THE ROYAL ENGINEERS JOURNAL.

Vol. X. No. 2. AUGUST, 1909.

CONTENTS.

CONTENTS.

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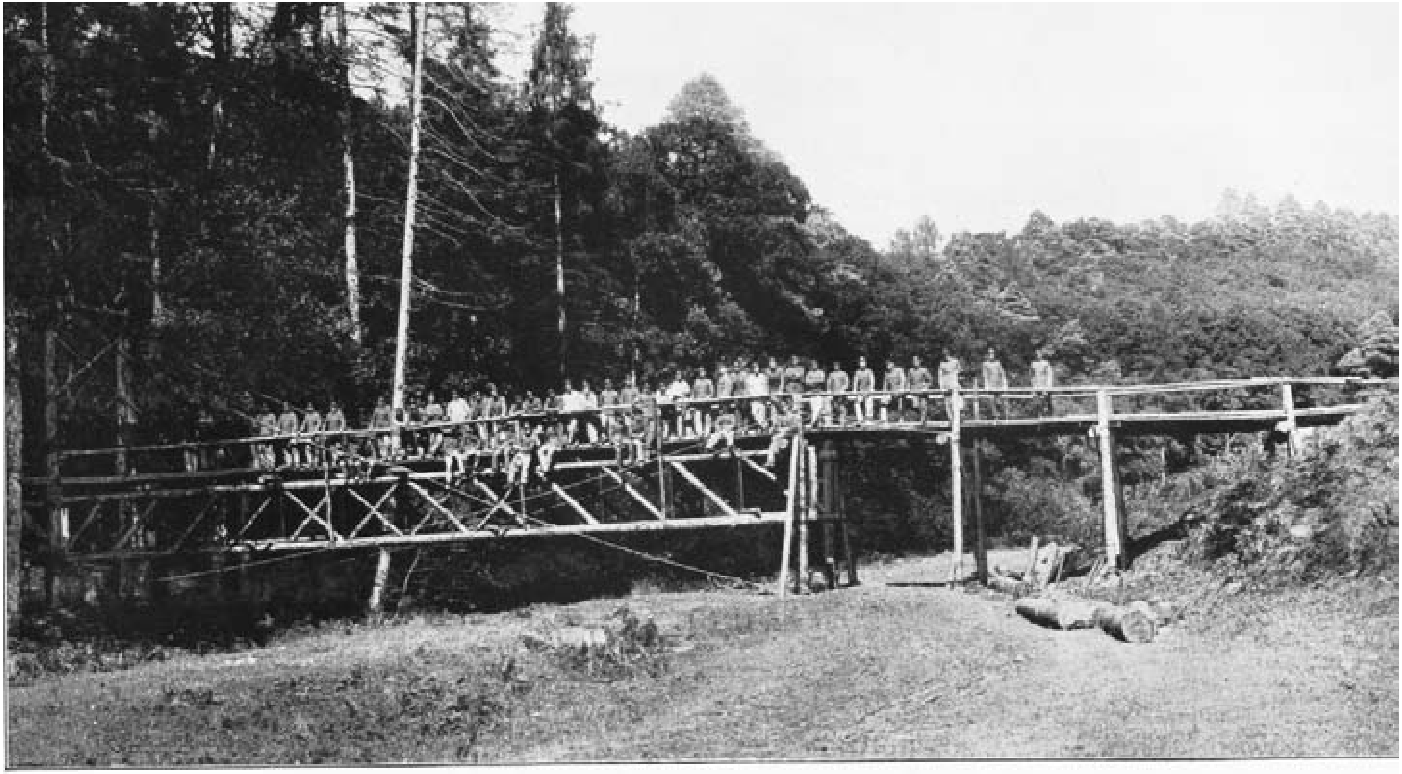
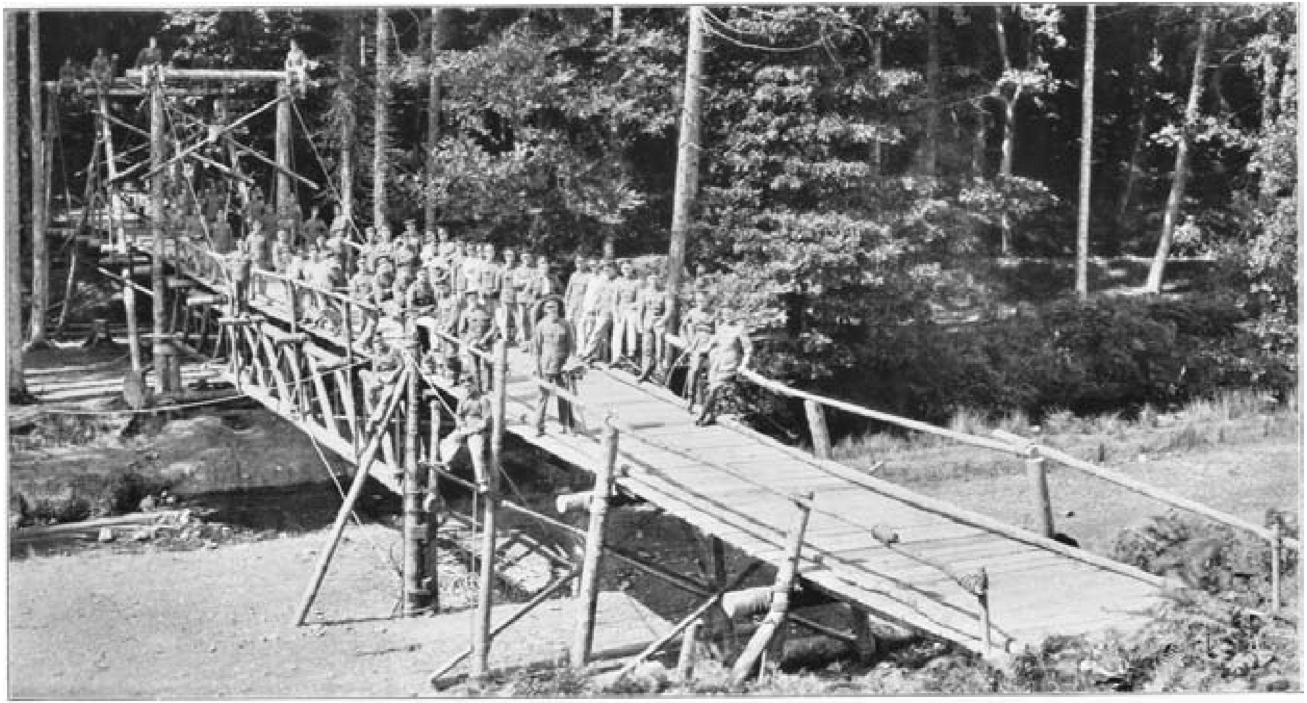


Part view of Bridge, showing Girder and Trestles.

IMPROVISED GIRDER BRIDGE 1



End view, showing the whole length of Bridge.

IMPROVISED GIRDER BRIDGE 2

IMPROVISED GIRDER BRIDGES.

By CAPT. C. OTLEY PLACE, D.S.O., R.E.

So many articles have recently appeared in the *R.E. Journal* on the subject of bridging expedients in the field, that perhaps some apology is needed when contributing yet another article on the same subject.

My excuse is that I do not remember of late years having seen any account of improvised girder bridges, and I think therefore a short description of a bridge of this nature, constructed by the 38th (Field) Company, R.E., in their last annual course, may prove interesting.

The bridge was constructed across the Valley of Glensiskin, at Kilworth, in August last, the total span being some 218′, and its component parts were :—

(*a*). Treble sling bridge ... ... 70′ span.
(*b*). Girder bridge ... ... 70′ span.
(*c*). Approaches and trestle bridges ... ... 78′ approx.

The girder and sling bridge being of the same span, it was easy to make comparisons between the two, both as regards efficiency when completed and the time, labour, and material expended in construction, and the advantage was all on the side of the girder bridge.

All the heavy spars for both bridges had to be cut down near the spot.

The girder bridge was formed of two girders placed 8′ apart, and the load was calculated at 5 cwts. per foot-run with a factor of safety of 3. The stresses were worked out graphically, and a complete drawing of the bridge made by Lieut. Collin. The girders were 72′ long, the clear span being 70′. Their depth was 6′, and they were of the ordinary braced girder type with vertical tension members. The latter consisted of wrought-iron bolts made from some old fencing material in the R.E. Yard.

The roadway was some 14′ above the ground, and as the girders were 6′ deep and 1′ had to be allowed for road bearers and transoms, the columns on which the girders rested were 7′ high.

At the trestle-bridge end these columns were lashed inside the legs of the vertical frame, which was made wide enough to allow of this being done. At the other end a vertical frame some $16\frac{1}{2}'$ high was erected of the same width, and the two 7′ columns similarly lashed inside the legs.

In each case the girders were raised one end at a time by means of differential tackle made fast to the capsills of the trestles, until they rested on the columns. The two end road transoms were lashed to both girders and vertical frame, and when this was done the capsill of the smaller trestle was removed, and the legs were used to support the handrail.

The flanges of each girder were formed of two trees, butt and tip alternating. The struts were spiked to the flanges, which were checked out to receive them. Great care is necessary when putting the girder together to ensure that the ties come truly vertical.

When the bridge was completed, infantry in fours were marched over without breaking step, and the bridge was perfectly stiff vertically. There was however a certain amount of lateral oscillation due to insufficient cross-bracing from one girder to the other, but this could easily have been remedied had another day been available.

If the construction of such bridges was contemplated in the field, it would be easy to supply 1″ round iron bolts and nuts and stout washers, the bolts being some 8′ long and unscrewed. Then when the depth of the girder had been decided upon, the bolts could be cut and screwed by means of the chest of stocks and dies carried by every field company. This would do away with the delay we experienced by having to make all our bolts and nuts by hand.

Were this done, a girder bridge could be erected in about half the time it takes to put up a sling or suspension bridge of equal span.

