern fortress assures the possession of a place in a limited sense only. The fall of a fortress—notwithstanding Paris—will not decide the close of a campaign, but recent history clearly shows that such a fall exercises a considerable influence on the political and military situation.

If, at the moment of the capitulation of Paris, the French flag had still flown on the ramparts of Strasburg and Metz as it flew above Belfort, there would have remained serious difficulties to Bismarck's policy. Without the fall of Port Arthur the Japanese would with difficulty have attained their final conquests in Manchuria.

Again it should be remembered that the best organized army, with its mobilization accurately prearranged, always requires a certain period of time before commencing operations. Mobilization requires generally a few days, and operations cannot be commenced at the moment of the declaration of war as in 1870. During this time communications ought to be absolutely protected against the enemy's enterprises.

It is then that fortifications are of the greatest assistance to the mobile forces that are ready to enter into action on the frontiers, not only as lines of defensive walls, but also for strengthening the more important points on the lines of communication, the junctions of roads, the centres of railway systems, to cover the passages of rivers, mountain passes, etc., and the nearer they are to the frontier the more efficacious they are likely to prove. Frontier fortresses have also other important objects. They serve to cover the mobilization, and to hold open the passes for the invasion of the enemy's country, especially when the frontiers are at short distances from great rivers.

The crossing of a river in front of the enemy is always a difficult operation which may be rendered less dangerous, if not entirely overcome, by the construction of bridgeheads or works of protection in the vicinity. The undisturbed passage of a river in such circumstances is the first step towards a powerful offensive.

Everything depends also upon gaining time, but fortifications should never force troops to fight behind ramparts and ditches, but should guarantee for them the best use of the ground, the mobility and capacity of manœuvring, and thus the possibility of assuming the offensive. The maxim of Frederick the Great "Regarding fortresses it is especially necessary to consider the ground, since that is what essentially constitutes fortification" was, for a long time, not understood in its true sense. He did not mean, as is sometimes imputed to him, that the fortress should be adapted to the ground, but that the ground should be utilized so as to complete the fortresses. With that Frederick established the more important objective of fortification: he accentuated the using of the ground in the following verses in his *Art de la guerre*:—

> Vous trouverez partout des forts, des citadelles,
> Que les mains des mortels n'ont jamais travaillés,—
> Postes que la nature a seul ainsi taillés
> L'ignorant voit ces lieux, mais c'est sans les connaître,
> Le sage les saisit. . . . .

And when he wishes to inculcate on the commanders of troops the necessity of a proper use of the ground, for the construction of fortifications, he returns always to the same idea.

But Frederick extended this idea of action. The fortress under his masterly hand, formerly a work of passive defence, became a living system of combat. His maxims remained for too long a time misunderstood, and it was only after the reawakening of Prussia that their value was appreciated. Even the works of Coblenz and Ulm have long been looked upon as antiquated, although their constructors fully grasped the importance of the reciprocal relation between the work and the ground.

The biased and inexact judgment which regulates field fortifications has, without doubt, léd to a certain repugnance in the application of the offensive. In our regulation exercises for the infantry, the belief in this idea in opposition to the offensive spirit is obvious, since a warning against its dangers follows upon a timid counsel for its employment. Similar repugnance existed some time ago against all use of the ground; it was ever held as subversive of discipline for the soldier to kneel or lie down.

To-day it is impressed upon the officers and non-commissioned officers that they are not to expose themselves uselessly to the enemy's fire, but are to seek cover as much as possible; and this not on humanitarian principles but with the object of preserving for as long as possible their intelligence and energies. Occasions always remain when if they wish they may prove their heroism in the presence of the enemy. Our army has learnt to employ its cavalry and artillery efficaciously, and it can also now realize how greatly it may profit by the art of the engineer, and the work of the pioneers.

Naturally much depends upon the education and instruction of the engineer and the pioneer. Both should be founded upon a tactical basis. The commander of troops knows his work thoroughly only when he has a perfect knowledge of what the engineer can do for him, and is familiar with his services and those of his troops. In conclusion the author considers that the mistrust in the engineer should now cease, not only as regards the fortresses he builds, which are not now of a purely defensive character, but also of all his other methods of warfare. The duties of the engineer, as far as is necessary and practicable, should become part of the knowledge of the army.

Marshal Moltke, when speaking to General Neil who commanded the French troops in 1859, took occasion to show that the engineer who had directed the Siege of Sebastopol had succeeded because he understood warfare, and had made use of all means without distinction, whether by mine or sap, or by battle in the open field. The engineer who takes these words to heart will perform the highest of his duties, and will contribute towards the maintenance of the true spirit of the offensive in the army.

E. T. THACKERAY.

BOOKS RECEIVED.

The Aeroplane. An Elementary Textbook of the Principles of Dynamic Flight. By T. O'B. Hubbard, J. H. Ledeboer, B.A., and C. C. Turner. 2s. 6d. net. Longmans, Green & Co., 39, Paternoster Row, E.C.

Spon's Architects' and Builders' Pocket Price Book and Diary, 1911. Edited by Clyde Young, F.R.I.B.A., and Stanford M. Brooks, L.R.I.B.A. 2s. 8d. net, post free. Spon & Co., 57, Haymarket, S.W.

Spon's Architects' and Builders' Pocket-Book. Memoranda Section. Edited by Clyde Young, F.R.I.B.A., and Stanford M. Brooks, L.R.I.B.A. 2s. 8d. net, post free. Spon & Co., 57, Haymarket, S.W.

Lord Roastem's Campaign in North-Eastern France. By Lieut.-Colonel Alsager Pollock. 2s. 6d. net. Hugh Rees, 119, Pall Mall, S.W.

The Gyroscope: An Experimental Study from Spinning-Top to Mono-Rail. By V. E. Johnson, M.A. 1s. 6d. net. Spon & Co., 57, Haymarket, S.W.

The Elements of Telephony. By Arthur Crotch. 1s. 6d. net. Spon & Co., 57, Haymarket, S.W.

The Principles of Aeroplane Construction. With Calculations, Formulæ, and 51 Diagrams. By Rankin Kennedy, C.E. 5s. net. J. & A. Churchill, 7, Great Marlborough Street.

The Outlines of Military Geography. By Colonel A. C. Macdonnell, late R.E. With 19 maps. 12s. 6d. net. Hugh Rees, 119, Pall Mall, S.W.

Elementary Aeronautics, or The Science and Practice of Aerial Machines. By Albert P. Thurston, B.SC. (LOND.). With 126 illustrations. 3s. 6d. net. Whittaker & Co., 2, White Hart Street, Paternoster Square, E.C.

CORRESPONDENCE.

RESISTANCE AND "DRIFT" OF A BULLET.

DEAR SIR,

There appear to be two statements in Lieut.-Colonel R. de Villamil's article in the *R.E. Journal* for January, 1911, which are in need of some support.

(1). As to the drift of a bullet being caused by it rolling on the air, the explanation is very simple, in that the bullet on leaving the rifle has its nose pointing above its general trajectory. During its flight the bullet's nose is pointing very slightly above the trajectory; although the bullet is continually tending to conform to that trajectory, yet actual coincidence of the axis of the bullet, to the tangent to the line of flight at any one moment, does not take place. The result of this is to produce a partial vacuum above the bullet and a compressed layer of air below it, and it is owing to the layer of air below being of greater density, that the rotation of the bullet, with its grooves caused by the rifling, takes more effect on the under layer of air than on the over layer.

A bullet can be made to rise in the air in an upward curve against gravity. There are two ways in which this occurs.

(*a*). By a bullet ricocheting and turning head over heels in its flight so that whichever end of the bullet is in front is always travelling in a downward direction; *i.e.* similar to the spin of a golf ball.

(*b*). By a bullet becoming unsteady in its flight owing to ricochet, and afterwards going to sleep again but with its axis not parallel to its line of flight; if its axis happens to be pointing well above the line of flight, as sometimes happens, the bullet will plane up the air on its lower side until such time as it has effected a compromise between its direction of flight and the direction in which its nose was pointing at the time it steadied down. During this process the bullet is travelling in an upward curve.