All that is needed beyond what is usually found in a fieldwork store is approximately—

1. Four spars equal in length to the gap.
2. One bolt and nut per yard-run of bridge, with 20 per cent. added to the number thus obtained.
3. One strut per yard-run.

The spars and struts have to be cut, and are therefore somewhat damaged for re-issue.

The advantages of such bridges appear to me to be as follows:—

1. They are stiffer than sling or suspension bridges of equal span.
2. They are easier to make.
3. They require less stores to be taken in the field, as the bolts and nuts weigh much less than the cables and lashings which would have to be taken otherwise.

EARLY TRAINING OF R.E. OFFICERS.

By CAPT. C. B. BONHAM, R.E.

THE fact of having been thrown in contact a good deal with various infantry battalions during the last three years, and being able to exchange ideas with officers in their Messes, has induced me to consider whether there is not more than the proverbial grain of truth in the opinion, occasionally expressed, that we, as a Corps, are inclined to live and work very much on what may be termed the water-tight compartment system.

With the object of satisfying a legitimate curiosity on this point, I have been at pains to introduce the subject occasionally in conversation with other R.E. officers, and have been led to conclude that there is little practical effort made to obtain real co-operation in training and exchange of ideas between units of other arms and ourselves; in fact, that there is a tendency to perpetuate the separate system.

It is very hard to see that anything but benefit would result from a far more intimate connection in peace training than exists at present between the officers of regiments with whom we have to co-operate in war, and ourselves.

The desirability of enabling officers to become conversant with the working of other arms is inculcated generally in the existing Regulations for Training, but the fulfilment usually leaves the matter in the shape of a piously expressed wish and little further.

No doubt this may be attributed, as far as allotting R.E. officers to work with other units goes, in great part to the pressure of Corps or works duties, which render it very difficult for C.R.E.'s to spare their services for even a day at a time. The contrary aspect of the question may be admitted to present fewer difficulties of this nature, but the acquaintance of even a large percentage of infantry and other officers, with the work of what is *per se* a subsidiary arm, would scarcely afford a working solution of the case.

It is with the former side of the problem therefore that it seems most important to deal. In carrying out R.E. duties we must be vastly more concerned in dealings with infantry, who form the bulk of the fighting forces, than with other arms, and it follows that an intimate acquaintance with that branch is of primary importance to us. Moreover, the early training and subsequent experience of most

R.E. officers, places them to a considerable extent in contact with artillery work and requirements.

To effect any far-reaching changes on the lines occasionally adopted at present, viz., detailing R.E. officers for a few days to attend battalion training and staff rides, or to lecture to infantry officers and N.C.O.'s, seems to present, as previously indicated, insurmountable difficulties on the score of interfering with current R.E. duties.

It is suggested that a beginning should be made at the other end of the scale, somewhat on the lines recently adopted by the R.A.M.C. in attaching single officers to battalions, not only to practise their profession, but to learn to know the men with whom they will have to deal on service, and their methods.

Four months with a battalion near the commencement of the R.E. officer's service would give him a similar experience, and should go far towards making him feel at home with the Service generally, and with its requirements of every nature.

Some such arrangement would fit in very well with another scheme frequently advocated. I refer to the attaching of officers, on joining, to a Service Company and Works Division before passing through the S.M.E. course, so that they may see for themselves the importance of the training they will get at Chatham—a point not always appreciated by those joining after a stiff course of study at the R.M.A. and the training for the previous entrance examinations.

The whole proposal amounts to this then, that officers should join at Chatham, on being commissioned, for a short course of drill and military duties only, and should then be drafted to service companies at home and in temperate climates for not less than one year, during which time they would be attached for four months or so to an infantry battalion, returning on completion for the S.M.E. course proper.

No attempt has been made to enter into details, but the mere outlines of a suggestion, which it is hoped would prove of benefit to the Service in general and to the Corps in particular, are put forward for consideration as a general problem, touching very closely the maintenance and enhancement of the value of the Corps, to the remainder of the Army.

MECHANICAL ROAD TRANSPORT IN INDIA.

By Lieut. F. W. Townend, R.E.

A Professional Paper dealing very fully with the question of mechanical road transport in India, and written by Capt. Manley, R.E., has lately been published by the R.E. Institute, and in this it is clearly shown that in many parts of the country the conditions are eminently suitable for the introduction of this form of transport. Capt. Manley has confined himself entirely to the consideration of the steam lorry, the steam tractor, and the ordinary motor car, in considering the problem, but it may interest some of the readers of this Journal to hear that another system has already been tried, namely, the road train.

During February of this year extensive trials of the Renard road train took place on the Gauhati-Shillong road—the very road described by Capt. Manley in his paper. I happened to be staying in Gauhati at the time, and through the courtesy of the manager of the train was permitted to accompany one of the runs. As there is no reference to this type of transport in the above-mentioned paper, a short account of the results of these experiments may be of interest.

The train was the ordinary Renard road train, as used in France and elsewhere. Its general system of working is probably sufficiently well known to most of the readers of the *Journal* by this time, but in case there are any who are unacquainted with it, I will briefly say that it consists of a locomotor, *i.e.*, a 25-h.p. 8-cylinder Daimler motor, with two or three wagons attached. There are several features which cause this system to differ from the ordinary trailer train as seen so commonly on English roads. Chief of these is that each wagon has a pair of driving wheels, and the power, instead of being all applied at the driving wheels of the motor, is distributed to each of the wagons by means of a universally-jointed shaft, which runs the whole length of the train. Thus it may be said that each wagon drives itself. Also, by means of a special steering device, every wagon follows exactly in the track of the locomotor, thus enabling the train to negotiate curves which would be impossible with the ordinary trailer.

The Renard Road Transport (India) Company brought out two complete trains at the beginning of the cold weather as a private venture, one going to Bombay, the other to Calcutta. The Railway Board agreed to give the train a trial, and selected the Gauhati-Shillong road for the experiment. Three trial runs to Shillong and back were made, the first being unofficial in order to put things into working order and to enable the driver of the train to get some idea of the road.

The broad results of the trials will be found collected in Tables A, B, and C attached, for which I am indebted to Mr. Lovegrove, of the Ceylon P.W.D. Comparing these with the figures in Capt. Manley's report, it will be seen that they more than hold their own. The consumption of petrol, which is easily procured in the district, works out very economically, and the carrying capacity of the train with three wagons may be taken as $13\frac{1}{2}$ tons, on the basis of $4\frac{1}{2}$ tons per wagon. From the table on p. 33 of Capt. Manley's paper, it appears that one train a day of this nature, would suffice to carry the whole of Shillong's requirements.

As regards the time taken *en route*, this is certainly capable of much reduction, and with drivers acquainted with the road and everything in smooth running order, the distance from Gauhati to Shillong should always be completed during the daylight. During these trials the driver was new to the country and had never seen the road before the first trip, and, as will be gathered from Capt. Manley's description, this is a fairly severe ordeal. The last 6 miles into Shillong, at 1 in 20, were especially trying in the dark, for the improvements mentioned by Capt. Manley were still in hand, and proved rather a hindrance than otherwise. The engine staff also proved insufficient for the task, and they were quite worn out before the journey was completed. This of course had its effect on the consumption of petrol and the speed attained, which under more favourable conditions would have been far better. A driver and at least two mechanics seem to be necessary until they have become familiar with the road. On the first trip we were delayed for three hours on the road owing to the stupidity of a bullock-cart driver, who allowed his cart to sprawl across the road on one of its steepest parts, with the result that in trying to pass it in the dark the near wheels of the last wagon slipped into the ditch at the side of the road, and we had great difficulty in righting things again.

Whether this form of road transport will be finally adopted or not, is a question for the Railway Board to decide; but it seems certain that some type or other will be introduced on this route. The results obtained in the above trials are, on the face of them, very favourable, and given expert driving—which is of course essential with so complicated a piece of mechanism—there seems to be no reason why the Renard train should not prove as efficient as any other means of mechanical road transport.

TABLE A.—*Particulars of Loads Carried, Weights of Train, Distances Run, Consumption of Petrol, etc.*

1. Date of trial ...	1st February.		5th February.		7th February.		12th February.		18th February.		27th February.	
2. Direction ...	Gauhati to Shillong.		Shillong to Gauhati.		Gauhati to Shillong.		Shillong to Gauhati.		Gauhati to Shillong.		Shillong to Gauhati.	
3. Composition of train ...	Locomotor and 2 trucks.		Locomotor and 2 trucks.		Locomotor and 3 trucks.		Locomotor and 3 trucks.		Locomotor and 2 trucks.		Locomotor and 2 trucks.	
	Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.
4. Tare weight of train...	10	5	10	5	13	10	13	10	10	5	10	5
5. Useful load carried ...	9	5	1	5	14	4	4	18	3	18	2	12
6. Gross weight of train ...	19	10	11	10	27	14	18	8	14	3	12	17
7. Total distance run, miles ...	64		64		64		64		65		64	
8. Gross ton miles ...	1,248		736		1,773		1,178		920		822	
9. Total ton miles of useful load ...	592		80		909		314		253		166	
10. Total gallons of petrol used...	48		29		Unascertained owing to leak in petrol tank.		34		50		37	
11. Gallon of petrol used per mile run...	0·75		0·45				0·53		0·77		0·58	
12. Miles run per gallon of petrol used ...	1·33		2·21				1·88		1·30		1·73	
13. Gallons of petrol used per gross ton mile ...	0·038		0·039				0·029		0·054		0·045	
14. Gallons of petrol used per ton mile of useful load ...	0·081		0·362				0·108		0·197		0·222	

TABLE B.—*Showing Aggregate Time Stopped and Running Time during each Journey.*

Date of trial ...		1. 2. 09		5. 2. 09		7. 2. 09		12. 2. 09		18. 2. 09		27. 2. 09	
Direction ...		Gauhati to Shillong.		Shillong to Gauhati.		Gauhati to Shillong.		Shillong to Gauhati.		Gauhati to Shillong.		Shillong to Gauhati.	
		Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.
Gross weight of train ...		19	10	11	10	27	14	18	8	14	3	12	17
		Hrs.	Mins.	Hrs.	Mins.	Hrs.	Mins.	Hrs.	Mins.	Hrs.	Mins.	Hrs.	Mins.
Total time spent on journey ...		17	3	9	25	24	0	11	17	17	5	10	19
Time occupied in stops during journey.	Voluntary ...	1	50	1	45	1	39	2	5	1	9		56
	Involuntary ...	3	33	*Nil.*		1	41		30	3	5		9
	Total ...	5	23	1	45	3	40	2	35	4	14	1	5
Total running time ...		11	40	7	40	20	20	8	42	12	51	9	14

TABLE C.