(2). As regards drift being caused by gyroscopic action, this very plausible and simple solution was examined into in 1904 or thereabouts, and probably has been examined into many times previously. The only drawback to it is that the bullet happens to drift in the wrong direction to suit this theory.

Yours faithfully,

A. B. CAREY,
Capt., R.E.

The Editor, *R.E. Journal.*

"DRIFT" OF A BULLET.

A Reply.

Sir,

I have to thank Major C. E. Phipps, R.A., for his courteous criticism on my paper. *Du choc des idées jaillit la lumière.* I have also to thank him for the information that projectiles sometimes drift to the left—*i.e.* in the reverse direction to that in which they ordinarily move.

I am afraid Major Phipps' third paragraph must have been written in haste and without due reflection. I certainly ignored the effect of air friction, for the simple reason that I do not think friction enters into the question at all; but I did *not* consider the projectile as travelling *in vacuo.* A bullet travelling *in vacuo* and *precessing* appears to me to be, *almost*, a dynamical absurdity, since a *couple* acting in a vertical plane would appear to be a *sine quâ non* for producing drift in a flying bullet.

I have carefully examined the *Textbook of Gunnery* and I find:—

(1). The "proof" is no proof at all, but simply an "explanation"—just as mine was.

(2). The explanation is not in the least like the one I offered. The only point they have in common is that they are both based on gyroscopic effects.

(3). The explanation appears singularly unconvincing: it seems to me to be an exceedingly pretty argument in a "vicious circle."

As regards No. 1, I feel sure Major Phipps will not dispute my statement. A comparison of my explanation and that given in the *Textbook* should also decide No. 2. The *essential* difference is that I make use of gravity in the formation of a *couple* (which is certainly *capable* of producing precessional movement) whilst the necessary *couple* is produced in the *Textbook*, by some curious "sidelong position" of the projectile which "following its nose to the right" calls a vertical couple into existence. The whole argument therefore can be confined to No. 3; and as my remarks are, I am aware, rather strong I must try and show that they are justifiable.

After a preamble, which I omit, the *Textbook* says:—

"But the general effect may be attributed to the observed *tendency of the projectile* [italics added] to move with its axis nearly tangential to the trajectory." This is hardly a correct statement of the facts. The *tendency* of the projectile is to move so that its axis is at *right angles* to the trajectory. The pressure of the air tending to turn the point *away* from the line of the trajectory. As Professor Perry says, (*Spinning Tops*) referring to this subject, "this pressure tends to make the projectile turn itself broadside on to the air." As a projectile *does* keep its axis, more or less, tangential to the trajectory there must be (*according to this explanation*) some other *couple*—more powerful than that produced by the air pressure—acting in the opposite direction; and it is by no means clear how this couple is generated. But to continue:—

"To keep the point of the projectile continually turning downwards into the tangent of the trajectory, the projectile must be acted upon, as in the case of a top, by a couple whose axis is towards the centre of curvature of the trajectory."

There can be no doubt that this statement is absolutely correct, if—as is apparently assumed—the point of the projectile is always *above* the trajectory. Even if the point be *below* the trajectory the same, or a similar, couple must be acting *to produce the same precession;* though in this case it would be turning the point *away from* the tangent of the trajectory. How is this couple produced, however? The *Textbook* continues:—

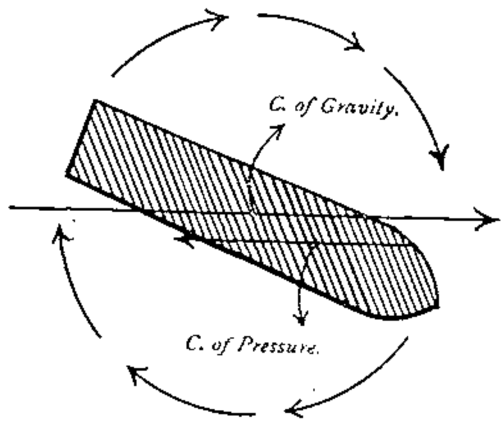
"This couple will be *called into existence* if the projectile moves in a slightly sidelong position, with its nose turned a little to the right of the vertical plane of motion; and now the drift may be supposed due to the projectile following its nose to the right, and a deflection to the right of the vertical plane of fire thus accumulates in consequence."

The wording of this paragraph appears decidedly cryptic and I am afraid the writer is "begging the question." He started to show *why* the projectile turned to the right, say, and now he is *assuming the drift* to *bring a couple into existence which shall be capable of producing this drift.* This appears to me to be something very closely resembling a "vicious circle." Of course, *when the precession is started* a secondary action *is* produced on the bullet—*but, most unfortunately for this argument*, this action *tends to raise the point of the projectile:* not exactly what is required by this theory. Granted the precession this secondary action follows; but what *starts the precession?* Besides what right has anyone to *assume* the projectile should move "in a slightly sidelong position, with its nose turned a little to the *right* of the vertical plane"? It appears incumbent on the writer to show some reason *why* it has a preference for the right rather than the left. The expression "the projectile following its nose" would lead one to suspect that the writer had been studying the dynamics of a golf ball. The two cases are not on all fours, for there is no gyroscopic action on a golf ball, whose nose is moving about, having been caused to do so by one of the weird instruments used by the golfer.

I think, therefore, that I am not making too strong a remark when I say that the *Textbook* explanation is really no *explanation* at all of the cause of "drift."

The explanation I offered will account for *certain facts*, but, as Major Phipps most rightly says, it will *not* explain certain other facts (which I was unaware of till he drew my attention to them) and so, though it may be the truth, it is not the *whole* truth. This is no reason why it should necessarily be "scrapped": it is *capable* of explaining drift *in one direction*, but there are other factors which must be brought into the fighting line, and I will endeavour to give another (shall I call it supplementary) explanation, which I hope will account for *all the facts* given in the *Textbook*.

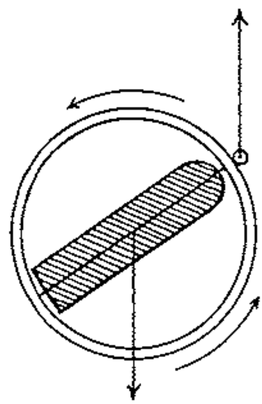
I must begin with the gun, since I am making an assumption; and I must consequently show it is a reasonable one and not in disaccord with probability. When the gun is fired the backward pressure causes a small rotation about some horizontal axis: the muzzle is very slightly jerked up and the block, or other support of the breech receives a blow. Almost immediately afterwards the reaction of this block raises the breech, causing the gun to rotate in the opposite direction about an axis passing through the trunnions: the muzzle is then very rapidly depressed. The projectile emerging from the muzzle, whilst the latter is rising rapidly, has its rear end raised a little so that its point is set *below* the line of the trajectory. This is my assumption, which is not in accord with the diagrams usually made of flying projectiles but appears to me to be a very fair one: besides it leads to a satisfactory solution of the problem, whereas the assumption of the opposite *does not*.



Next, the air exerts a pressure on the projectile tending to retard its motion. Since the projectile is inclined at a small angle (much exaggerated in the diagram) to the line of flight the centre of pressure of the air does not pass through the centre of gravity of the projectile but through some point *in front of it* (see sketch diagram). Lord Rayleigh has given a formula for calculating the distance from centre of gravity to centre of pressure for a perfect fluid but I am not aware that it has ever been calculated for a viscous one. The stress of the air forms a *couple tending* to cause rotation of the projectile in the direction of the circular arrows—to set it, in fact, broadside to the line of flight. Since the projectile is spinning rapidly about its principal axis, it resents having the direction of this axis of rotation changed and *precessional* motion takes place: the point turns out of the plane of the paper and towards the spectator. All this is quite elementary and can be seen with a gyroscopic top, or better still with a properly balanced gyrostat.

If this action were continued indefinitely the point of the projectile would tend to be set further and further away from the line of the trajectory, and this we know is not the case (see *Textbook*).