Details of Speeds at which the Train Travelled

Date of Trial.	Direction of Journey.	Section of Road Miles.	Average Speed. M.P.H.	Useful Load. Tons.	Useful Load. Cwts.	Gross Load. Tons.	Gross Load. Cwts.	Remarks.
1. 2. 09	Gauhati to Shillong.	0·75 to 6·00 6 ,, 44·75 14·75 ,, 64·75 0·75 ,, 64·75	8·00 6·50 3·92 5·48	9	5	19	10	Daylight failed at 43rd milepost. 21¾ miles travelled after dark. Time spent on journey, 17 hours 3 mins. 3 consecutive miles run at speed of 11 M.P.H.
5. 2. 09	Shillong to Gauhati.	64·75 ,, 54·00 54 ,, 7 7 ,, 0·75 64·75 ,, 0·75	7·97 8·34 9·15 8·35	1	5	11	10	Trial finished in daylight. Time spent on journey, 9 hours 25 mins. 3 consecutive miles run at speed of 10 M.P.H. 1 mile at 12 M.P.H. twice.
7. 2. 09	Gauhati to Shillong.	0·75 ,, 7 7 ,, 54 54 ,, 64·75 0·75 ,, 64·75	6·70 3·51 1·79 3·15	14	4	27	14	Daylight failed at 23rd milepost. 31¼ miles travelled after dark. Time spent on journey, 24 hours. 5 consecutive miles run at speed of 7·14 M.P.H. 1 mile at 7·5 M.P.H. twice.
12. 2. 09	Shillong to Gauhati.	64·75 ,, 54 54 ,, 9 9 ,, 0·75 64·75 ,, 0·75	7·50 7·28 8·08 7·35	4	18	18	8	Daylight failed at 10th milepost. 9¼ miles travelled after dark. Time spent on journey, 11 hours 17 mins. 3 consecutive miles run at a speed of 9·5 M.P.H. 1 mile at 10 M.P.H. twice.
18. 2. 09	Gauhati to Shillong.	0 ,, 7 7 ,, 50 50 ,, 65 0 ,, 65	7·37 5·26 4·02 5·06	3	18	14	3	Daylight failed at 51st milepost. 14 miles travelled after dark. Time spent on journey, 17 hours 5 mins. 3 consecutive miles at speed of 10 M.P.H. 4 consecutive miles at 9·75 M.P.H. 1 mile at 12 M.P.H.
27. 2. 09	Shillong to Gauhati.	64·75 ,, 54 54 ,, 7 7 ,, 0·75 64·75 ,, 0·75	6·86 6·68 9·87 6·93	2	12	12	17	Trial finished in daylight. Time spent on journey, 10 hours 19 mins. 3 consecutive miles run at speed of 11 M.P.H. 6 consecutive miles at speed of 10·30 M.P.H. 1 mile at 12 M.P.H. twice.

NOTES ON SOME AMERICAN BATTLEFIELDS.

By 'MILES.'

WHILE travelling on leave in the United States in the autumn of 1908, the writer took the opportunity of visiting some of the battlefields in Virginia and Maryland, and the following notes may possibly be of interest to those who have studied the history of the Civil War. It is presumed that anyone who reads this article is already familiar with the main outlines of the campaigns of 1863 and 1864, and it will therefore be unnecessary to give any description of the operations, except in so far as a brief outline of some special incident may be necessary to elucidate the remarks made on the battlefield in question. The writer had the good fortune to make the acquaintance at Fredericksburg, Virginia, of an ex-Confederate officer—Capt. Murray-Taylor—who served throughout the war on the staff of General A. P. Hill, and formed one of the small group of staff officers who accompanied Jackson on his reconnaissance down the plank road toward Chancellorsville on May 2nd, 1863, having his horse killed under him by the same volley that mortally wounded Jackson. He was also at the side of A. P. Hill when he was killed in Grant's final and successful assault on the Confederate lines round Petersburg. To Capt. Taylor the writer is indebted for much kindness and hospitality, and for a great deal of most interesting information about incidents in the battles fought round Fredericksburg.

It is hardly an exaggeration to say that Fredericksburg has witnessed more fighting in its immediate neighbourhood than any other town on either side of the Atlantic. Within a radius of 12 miles there were four great battles fought in two years, Fredericksburg in December, 1862, Chancellorsville in May, 1863, and the Wilderness and Spotsylvania in May, 1864. In these battles the casualties on both sides reached a total of over 100,000 men. What lends a particular interest to the study of the ground over which these battles were fought, is the fact that it lies to-day in almost exactly the same condition as it was 45 years ago. Part of Fredericksburg has been rebuilt, but for the most part it remains the same quiet, self-contained country town that it was before the war. Its inhabitants can still point out on the walls of some of the houses, the marks of cannon balls recalling General Burnside's bombardment previous to the battle of December, 1862, when the greater part of the town was laid in ruins. Salem Church, a quaint little red-brick building on the plank road 3 miles out from the town, still shows the marks of the bullets it received during Sedgwick's attack on May 4th, 1863. Further west one can follow for miles through the woods, the entrenchments made by the armies of Lee and Grant. But for a slight filling up of the ditches, these remain in exactly the same condition as in when vacated by the troops in 1864. The only considerable alteration that has been made in any part of the four battlefields, is the formation of the large National Cemetery on Marye's Hill, behind Fredericksburg, the scene of the disastrous Federal assaults in Burnside's battle. The celebrated stone wall—which formed the front line of the Confederate position on the hill—is still there and remains practically untouched. At the foot of the hill, there now stands a monument to General Cobb, who was mortally wounded while in command of the Confederate troops at this point. Readers of Henderson's *Stonewall Jackson* will remember his moving description of the last interview between Cobb and Jackson on that occasion.

Turning to the battlefield of Chancellorsville, the Chancellor House, which was partly burnt down at the time of the battle, has since been rebuilt. At the present time it stands unoccupied and in a somewhat dilapidated condition, looking in fact much as it must have appeared on May 3rd, 1863, when the enemy's shells were bursting over it, in the final Confederate assault on that day. One can still see the pillar against which Hooker was leaning when the bursting of a shell, which struck the house, threw him senseless to the ground. The wide clearing in which the house stands, remains as it was at the time of the battle. All around it lie the dense thickets of the Wilderness, while round the western edge of the clearing, one can still trace the epaulements thrown up for the guns which were hurriedly placed here by General Pleasonton, to resist Jackson's final attack. Following the plank road for about three-quarters of a mile, one comes to the spot where Jackson was standing with his staff when the fatal volley was fired which mortally wounded him. The account of this disaster, as told to the writer by Capt. Taylor, who was at the time lying on the road pinned beneath his fallen horse, agrees in almost every respect with the wonderfully graphic description by Henderson. A monument has been erected to Jackson under the trees by the roadside, as near as possible to the spot where he fell. It is a plain column of dressed granite, bearing on it the simple inscription "Lieut.-General T. J. Jackson, C.S.A. Died May 6th, 1863," and under this are inscribed the words used by Bee at Bull Run, "Look, there is Jackson standing like a stone wall!" From this point it is easy to form an idea of the situation at that moment as it must have presented itself to Jackson's mind. In front, the plank road, about 40′ wide, runs in a dead straight line towards Chancellorsville through the woods on either hand, the house itself being only hidden from view by a slight intermediate rise in the ground. That house formed Hooker's headquarters. The rout of the Eleventh Corps had left the road absolutely open, for with the exception of a few regiments hastily collected together from different quarters, and the Federal batteries massed round the edge of the clearing, there was nothing to oppose the Confederate advance to Chancellorsville. Standing there beside the monument and looking down the plank road, one can realize clearly how it was Jackson's untimely fall—and with it the removal of the directing brain of the Confederate assault—that alone saved Hooker's headquarters from capture and his army from a terrible disaster.

It is a curious fact that the exact route, followed by Jackson in his march round Hooker's right flank, remains more or less uncertain. The generally accepted route is that indicated by Henderson in the map of the battlefield attached to his *Stonewall Jackson*, Vol. II. But it seems doubtful whether the column could have covered so long a distance, as is here indicated, in the time which the march is recorded to have taken. Capt. Murray-Taylor, who accompanied the column and was intimately acquainted with the ground, informed the writer that he himself was uncertain as to which was the road actually followed. Nor is this to be wondered at when one has seen the Wilderness and realized how like each other all the forest tracks are. It will be remembered that Jackson obtained the services of a local guide to lead him through the woods, and it can be easily understood how, in the excitement and preoccupation of the ensuing battle, the details of the march may have passed out of the recollection of those who took part in it. The spot where Lee and Jackson held their last consultation, is marked by a small stone with a brief inscription chronicling the fact, set up at a point where a branch road from Catherine Furnace runs into the plank road within a mile of Chancellorsville. This is one of the very thickest parts of the Wilderness, and it is easy to understand how possible it was for Lee to conceal from Hooker the smallness of the force still facing him, and to amuse him by feint attacks on his front at Chancellorsville, while Jackson, concealed by the forest, was marching round to fall upon his flank and rear.