If we next examine the projectile in plan (sketch—also exaggerated), the arrow showing the line of flight and the curved arrows the direction of the precession. The pressure of the air here, as in the other case, is acting as a couple and tending to turn the point of the projectile away from the line of flight. In other words it is trying to *increase the precession*; and as Lord Kelvin first pointed out if you "hurry up the precession" of a top you cause it to rise up against gravity. Similarly, here, the air in trying to "hurry up the precession" causes the point of the projectile to *rise* towards the line of the trajectory: and not to be drawn *downwards* as described in the *Textbook.*



Granted the assumption all the rest follows, naturally, from the laws of rotation. We have two *couples*, one tending to force the point of the projectile downwards in the vertical plane, whilst the other tends to raise it: both however tend to turn it horizontally out of this vertical plane. If this continued indefinitely the point of the projectile would eventually be raised above the line of the trajectory, when a *reverse precession* would be started. The projectile, however, being inclined horizontally at a small angle to the line of flight is being acted upon by an accelerating force on one side so that it does not travel forwards in a straight line viewed horizontally but along a (kind of) parabolic curve: the spinning axis of the bullet getting nearer and nearer to the tangent of this curve so the deflecting force—that which forces it sideways out of the direction of flight—as well as the rotating force are gradually diminishing in intensity. Eventually the axis of the projectile will be, both vertically and horizontally along the line of the tangent to the trajectory. When this occurs all rotational stress will cease; nor will it come into operation again until the axis of the projectile gets out of the proper alignment.

The foregoing will I hope explain:—

(1). How the point of the projectile is turned out of the vertical plane.

(2). Why the axis, about which it is rotating is always kept very nearly in line with the tangent of the trajectory.

(3). Why "drift increases rapidly with the elevation" (*Textbook*), for the greater the elevation the more severe must be the blow, or pressure, exerted on the projectle as it is leaving the muzzle: and consequently the more must the point be depressed below the line of trajectory.

(4). "Counter-drift" or "reverse drift" (if I may coin a word) will take place whenever the point of the projectile rises *above* the line of the trajectory. I have no details enabling me to say how this actually is caused, but there are two *possible* causes:—(1). The projectile may be leaving the muzzle of the gun whilst it is being jerked *downwards*, (extremely improbable) or (2) if the action of "hurrying up the precession" is too violent the point of the projectile may not only reach the line of the trajectory but actually overrun it a little.

Crabtree's explanation I cannot follow. He says referring to the "hand gun" (page 53):—

(1). Spin of rifle bullet is left-handed.

(2). Nose of bullet is above the trajectory.

(3). "Wind pressure on the under side of the nose-end of the bullet *tends* to tilt the point upwards, but

(4). "Results instead, owing to gyroscopic action, in the bullet working over slightly *to the left.*"

An experiment with a small gyroscopic top suspended, as shown, should convince anyone that the result is *exactly the reverse.*

I think the whole difficulty in understanding the subject of drift is chiefly caused by the *assumption* that the point of the projectile is *above* the line of the trajectory instead of *below* it.

Yours faithfully,

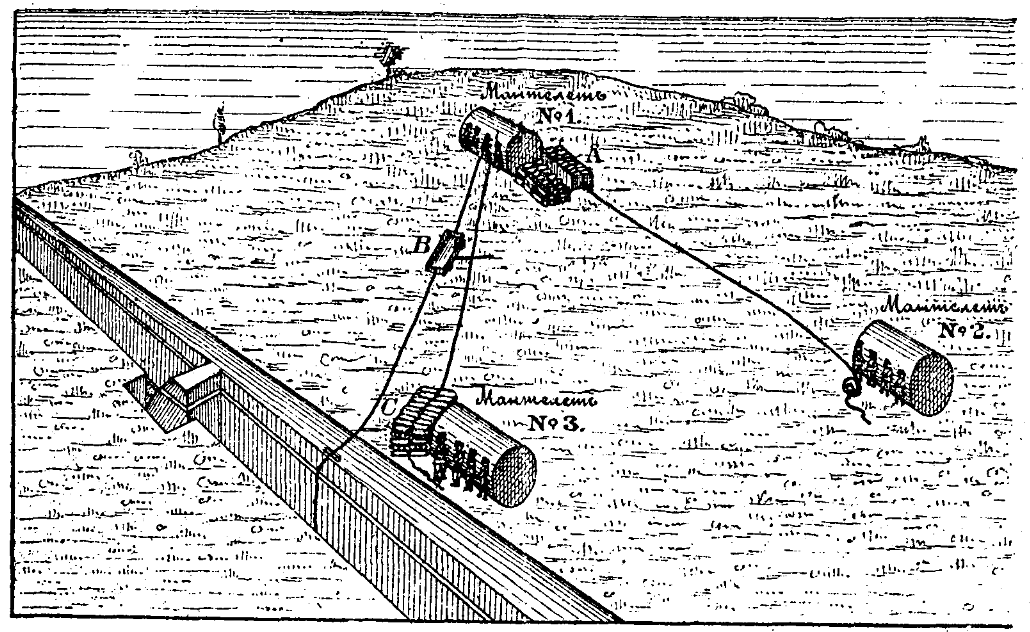
R. DE VILLAMIL.

February 8th, 1911.

The Editor, *R.E. Journal.*

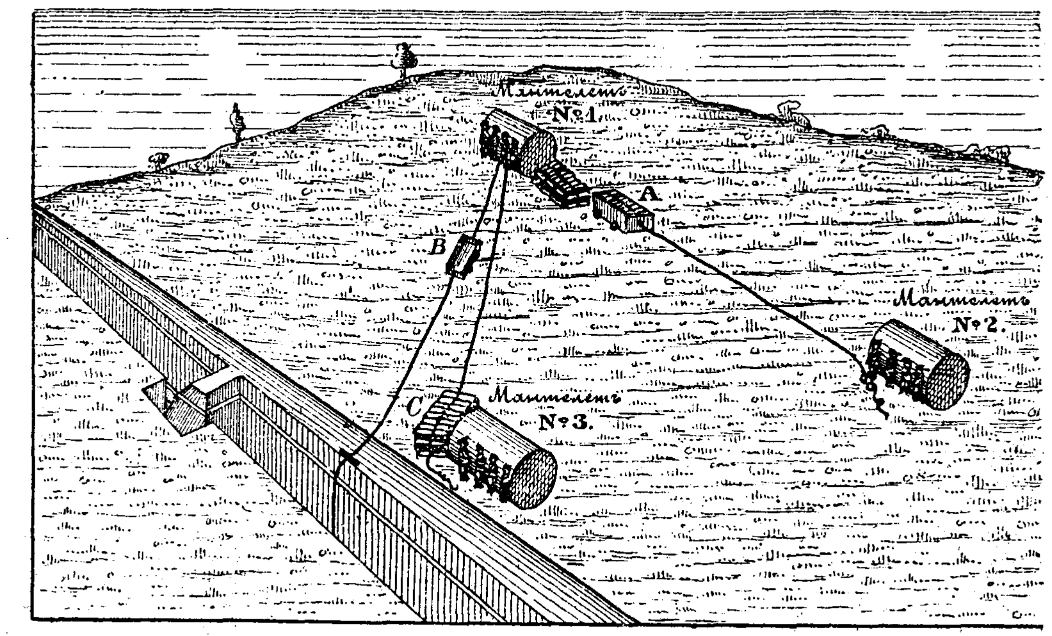
SAP ROLLERS IN THE RUSSO-JAPANESE WAR.

FIG. 1.