The battlefield of Spotsylvania is in many ways as interesting as that of Chancellorsville. Wandering through the woods one comes upon trenches, rifle pits, and gun epaulements everywhere, line after line, sometimes three deep, often in the most unexpected places, and running in every sort of direction. Relics of the battle, in the shape of bullets, fragments of shells, rusted bayonets, etc., can still be picked up in large numbers. They are genuine relics, not *imported* ones, such as those which are brought in cart loads and dumped on the site for the amusement and gratification of tourists at Waterloo and other famous battlefields. There are no tourists to cater for at Spotsylvania, for none go there. The battlefield remains in exactly the same condition to-day as when it was evacuated by Lee and Grant in May, 1864. Its most striking peculiarity is the absence of any well-marked natural features. The position occupied by the Confederates, followed the contours of the low crest which forms the water parting between the two little streams—the Po and the Ny. The greater part of this ground is covered with thick woods, except in the neighbourhood of the Court House, where it is fairly open. Lee must have had a wonderful eye for ground, for this position, taken up at a moment's notice almost in the presence of the enemy, was the best that could have been found anywhere in that vicinity. Its good points are shown by the fact that during the 15 days the battle lasted, Grant tested every portion of the line, and expended from 15,000 to 20,000 men in vain efforts to break through. Only at one point can the position be said to have been defective. This was at the famous salient, or "Mule Shoe," the scene of the desperate fighting on May 12th. This action affords an excellent example of the extraordinary nature of the fighting in such a locality as the Wilderness. Lee's line at this point formed a very prominent salient—shaped somewhat like a horse-shoe—following the edge of a thick wood, which had been prepared for defence by constructing breastworks of logs. In front stretches an open space about 400 yards wide, separating the salient from the belt of woods which marked the Federal line. On the night of May 11th, Grant, unknown to the Confederates, massed Hancock's Corps opposite the salient. The assault was delivered at dawn of the 12th, a heavy mist concealing the attacking troops until they were within a short distance of the enemy's line. The breastworks were carried with the bayonet almost without a shot being fired, and part of the attacking column running down a lane, which gives access to the base of the salient, got in rear of, and captured, Johnson's Division, which was holding the angle. Had Hancock been able to follow up the success so brilliantly won, Lee's Army might have been destroyed. But his troops had lost all order in their advance, and the dense thickets prevented them from realizing the extent of their success. Lee brought up reinforcements from Hill's Corps on his left, and the Federals were forced back to the breastworks they had just captured. Here the struggle continued for hours, the Federal and Confederate troops shooting and stabbing one another across the breastworks. So shocking was the aspect of the ground after the battle, that this corner of the line came to be called the "Bloody Angle." Finally Lee withdrew his troops to a fresh line of entrenchments which had been rapidly thrown up across the base of the salient, and so the fighting ended. For many years there stood here the stump of a tree which had been cut in two by the rain of bullets during the struggle for the breastworks, but it has now gone. A monument has been put up at the "Bloody Angle" to a Massachusetts regiment which lost 60 per cent. of its strength in this fearful *mêlée*. It is a pity that no memorial of any sort has yet been erected to the memory of the brave men of Gordon's Confederate Division who faced them for so many hours on the other side of the breastworks.

An examination of the ground shows clearly why the salient was selected. It is the only position in this vicinity from which a good field of fire can be obtained to the front and flanks. Everywhere else the dense woods make it impossible to see 20 yards ahead. This is shown clearly by the remarks on the fighting at the salient which General John Gordon makes in his *Reminiscences of the Civil War*. All that he heard of Hancock's assault were a few scattered shots, followed by a mysterious silence. No one knew what had happened, and all that Gordon could ascertain was that a large body of the enemy seemed to have broken through somewhere near the salient, and was apparently moving in rear of the Confederate lines. The statement appears incredible until one realizes how restricted is the view in these thick woods, which are quite large and dense enough to have swallowed up the whole of Hancock's Corps from sight or sound.

Another battlefield which the writer visited was Gettysburg. The contrast between this field and that of Spotsylvania is a most striking one. The principal characteristic of Spotsylvania, as already noted, is the absence of conspicuous features. Gettysburg, on the other hand, is one of the most well-marked battlefields to be found anywhere. The one is covered with dense woods; the other is, for the most part, very open ground. The maximum range at Spotsylvania was a few hundred yards. At Gettysburg batteries came into action at over 2,000 yards range. There is scarcely a monument of any sort at the former. At the latter there are between 400 and 500. In this respect Gettysburg must certainly hold the world's record. In some places, particularly on Cemetery Ridge, there are so many that they seem to almost jostle one another for space, producing a somewhat incongruous effect. A single adequate monument, dedicated to the memory of all the regiments that fought at this point, would probably be much more impressive. The whole of the ground over which the battle was fought has been taken over by the United States Government and converted into a National Park. Under the direction of a Board of Commissioners much has been done to make it attractive to visitors. Avenues have been laid out in all directions, following in many places the positions taken up by the hostile lines; observation towers erected, from which excellent views over all parts of the field can be obtained; and guns, actually used during the war, have been placed to mark the positions occupied by the artillery on both sides during the battle. All this makes the study of the battlefield most interesting, although it may be doubted whether the alteration of the natural features of the ground, by the construction of the numerous avenues, is altogether a good thing. Lieut.-Colonel Cope, U.S. Engineers, one of the National Commissioners, who was himself an eye-witness of the battle, gave the writer much interesting information, and was most kind and obliging in every way.

In all descriptions of the natural features of the battlefield much stress is laid on the importance of the Cemetery and Seminary Ridges, which formed the positions of the Federal and Confederate Armies respectively on the second and third days of the battle. It is surprising therefore to find how relatively insignificant these two ridges are. Cemetery Ridge is in reality only a slight swelling or corrugation of the ground, which would be barely perceptible but for the broad glacis slope, absolutely bare and open, which it presents to the west. Cemetery Hill—described by one writer as a "bold promontory" and by another as a "rocky headland"—is not a conspicuous feature by any means. It is an oval-shaped hill with easy slopes on all its faces except the east, where the gradient is steeper. The expression, often used, that from the summit of the hill one looks down into the streets of the town, gives an exaggerated impression of its height and abruptness. Surveying the Federal position from the Lutheran Seminary, which stands on the ridge of that name, the conspicuous points that strike the eye are Culp's Hill, rising up behind the town on the left, and Round Top or Sugar Loaf Mountain looming up in the distance on the far right. But for the tall monument which stands in the cemetery grounds, Cemetery Hill would escape almost unnoticed. The same may be said for the Seminary Ridge, which played an almost equally important part in the battle. It forms not so much a "ridge" as an "escarpment," the slope being sometimes on one side, sometimes on the other. Thus the south end of the ridge, from which Longstreet's assault on July 2nd was delivered, shows from the Federal position simply as a dark line of woods, seen across a wide stretch of flat fields. Behind this belt of woods the ground falls away sharply towards a stream called Marsh Creek, and it is this escarpment that constitutes the so-called ridge.

The most celebrated episode in the Battle of Gettysburg is undoubtedly the famous charge of Pickett's Division on Cemetery Ridge. This is as much an historic event in America as the charge of the Light Brigade at Balaclava is in this country. The circumstances are, no doubt, familiar. General Lee's intention was to break through the centre of the Union line holding Cemetery Ridge, and for this purpose he formed an assaulting column of some 14,000 men, composed of Pickett's Virginian Division and a mixed division under Trimble and Pettigrew. It was intended that the remainder of A. P. Hill's Corps should support the attack, but owing to a blunder, which has never yet been satisfactorily explained, the order miscarried and the two divisions advanced entirely unsupported. Trimble and Pettigrew were beaten back, without crossing bayonets, by the terrible cross fire of artillery and small arms, but Pickett's Division, in spite of the most frightful losses, succeeded in reaching the low rubble wall which formed the enemy's front line and planted their flags on Cemetery Ridge. Had the supports been now at hand Pickett might have made good his foothold, but not a man was sent, and after a desperate hand-to-hand struggle over the stone wall, the Virginians were forced back and the assault ended in complete failure. In this charge Pickett's Division lost every field officer and 2,843 rank and file, out of 5,000 who took part in the attack. An examination of the ground, over which this celebrated charge was made, forms a most interesting study. Many descriptions of the attack speak of the Confederate columns advancing "to storm the heights." This is misleading. The track followed by Pickett's Division leads across a perfectly flat plain, about 1,000 yards in width, until the Emmittsburg road is crossed, when the ground rises slightly towards the low crest of Cemetery Ridge. The strength of the position lies not in the difficulties of a steep ascent which is non-existent, but in the broad glacis slope without a vestige of cover, over which the attacking troops had to advance to the assault. This spot has been called the High-Water Mark of the Confederacy, from the generally accepted opinion that had Pickett been adequately supported the Confederates would have won the battle, and the South the recognition of her independence. At this point there stands the only Confederate monument on the battlefield. A granite scroll about 3′ high marks the spot where General Armistead fell at the head of his brigade in the heart of the Union lines. It bears the plain inscription "Brigadier-General Lewis A. Armistead, C.S.A., fell here July 3rd, 1863." Amidst the vast number of stately and imposing edifices which crowd the Cemetery Ridge, and are erected to the memory of Union officers and men, this simple tribute to a Confederate soldier has the most impressive effect, constituting as it does the sole memorial of one of the finest feats of arms recorded in history.

There are many other most interesting incidents in this the decisive battle of the war, but considerations of space prevent a reference to them in this article.

In conclusion, the writer of this article would like to record not only the unfailing kindness and courtesy with which he was met wherever he went in Pennsylvania, Virginia, and Maryland, but also the great willingness on the part of those whom he met to give him any information and assistance in their power.

ROMAN AND EARLY BRITISH TERRITORIALS.

By COLONEL S. A. E. HICKSON, D.S.O., R.E.