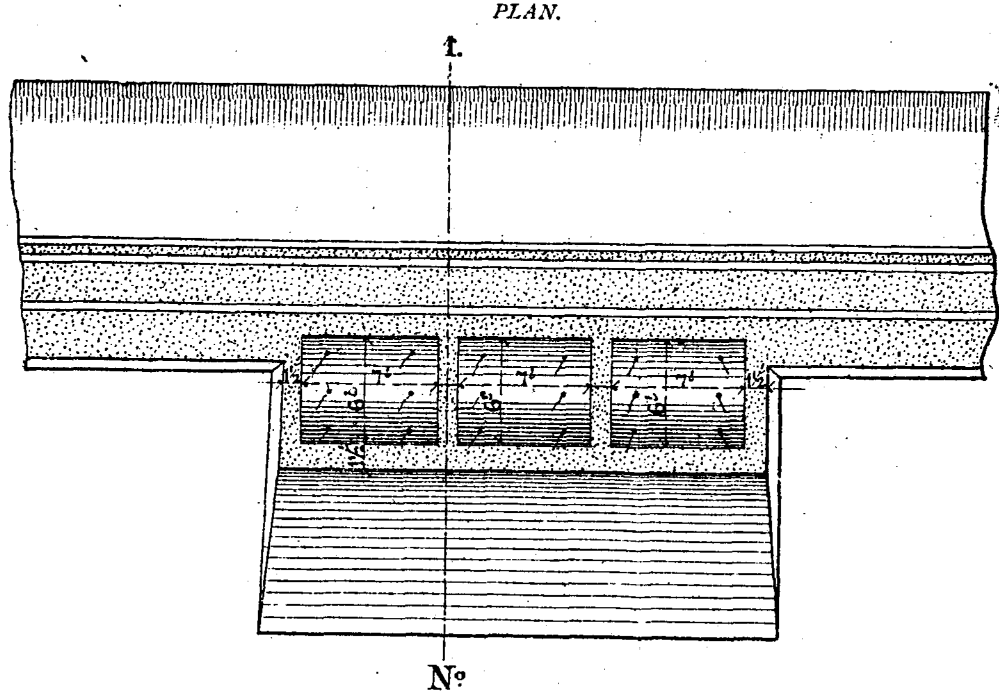
Securing the Mantlet,

FIG. 2.

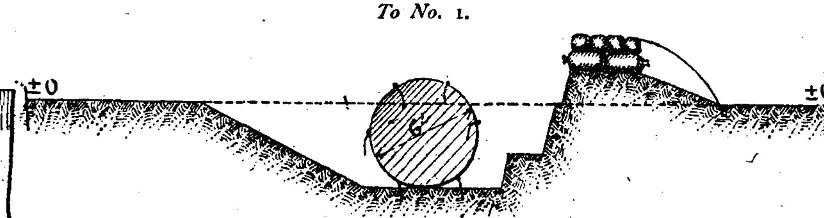


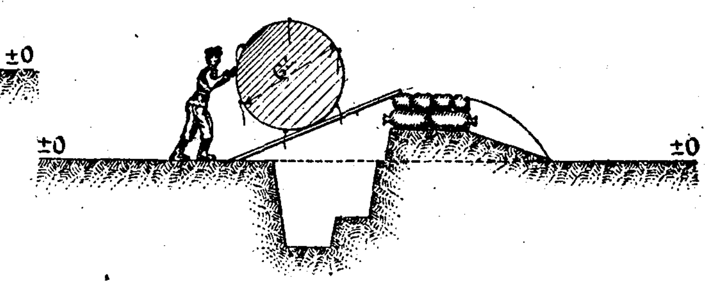
Rolling the Mantlet to the Top of the Parapet.

PLAN.



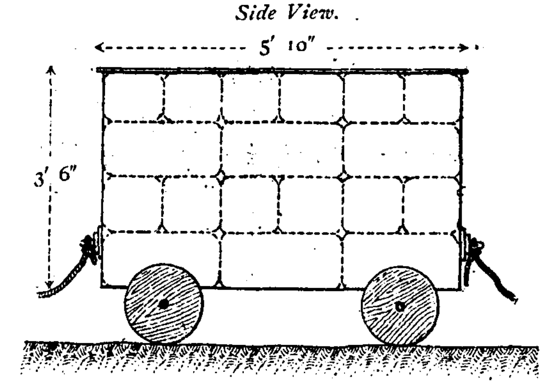
To No. 1.



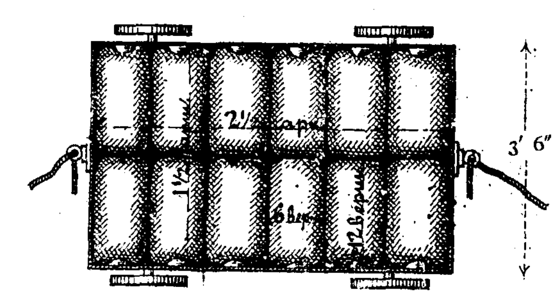


Truck A.

Side View.



Top View.