THE details of the decline of the ancient Roman military system of the republic, by Colonel O. E. Ruck in the *R.E. Journal* for May, are of particular interest, more especially as he gives references. All your readers however may not be acquainted with the ancient Roman republican constitution as a whole, or such records of it as still exist, and were so carefully examined early last century by Niebuhr, whose investigations were continued by Mommsen. This constitution, generally known as that of Servius Tullius, is thus described by Mommsen :—"Under the Servian constitution the duty of service and the obligation connected with it of making advances to the State in case of need (*tributum*), instead of being imposed upon the possessors of the land, the domiciled or freeholders (*adsidui*), or the wealthy (*locupletes*), whether they were burgesses or merely *metoeci*, service in the army was changed from a personal burden to a burden on property." This is just what Dr. Stubbs in his constitutional *History of England* describes as taking place in this country during the Saxon period. In the Roman system Dr. Mommsen continues : "Every freeholder, from the seventeenth to the sixtieth year of his age, was under obligation of service, including children in the household of fathers who were freeholders, without distinction of birth ; so that even the emancipated had to serve, who in an exceptional case had come into possession of landed property. . . . The body of men liable to serve was distributed according to the size of their portions of land into five summonings (classes from *calare*). Of these however only those liable under the first summoning or those in possesssion of an entire hide of land were obliged to find complete armour, and, in that point of view, were pre-eminently regarded as "those summoned to war service" (*classici*). The four following ranks of smaller land owners, the possessors respectively of three-fourths, of a half, of a quarter, of an eighth of a normal hide, were required to fulfil service, but not to equip themselves in complete armour." It is from this system that we have our own word "class," and upon this system was founded that splendid early English system of national defence, which merged from the Saxon *Trinoda necessitas* and "fyrd," and from the Oath of Allegiance which bound every Englishman by service to the King. The "Assize of Arms" of the reign of Henry II., in which this English system first took written form, follows exactly the lines of the Constitution of Servius Tullius, its first three clauses running as follows :—

(1). Quicunque habet feodum unius militis habeat loricam et cassidem clypeum et lanceam, etc.

(2). Quicunque vero liber laicus habuerit in catallo vel in redditu ad valentiam de XVI. marcis, habeat loricam et cassidem et clypeum et lanceam, quicunque vero liber laicus habuerit in catallo vel redditu X. marcas habeat aubergel, et capellet ferri et lanceam.

(3). Nem armes burgenses et tota communa librorum hominum habeant wambais et capellet ferri et lanceam.

Thus in England there were four classes. The system of universal obligation to military service, thus founded, was expanded under the Statute of Winchester of Edward I.; and there were many revisions of it, especially by Henry VIII. It continued to be the mainstay of our national defence up to the time of the Spanish Armada, when it fell into disuse by reason of the argument of the extreme blue-water school, which then came into existence under the title of "Worshippers of Neptune." As in the case of Rome, universal service gradually decayed away and the Imperial legions, formed of professional soldiers, took its place; so in England the "fyrd," *i.e.*, the national levy or militia, was replaced by a standing army, raised when occasion demanded or panic arose, and disappearing with the swing of the pendulum to peace. We have thus now no self-supporting continuous system such as we had up to the sixteenth century, when in 1557 a Venetian ambassador reported as follows to his Government concerning it:—"As to the land forces (of the English), aptness, courage, and inclination supply the deficiency of other qualities, and when in action no natives in any quarter of the world fight with an equal degree of ardour and contempt of death. . . . As the hopes of a country rest principally on the valour of the rising generation, boys from the age of nine are taught to draw the bow, in the use of which their dexterity is incredible. There are few who cannot lodge the arrow within half a palm of the mark. In the more experienced, force is so effectually united with dexterity that they are reported to pierce not only the corslet, but a complete suit of armour." A note explains further that "An English arrow with a little waxe put upon the point of the head will passe through any ordinary corselette or curace." Hume (Vol. I., p. 67) also relates how King Alfred, "after rebuilding the ruined cities, particularly London, which had been destroyed by the Danes in the reign of Ethelwolf, established a regular militia for the defence of the kingdom. He ordained that all his people should be armed and registered." He had besides a central force consisting of his thegns and ten trained men from every town, and the scientific use he made of this central force, combined with the local territorial levies of London, Kent, and Surrey at one time, and of Devon at another, etc., etc., in driving off the Danes when they came again in 893 and attacked simultaneously the north and south of Kent and Exeter, is well worth studying.

FIRE APPLIANCES IN BARRACKS.

SOME NOTES ON WORKING.

By CAPT. E. H. HARVEY, LATE R.E.

THE following notes and suggestions have been put together in the hope that they may be of some use to Division Officers, R.E., in connection with various small questions affecting fire appliances and water supply in barracks, that often arise in the course of daily work.

To officers of experience I am afraid that many of the points alluded to will appear trivial and to possess no novelty, but there are some who may not have had much occasion to deal with the matter, and as information on the subject of fire appliances exists in rather a scattered form, and as the D.O., R.E., is from time to time referred to for advice on fire-protective arrangements, perhaps the following may be of service in connection with certain points which I have known to give rise to correspondence and minor difficulties.

I have in previous papers gone more fully into the technical side of the question, and will therefore confine myself to some practical suggestions.

Water Supply.—The importance of having fire mains of ample size is now well known, and in testing any system it is essential to ascertain that the required supply can be continuously maintained, keeping the hydrant jets at work for some little time, and noting whether any serious variations occur through the opening of other branches and services. A main, though theoretically large enough to deliver an adequate fire supply at its extreme end, is frequently liable to be temporarily affected by the above cause, and therefore a margin should be allowed to counteract these draughts of water for domestic supply, and to give a fair chance of obtaining sufficient for immediately dealing with an outbreak of fire. It is needless to say that in many cases a poor pressure at the commencement can never be compensated for by the full supply when it is too late.

Supply from Hydrants.—Where the hydrants have to supply fire engines more frequently than direct jets it is most important that the delivery should be ample; 350 to 400 gallons per minute should be allowed for the supply of an average-sized steamer, and 500 gallons for larger engines.

Special meters can now be obtained for ascertaining the rate of delivery from hydrants, but a rough-and-ready way is, of course, by taking the time of filling a tank of known capacity. I have effected this with a 100-gallon cistern (from store), a standpipe, and a very short length of leather hose, similar to that which would deliver the water into the canvas "dam" or the cistern of an engine. The water must be fully turned on and running full-bore before the end of the hose is (quickly) dropped into the tank and the timing commenced. This method of testing, though simple, requires to be carefully done, to ensure a fairly accurate result.

New Hydrants.—When new barrack works are being completed it is very important to see that subsequent to the laying down of the hydrants any making up of the roads and parades has not caused the level of the outlet and key-spindle to be too deep below the surface. It may even be necessary to fit a lengthening piece to the outlet and lengthen the water key, though with careful levelling there should not be much mistake.

Hydrant covers, again, may be carelessly covered up with gravel, and it is most desirable before handing over new hydrants to see them *all* tested with standpipe and key, and if possible hose and branch-pipe, so as to make certain that the supply is equal to what was provided for.

Marking Hydrants.—Barrack hydrants, being often in the middle of large gravelled surfaces, are not always easy to locate at night. It is a great help if the iron covers are painted white and then lime-whited, the limewhite being renewed periodically by the regimental conservancy men or pioneers, who should have a list of the hydrants and thus become well acquainted with their positions. Even when they have become rather faded from the effects of rain, the covers are still easily seen on a dark night. In snowy weather the distance from the wall-mark will require measurement in any case, if the hydrant has to be picked up.

On the wall-marks of hydrants and sluice valves it may in some cases be well to paint arrows showing the direction for turning "on" or "off."

By-pass.—To ensure that the by-pass is not allowed to get set fast, a local arrangement should be made with the Water Company for it to be periodically turned on in the presence of their representative, who will then re-seal it. This occasion, with the concurrence of the O.C. troops in the station, is a favourable opportunity for thoroughly practising fire drill with all available appliances, and also for affording the local public fire brigade an opportunity of testing the supply, with reference to the capacity of their own engines. A list of approximate dates on which the by-pass is turned (say quarterly) may with advantage be kept on the wall of the D.O.'s Office, together with a list of the hydrants (and fire tanks, if any).

In practising fire drill it is of great importance that some reliable men should be *permanently* told off at all fire alarms to attend to and, if necessary, actually turn on the by-pass. And a particular point to notice is that immediately the by-pass has been turned on, a sentry or policeman should be posted on it to prevent interference, unless ordered by the senior officer present. It is most desirable that the men who have this duty should be practised in actually opening the valve, for, as people will know who try it, it is not quite as easy to start a sluice valve which may be a little stiff as would appear in theory. And in regard to the posting of the sentry, I have heard of a case at a serious barrack fire in which the by-pass, after being once turned on, was shut off again, with the best intentions, by a later arrival, who thought he was opening it.

Sunk Tanks.—Sunk tanks, though a necessity in many isolated situations where there are no water mains or only a small domestic supply, have the objections pointed out in a book written many years ago by Mr. Braidwood—the chief of the first large organized fire brigade in London* and the predecessor of the late Sir E. M. Shaw—that they confine the engines to particular spots, often necessitating, if not very numerous, long lines of hose, and that they are sometimes too small, leading to a failure of the water at perhaps a critical moment. As a storage of water for commencing operations, where there are hydrants which can be charged with water soon after an outbreak, though ordinarily under intermittent service, tanks have, of course, their value. In the Winchester barracks, as a "first-aid" measure, three large 1,400-gallon cisterns over latrines adjacent to a large range of buildings were fitted with 3″ outlets and suction-hose connections, so as to enable a manual engine to commence work till the hydrants were turned on. Ordinarily however a reserve tank, even if only for "first aid," should hold at least an hour's supply for the barrack engine at full power.

Siting Tanks.—In placing tanks for the protection of any building it is very desirable to consider the direction of the prevailing winds and, if possible, to arrange *two* or more tanks, so that alternative positions may be found for the fire engines if a strong wind is blowing. Otherwise, as in a case I have heard of, the only available tank may be close to leeward of the fire, and the men unable to work for heat and smoke. Another point to remember in barracks is the limited range of the manual engine, especially if the building to be protected is of any height. It will always be useful in considering the protection of any buildings, whether new or existing, to practically test the engine on the furthest points of the roof from the water supply, and so find out its radius of action, before setting out any tanks.

Manual Engines.—The standard engine now used by the War Department is the "No. 1," or large size; the small "No. 2" engines are being expended by degrees, but are yet to be found in service. Useful as light appliances for very small buildings in steep hilly

* The "London Fire Engine Establishment."

places, their capacity cannot be said to be great, and, besides being of inferior power, they use both a smaller suction ($2\frac{1}{4}''$) and a smaller delivery hose ($1\frac{1}{2}''$) than the "No. 1" manual, which takes the standard size of hose used by most public fire brigades ($2\frac{1}{2}''$).* Where the two sizes of engines are in use together there is always risk of some confusion with the different-sized hose connections, involving the use of various "adapters." The manual engine, it may be observed, is often described in terms of the bore in inches of the pump cylinders, "No. 1" being a "7″ engine." A very widely-used size in England is the "6″ engine," this size having been adopted in London during the time of Sir E. M. Shaw's command, previous to the full equipment of the London Fire Brigade with steamers.

The 7″ engine (the same size as the War Department "No. 1") was preferred by Mr. Braidwood, but in his time the steam fire engine was in its infancy and London fires had to be dealt with by manual pumps.

It must be remembered that in buildings of small height and moderate dimensions a great deal of useful work has been done in the past and can still be done by manual engines. One objection to their use, though, of course, not the chief one, viz., their lack of power for many modern conditions, is the difficulty of always getting labour at once when required, especially in rural out-districts or in the dead of the night in residential localities. This condition does not exist in barracks and similar institutions, and these engines will always have their use, at least as "first aid," till steam appliances can be got into action; for instance, where a steamer is maintained at a works or at a Government establishment, and where there may be no facilities for keeping the boiler hot, and also a poor pressure on the hydrants to rely on while steam is being raised from cold water.

Notes on Working Engines.—Dealing now with one or two points that come to notice at ordinary fire practices, it is particularly important that all soldiers who have to do with the barrack fire engine should thoroughly understand the use of the valve on the suction pipe (worked by a handle in the rear "well" of the engine), which sets the pump to draw water either from the "well" itself or through the suction inlet and hose.

This may seem a trifling thing to allude to, but I have several times seen men in charge unable to get their engine to work through lack of this information,—the handle happening to be turned the wrong way. Also the valve should be turned to and fro periodically, or it is certain to get set fast.

Mode of Supply of Water.—A certain amount of difficulty arises at times in making connection between the engines and various-sized hydrants, and the R.E. are referred to. There is however no

* The figures in brackets denote size of waterway in the hose couplings, *i.e.*, their internal diameter.

difficulty if the simple course is adopted of providing a short length of hose which fits the standpipe and hydrant, and putting the open end of it in the engine "well," turning the handle of the suction valve above alluded to *across* the engine.

The "break of gauge"—to use a railway expression—then occurs at the engine, and it is no matter whether the delivery hose and connections (other than the length referred to above) fit the hydrant or not. I have seen difficulties arise, leading to correspondence, because of it being apparently thought essential that the suction hose should be connected *direct* to the standpipe on the hydrant.

This is apt to come to notice in places where a barrack is provided both with hydrants and sunk tanks, and the engine is worked from either in turn.

Connecting Direct with Hydrants.—Adapters, known as "screws, double junction," for connecting the "No. 1" engine suction, with outlet of standpipe, are double-ended screw collars forming an article of store, and provided by the A.O.D. for use in cases where it is specially desired to connect the engine suction *direct* to the standpipe. This method of working has certain advantages, especially where the water pressure on the mains is intermittent, as at high levels,—the suction of the engine in such cases tending to hasten the flow of water in the hydrant, and, on occasion, enabling a jet to be got to work more quickly.

To summarize the foregoing remarks, it may be mentioned that there are three ordinary ways of supplying the manual with water.

(1). Through the suction inlet and suction hose (with strainer), handle of suction valve turned "*fore-and-aft*" in the engine, as when lifting from a stream or tank.

(2). The same, but with the suction hose connected direct by means of a "double junction" screw to a standpipe.

(3). From the "well" of the engine itself, with the handle of the suction valve turned *across the engine*, and the end of a hose from a hydrant (or in some cases from another engine nearer the water supply) placed in the "well."

For the reasons already given, this last is the most generally convenient way of working from hydrants. A short curved copper bend—known as a "goose-neck"—is provided to attach to the open end of the supply hose, and hook on the side of the engine "well."

Placing the Engine for Work.—In working from hydrants, though *usual*, it is by no means *necessary* that the engine should be placed close to the hydrant—unless directly connected thereto—and by a little experiment it will often be found possible to greatly increase the effective radius of action of a hydrant aided by an engine by stationing the latter near the building to be reached and laying down a line of several lengths of hose between it and the hydrant. The latter will often have force enough to deliver a good supply at low pressure through a long line of open hose to a point quite near a building, where the engine can then be placed, and throw a jet that will cover the roof. To give two instances that I have tested, the top floor of a three-storied barrack block standing back in an enclosure was, at its furthest end from the nearest available hydrant, quite out of reach either of a jet from the hydrant *direct*, with a low pressure of about 25 lbs. per square inch, or of the jet from the manual when worked *near* the hydrant with the short length of hose supplied for the purpose. But by laying about 150′ of hose between the engine and hydrant the former was brought to a close range, which easily enabled it to cover the building.

In another case about 250′ of hose were required to reach some one-storied workshops, and the jet from the manual, (a rather old one in this case), when near the hydrant, and that direct from the hydrant itself, were equally feeble; but on moving the engine up to the front, 200′ from the standpipe, and filling it from the open end of the hose. the quantity of water was still found adequate, and a full-powered jet was thrown at short range.

This method of working is worth testing in any case where there is difficulty in reaching outlying parts of the barracks, though, of course, the more hydrants the better. It has been said that hydrants are cheaper than hose in the long run, and the less the length of hose through which the water has to be forced, the better the result, especially with the unlined canvas hose.

Ladders and Fire Escapes.—In dealing with many fires it is of utmost importance to have efficient means for getting on to the roof, and it is well to note that the ordinary telescopic fire escape on a wheeled carriage is, though primarily intended for life saving, a most important appliance also in aiding the work of extinction, by enabling the hose to be safely and conveniently worked at roof level or conveyed on to the roof itself. Long ladders of ordinary construction are springy and awkward to handle, and the safety and convenience of a proper telescopic escape are invaluable by comparison.

Great care should be taken, though, that only men who are taught the proper handling of an escape should be allowed to use it, as otherwise it is dangerous in unskilled hands.

Various compact and convenient fittings are to be obtained, consisting essentially of some form of pipe-bend and adjustable branch-pipe that can be attached to the head of an escape ladder, and take the heavy weight of the hose off the hands of a fireman stationed on the ladder, enabling him to direct a jet from any desirable level into the highest parts of a burning building. These fittings would, as a rule, only be supplied where there are standing fire brigades.

Fire-escape Shed.—In a fire-escape shed it will be found convenient to fit a cross piece or cross sling, so as to enable the ladders to lie balanced horizontally on their carriage ready to travel. (I allude to the modern "horizontal-running" escape now generally in use, having a special winding gear to elevate it, as well as a winch to extend the ladders). In Winchester Barracks a cross sling of wire rope was provided, with an outer covering of leather where the weight of the ladders came. An eye-splice was made at one end of the sling—dropping over a hook on the side wall—and thus capable of being easily cast off when the escape was run out.

First-floor Ladders.—The "first-floor ladder" is an ordinary and useful adjunct to an escape for use in enclosed courts and gardens; it is a short detachable length carried loose, but is, of course—as its name implies—only useful for a limited height.

Access to Buildings for Fire Escapes.—A most important matter for all who have to do with the fire protection of buildings is to consider the means of access to such high windows as overlook *closed courts and gardens.* Wherever possible, openings wide enough to admit the ordinary wheeled escape should be made, and a little forethought on this point may at any time prove to be the means of saving life. Many high buildings are partially surrounded by walled enclosures, and means of access for the fire escape is difficult or impossible. The openings may, if necessary for privacy, be closed with some light and easily removable palisading. At a notable hotel fire which I witnessed a few years ago the rescue work had been greatly hampered and some life lost in the earlier stages through the inaccessibility of high parts of the building from the above causes.

Where it is impossible to get this direct access, fire-resisting balconies should be provided leading to convenient points above the street, or in the case of rows of buildings, from the top windows of each to the nearest on the other side of a party wall. Recently, also—in the matter of the appliances themselves—specially light telescopic escapes are made, which can be detached from their carriage and carried into enclosed places.

Chemical Appliances.—Chemical "first-aid" appliances—known to firemen as "Kemik's"—have come much into favour in this country recently, but care should be taken to obtain only reliable makes and to ask expert advice, if possible, from practical firemen. Fatalities have occurred through the explosion of these machines. A good deal of discussion has taken place as to the value of the gases liberated in aiding the extinction of the fire, but whatever this may be, the primary use of the gas is to generate at once the necessary pressure; and many such machines are now worked by compressed air, contained in a small cylinder attached to the water tank, instead of by chemical action. One great thing to remember about this class of appliance is that it is soon exhausted, and if it has not by then extinguished the fire, other means should have become available on the spot to complete the work.

Hose.—With the general introduction of canvas hose, the questions of thorough drying and careful handling become of the greatest importance. Every man who has to use it should know the right way of laying it down, with a view to the avoidance of that unnecessary dragging about which so quickly ruins the material.