Description of the means for constructing Trenches with the aid of the "Flying Sap."

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REPORT.

DURING 1910 241 Officers received treatment. 174 Operations were performed.
OFFICERS ADMITTED :—Royal Navy and Royal Marines, 33; Royal Indian Marine, 3; Royal Artillery, 24; Royal Engineers, 20; Cavalry, 9; Foot Guards, 1; Infantry, 74; A.S.C., 1; R.A.M.C., 2; A.V.C., 4; A.P.D., 2. Indian Army—Indian Army 7, Cavalry 11, Infantry 46, I.M.S. 1—65.
Staff, Unemployed, etc., 3.

TOTAL—241.

Dr. Balance Sheet, 31st December, 1910. Cr.

Dr.	£ s. d.	£ s. d.	Cr.	£ s. d.
To Received in Advance in respect of Annual Contributions		202 12 0	By Investments...	40,699 5 8
,, Balance—Viz., Excess of Donations over Initial Outlay and Current Expenditure to 31st December, 1909	43,099 12 0		,, Cash at Bankers	3,578 3 4
,, Excess of Current Income over Expenditure ...	975 5 0			
		44,074 17 0		
		£44,277 9 0		£44,277 9 0

Dr. Income and Expenditure Account, Year ending 31st December, 1910. Cr.

Dr.	£ s. d.	£ s. d.	Cr.	£ s. d.	£ s. d.
To Rent, Rates, Taxes, Water and Insurance		708 1 2	By Subscriptions applicable to the Year, viz. :—		
,, Repairs and Alterations to Hospital ...		512 17 1	His late Majesty King Edward VII.... ...	100 0 0	
,, General Maintenance Expenses—			H.M. King George V....	100 0 0	
Salaries and Wages ...	1,398 0 3		Sir Walpole Greenwell, Bart.	100 0 0	
Washing	272 10 5		Sir E. Cassel, Bart. ...	100 0 0	
Provisions and Household Stores	2,040 18 3		S. Neumann, Esq. ...	100 0 0	
Wines and Spirits ...	67 16 3		J. Larnach, Esq. ...	100 0 0	
Fuel and Light	246 12 0		W. Burns, Esq.	50 0 0	
Clothing, House Repairs, Telephone, and other incidental expenses ...	391 0 4		Lord Burnham	100 0 0	
		4,416 17 6	S. E. Palmer, Esq. ...	100 0 0	
,, Surgical Dressings, Medicines, Pathological Reports, Massage, and Sundry Fees		950 1 7	Sir H. Praed, Bart. ...	10 10 0	
,, Balance carried to Balance Sheet		975 5 0	Miss Keyser	100 0 0	
			Sister Agnes	100 0 0	
			Lord Rothschild	100 0 0	
			Alfred Rothschild, Esq.	100 0 0	
			Leopold Rothschild, Esq.	100 0 0	
			C. E. Keyser, Esq. ...	100 0 0	
			Mrs. Livingstone Bruce	20 0 0	
			Margaret Lady Waterlow	10 0 0	
			Mrs. Bischoffsheim ...	50 0 0	
			Lord Strathcona... ...	105 0 0	
			Sir Edward Sassoon, Bart.	50 0 0	
			Arthur Sassoon, Esq., M.V.O.	50 0 0	
			Viscount Iveagh... ...	100 0 0	
			Sir E. Hambro, Bart. ...	100 0 0	
			Baroness Eckardstein	100 0 0	
			Lord Michelham... ...	100 0 0	
			E. Gordon, Esq.... ...	2 2 0	
			C. Gordon, Esq.... ...	2 2 0	
			Mrs. G. Goddard ...	1 1 0	
			S. Gordon, Esq.... ...	2 2 0	
			Mrs. A. M. Corry ...	20 0 0	
					2,172 17 0
			,, Dividends on Investments		1,870 19 8
			,, Subscriptions and Donations per Officers of the Navy and Army and Retired Officers		3,519 5 8
		£7,563 2 4			£7,563 2 4

We have examined the above Statements of Accounts with the books and vouchers of the Hospital, and find the same to be correct.

18th February, 1911. PRICE WATERHOUSE & CO.