Hose Reels and Hose Carts.—The hose reel is being now largely superseded in public practice by light hose carts, which enable the coils of the hose to be more readily examined and dried, but the reel enables the hose to be more quickly laid down by persons of little skill.

Tanned canvas hose is valuable in hot, damp climates as being less liable to decay.

A small but useful addition, which I have not always seen on W.D. hose reels, is a couple of straps or clips to enable a large T-headed hydrant key to be carried on the reel itself; otherwise the key may not be instantly available at the spot required, especially at night. Small gear has a great tendency to get separated and mislaid in the hurry of a fire alarm, and should always be kept on the machine to which it belongs.

Hose Couplings.—In ordering hose and connections I may remark that, with reference to the expression "brigade thread" or "brigade gauge," there are two gauges which are often so described; one is the *old* "brigade V-thread," the well-known sharp-edged thread in very general use, and introduced about 80 years ago by Mr. Braidwood; the other, the much larger round thread introduced later by Sir E. M. Shaw into the London Fire Brigade.*

Various kinds of instantaneous couplings (as R.E. officers will know) are now in extensive use. Details of screw couplings with their sizes are shown in the "Vocabulary of Stores" (Barrack and Hospital Services).

General Notes.

In concluding these remarks, I should wish to add a few words as to recent progress in the subject of fire appliances generally since a paper which I sent in in 1906.

The continued increase in the use of motor fire appliances is very notable, and cities and towns which have hitherto held aloof are now following the trend of affairs in this matter. The petrol motor engine (*i.e.*, a motor pump) seems likely in many places to rival the "steamer" in usefulness. It has the advantage over the self-propelled steamer that no expenditure is incurred for gas, or other heating, while standing. Also, having no funnel or boiler to take up space, long life-saving ladders can be carried overhead on the same vehicle as the pump.

* The official title "London Fire Brigade" has recently superseded that of "Metropolitan Fire Brigade," the forces of other chief cities in the Empire having adopted the latter title in some cases.

The now well-known "Fire King" steam motor of Messrs Merryweather's design has done, and is doing in many places, since its introduction some six years ago, a vast amount of useful work. To remedy a difficulty that has arisen in some towns—the cost of gas for keeping the boiler always under a good pressure of steam—the makers have recently introduced a slow-combustion stationary boiler, with instantly detachable connections, that are made with the boiler of the motor while standing on duty in the station. A great saving is claimed by this system, and moreover no gas need be laid on to the station.

Where a competent engineer is kept permanently in charge, it seems not unlikely that the petrol motor pump may become the fire engine of the future in large town brigades, though the horsed steamer will probably always have a great field of usefulness in many places where the local resources do not allow much opportunity to the fire brigade for motor-driving practice on the roads.

It is to be observed that London and those of the large cities and towns which first adopted motor appliances are, as the result of their experiences, extending the use of motor traction and erecting stations where none but motor machines are kept.

It would appear that some form of the motor-driven and motor-propelled pump, such as the petrol fire pump just alluded to, might prove a valuable adjunct to the water-supply equipment of R.E. companies, particularly on account of its requiring no feed-water *en route*. A petrol motor fire engine from Glasgow is recently reported to have run 16 miles in 34 minutes to an out-district fire, and to have done good work on arrival, showing the great utility of this class of pump for travelling, without halts for feed-water.

A typical petrol fire appliance of the latest type (as adopted in London and other British cities) is driven by a 40–50 H.P. motor, and carries a 55′ telescopic escape, 1,000′ (or more) of canvas hose with hydrant connections, and a 40-gallon chemical (or compressed air) engine for small fires. Eight men can be accommodated on the vehicle, and a speed of 20 to 30 miles an hour obtained on the level. A petrol-driven pump may form a part of the machine also, but is more usually mounted on a separate vehicle, similar in power and speed to that just described, and doing the work of a steamer.

Comparison of petrol with steam machines in fire-brigade, as in other work, is difficult until long experience in practical results and expenses of working has been gained.

Alluding to the large chemical fire engines used by public brigades, the tendency is to adopt a *single* cylinder only. In the event of this not being found sufficient to overcome a fire, it will then generally be worth while to complete the work with a hydrant, in preference to the disadvantages of the weight and complication of having two chemical tanks capable of alternate action, as in some designs of chemical engine. Of course, where the water supply in the mains is exceptionally unreliable, the double-cylinder machine would have its special value.

For a certain and very common class of small fire, involving the cutting away of floors and woodwork, and an *intermittent* delivery of water as the burning parts are opened up in turn, the "Brigade" hand-pump still holds its own against chemical machines, which empty themselves in a few minutes, and it is well to remember this in considering the fire equipment of any buildings.

Some very interesting and comprehensive tests have recently been made—and the results published—by the British Fire Prevention Committee, giving comparative results of the working of small chemical and patent appliances and of the ordinary "Brigade" hand-pump and buckets. These tests should be carefully noted by any who are interested in the subject. The experiments tend to confirm the general experience gathered in practice, viz., that the various small chemical "extincteurs" and other patent "first-aid" devices, while very handy in many situations in checking a fire at its commencement, should be quickly supplemented by an ordinary water supply, so as to make a certainty of the job on which they may be engaged.

It must be remembered that public exhibitions of the many forms of fluid and "dry-powder" extincteurs are usually made *in the open*, and practically represent the effective use of these appliances on cases of fire suitable to their capacity. Many other cases of fire—such as occur daily *indoors*—will require other means to deal with them, since, owing to the heat and smoke, it will be impossible for the users of the patent appliances to get close enough to the seat of the fire. A "first-aid appliance" should, for this reason, be capable of throwing a *jet*—even if small—to some little distance, and not require too close an approach to the flames. The "personal element" also will always count for a great deal in using such apparatus. The coolest person may tend to become flurried when his own home and possessions are in danger, leading, probably, to a far less efficient and certain result than the professional operator—or skilled fireman, if he be called in—attains at any exhibition.

Nothing has yet been found more useful as an auxiliary to the ordinary bucket than the light hand-pump, throwing a good jet—small, no doubt, but strong and continuous. These are however only fitted to carry on the first attack on an ordinary small fire, or to tide over the interval that is required until full-powered engines or hydrants can join in the work should the fire prove serious.

Speaking of small gear generally, various improvements continue to be brought out; among such being a useful "spark deflector" for steam fire engines, enabling the stream of sparks from the funnel to be thrown in any given direction—an important precaution in crowded situations—when the engine may have to work very close to buildings.

CAPTAINS SIR THOMAS ROTHERAM, KNT.,
AND
NICHOLAS PINNAR,

DIRECTORS-GENERAL OF FORTIFICATIONS IN IRELAND, 1617—1644.

By LIEUT. W. P. PAKENHAM-WALSH, R.E.

ON the death of Sir Josias Bodley in 1617 (see the *R.E. Journal* for October, 1908), Capts. Sir Thomas Rotheram, Knt., and Nicholas Pinnar, "being ancient servitors of good merit in Ireland, made humble suit to the King that the office lately held by Sir J. Bodley might be conferred upon them, on condition that the third part of the entertainment assigned to Sir Josias should from henceforth cease and be abated." This petition was granted, and their fee fixed at 10s. English a day for life.*

Of the antecedents of these two men little is known. Sir Thomas Rotheram apparently came to Ireland about the same time as Bodley (1598), and was recommended as "having deserved well in the wars, especially at Kinsale (1601–2)," where he served as a Captain of Foot. Subsequently his name appears as a Member of the Council of the Province of Connaught, and also as a member of several commissions.

Nicholas Pinnar came to Ireland in May, 1600, as a Captain of Foot in the army sent to Lough Foyle under Sir Henry Docwra. His company being disbanded on 31st March, 1604, he was assigned a pension of 4s. a day, and in 1610 he offered as a servitor, "not in pay," to take part in the Plantation of Ulster, and was allotted 1,000 acres in County Cavan in the following year. He did not however meet with success, and abandoned the project.†

In a "List of Concordatums as have to be paid out of the Treasure and Revenue between October 1st, 1617, and March 31st, 1618,"‡ there are the following entries:—

"4th February, 1617.—To Sir Thomas Rotherhame, Knt., for viewing Castles and forts of Monaghan, Moyerie, Mountjoie, and Charlemount, wherein he abided 20 days."

"10th March, 1617.—To Capt. Nich: Pynnar for employ[t] in the Provinces of Ulster and Connaught, to view the forts, etc."

* Privy Seal, Westminster, February 9th, 1617. R. 2. Patent, Dublin, February 27th, 1617. 15. 6a. pars. d. R. 4. The Irish £1 was only worth 16s. 8d. English.

† *Dictionary of National Biography.*

‡ Calendar of State Papers, Ireland, Vol. 234, p. 195.

At this time a new office of "Master Carpenter" was instituted under the following patent* :—

"Whereas We think it convenient and necessary, as well for the reparation of Our castles and houses, as for the erecting of other buildings and works within this Our Kingdom of Ireland, that there be from henceforth constituted and appointed an Office of Master Carpenter, for Us, Our heirs and successors in that Our realm of Ireland, for the better erecting and finishing of the said works from time to time. Know ye, therefore, that by these presents We do constitute, ordain and erect an office or place of Master Carpenter, to be employed in all Our buildings and works in Ireland, the works belonging to Our office."

John Bannister was the first appointed to this office,† and the only other recorded holder of it was John Mills (vice Bannister, deceased) in 1661.‡

In 1618 Pinnar was appointed "Muster-Master" in Munster and Connaught,§ while on November 30th of that year there is a "Report of a survey of the number of acres in County Longford and Ely O'Carroll by Sir Thomas Rotheram, W. Parsons, Surveyor-General, and Nicholas Pynnor."‖ On November 28th, 1618, they were appointed Commissioners under the Great Seal of Ireland "to survey and to make a return of the proceedings and performances of conditions of the undertakers, servitors, and natives planted" in the six escheated counties of Armagh, Tyrone, Donegal, Cavan, Fermanagh, and Londonderry, on which work they were engaged till March 28th, 1619, and the report of which is in a MS. "Book of the Plantation of Ulster, by me, Nichollas Pynnar."¶ This was printed by Walter Harris in his *Hibernica, or some Antient Pieces relating to the History of Ireland*, in 1757, and again by the Rev. George Hill in his *Plantation of Ulster*. It is frequently referred to by subsequent writers and called "Pynnar's Survey," but a more valuable survey** was made three years later.

The following description of the fortifications of Londonderry is taken from "Pynnar's Survey," and there is also a lengthy description of Coleraine :—

"The City of Londonderry is now compassed about with a very strong wall, excellently made and neatly wrought, being all of good lime and stone, the circuit whereof is 284 perches and $\frac{2}{3}$, at 18 feet to the perch,

* 16. James I. 4a. pars. f. R. 42.

† Patent, January 15th, 1618.

‡ Patent, September 13th, 1661. 13. Ch. II. 5a. pars. f. R. 6.

§ Calendar of State Papers, Ireland, 1618, p. 227.

‖ *Ibid*, p. 218.

¶ *Carew Papers*, Vol. 643, p. 93, and Stearne MSS. F. I. 19. Trinity College, Dublin.

** Sloane MSS. 4756.

besides the 4 gates which contain 84 feet, and in every place of the wall it is 24 feet high and six feet thick. The gates are all battlemented but to two of them there is no going up, so that they serve to no great use."

On November 3rd, 1621, the Lord Deputy and Council forwarded to the Privy Council an "Estimate from Capt. Nicholas Pynnar for what is needful for the repair of the fort near Galway," and "building 10 houses for soldiers and another house for certain officers"; also an estimate by Pinnar for the repair of the fortifications at Castle Park (Kinsale),* and again on December 5th "Capt. Pynnar's survey of repairs for the castle of Limerick, the forts of Galway, Duncannon, Halebowling, Castle Park, and Banaghor, and the petition of Malby Brabazon for the repair of Ballinasloe Castle with order thereon."†

On September 2nd, 1623, the Lord Deputy wrote from Chichester House concerning the ruinous state of the forts and castles, and enclosed an estimate by Pynnar for their repair amounting to £3,000, stating that if not repaired they had better be razed. The following extracts are taken from Pynnar's report‡:—

"Repair of Forts.

"Note of money desired for the reparation of forts and castles to make them defensible against Irish rebels till a greater charge is bestowed to make them hold out against foreign invasion.

Leinster.—Mariborough, Phillipston, Leighlin, Wexford Castle.

Mounster.—Dungarvan Castle, in great decay, estimate £1,000, which is omitted by reason of the greatness of the charge.

Connaught.—Athlone Castle, for building and finishing the tower and scouring the ditches. The Sept of the Kellyes are bound yearly to allow to that Castle 300 men's labour. A castle to be built in the middest of the Curlewes, one mile and a half from the Abbey of Boyle. Also a fort and wooden bridge at Drumrussie (? Carrickdrumrusk) being a passage into the County Leitrim, and highway for all stealths from County Roscommon, in O'Rorke's Country and from the Brenny into Roscommon. Burrishowle, to strengthen.

Ulster.—Liffer, charge valued at £500 or £600 by Sir Jos. Bodley, has been bestowed upon it, which makes it defensible against Irish rebels; £200 was borrowed of money assigned to Sir Jos. for Munster works. Colrane and Carrickfergus Castles in great decay and walls of town to be repaired by inhabitants out of entertainment allowed them. Moyrie Castle, Mountnoris, to strengthen. Massarene, Castletone, Culmore, £600 or £700, but if the ward be removed to Greenecastle it is needless to bestow any more than £100 spent,

* Calendar of State Papers, Ireland Vol. 236, p. 339.

† *Ibid*, p. 340.

‡ *Ibid*, Vol. 237, p. 429.

borrowed of money assigned for works in Munster; Greencastle fitter for a ward than Culmore, as may appear upon draught of establishment now sent. Dungannon,* to make it defensible against the Irish rebels; but if his Majesty shall be pleased to assign it as a seat for the President, and to the building of it will allow the next Easter and Michaelmas rents of Tirone, he will, with some help of the country, cause it to be built fit for the President, when his Majesty shall appoint one, which otherwise will cost his Majesty much more to build it. Castlenedoe, Donnegall, Eniskillin, Cloughouter, Dungevin, Enislaughlin, total £2,841 13s. 4d. sterling, and for a Castle on Longford side of the Shannon, £200. Omy Fort, when finished at £800 or £900 was brought to the perfection it is now at by Capt. Edmonde Leighe, now deceased, who bestowed on it, of his own proper goods, £500 sterling, whereof he has yet received but £100 paid out of the rents of Tirone, which he has left his wife to relieve her and satisfy divers debts that he owed by reason of that building.

No part of these sums is of the project formerly made by Sir Jos. Bodley for which there was money assigned."

On April 11th, 1624, the Lord Deputy sent to the Privy Council a "survey by Capt. Pynnar on the ruins of Dublin Castle, with an estimate," and desired directions for its repair.† In the same year Pinnar prepared some drawings of the rivers, forts, and castles of Ireland, which are still extant.‡

The following letter, from the Lord Deputy to the Privy Council, dated Dublin Castle, 10th March, 1624–5§, gives an insight into the delays and difficulties experienced, owing to the extreme centralization, which caused everything to be referred to London:—

"Having had a sight of a letter lately arrived to Lord Docwra, from the Council of War there, directing them to deliver to Sir Thos. Rotheram and Capt. Pinner £1,000 for the building of 3 new citadels at Waterford, Cork, and Galway, in each place one, and they to be the first works which should be begun, and the preparations to be made presently, and when his warrants of assistance were craved for taking up of carriages and materials he was in doubts what to do: 1st because he had received no information of it himself from the Privy Council that might be his sufficient warrant to appear. 2ndly because of the danger of disorder in the two towns of Cork and Waterford if they should be alarmed at these preparations for putting bridles in their mouths, having in former times given sufficient testimony of their impatience to submit to it, as may witness the not-to-be-forgotten violence wherewith Cork fell upon the new fort, then building to command them, when upon notice of the Queen's death, they fell furiously upon it and pulled it to the ground,

* Dungannon is in Tyrone, and is not the same as Duncannon, mentioned elsewhere, which is near Waterford.

† Calendar of State Papers, Ireland, Vol. 238, p. 479.

‡ Additional MSS. No. 24200, British Museum.

§ Calendar of State Papers, Ireland, Vol. 240, p. 569.

notwithstanding that Tyrone was then overcome and the heart of the rebellion broken.

Upon these considerations he conceived it the safest course, to publish it for his intention to begin the fortifications with the repair of the fort of Halbowlinge, in the mouth of the River of Cork, and with the enlarging of the fort of Duncannon in the mouth of the River of W'ford (for he had already made sufficient preparations out of the poor portion of Concordatum monies) and under these two colours to lay in at the several towns their several preparations, and upon the arrival of the new companies with their supplies, to place in W'ford a garrison of 400 or 500 men and in Cork 300 or 400 more, to repress any resistance of the proceedings of the Engineers, for they might resist without these forces to contain them in their duties. The opinion of some of the Council here, being the best experienced men of war in this kingdom, agreeing with these views of his, he is resolved so to proceed and thus humbly presents it to their view.

Complains that being deprived of all power to do any man good by his own authority, here or there, by his recommendation, makes all men shun relation to him and dependency upon him. . . . Appeals to them whether it is not fit that the number and places of the new forts to be erected and the old to be repaired, being resolved upon there, it should not be remitted to them who are on the spot to choose which of them shall first be begun, which next, and which last. . . . Presses for more timely answers."

On April 5th, 1625, Sir Thomas Rotheram and Capt. Nicholas Pinnar, "Overseers of the Fortifications," reported from Waterford to the Lord Deputy, concerning the new citadel to be erected there, that "on arriving here we consulted with Sir George Flower and settled that the best place to build the fort was at St. Patrick's Gate where Capt. Yorke began one. Our Engineer, Capt. Noon, says that it is stronger than the citadel of Antwerp or Ghent. We can make the fort so that we pass through the town wall to go into it. Our arrangements will be to flank all the streets, and two or three of the towers will be brought into the work. A poor man, whose garden we are going to build over, should be compensated. We can begin our work at once as the town is all the King's and no one will withstand us." And again from Cork on April 11th that "in our last we forgot to mention the old fort across the river at Waterford. We inspected it but found nothing but the walls and a very rocky floor inside. The distance between this fort and Christ Church* is 323 yds., we took it with our instruments and did not differ a foot from Capt. Fredericks. We should advise that it be either strengthened, which would be expensive, or razed; for an enemy taking it would be able to bombard the town." To this there is a marginal note, presumably by the Lord Deputy—"Nothing to be

* The Cathedral of Waterford.

done as yet, till Council of War decide, but new fort to be begun as suggested in their letter of April 5th, 1625."

Rotheram and Pinnar then proceed to deal with the fortifications of Cork, from which the following extract is taken. It is not clear who wrote the quaint marginal notes, presumably the Lord Deputy.

"We crave your attention to the following points:—

1. Does your Lordship require store houses and munition houses built? also lodgings for the soldiers. — *Such buildings are necessary to the fort.*

2. Do you think fit to make carriages for the ordnance? The guns are all dismounted. — *Peradventure these things can be done.*

3. Should the old shovels be taken out and used? — *Order shall be taken for these presently.*

4. Shall we rebuild the fort at the South side of the town on the way to Kinsale on the site of the former fort? It is a good position and the fort need not be so large as in the old times. — *This opinion well approved.*

5. The citizens have abused the fort, built houses in it, and made a lime kiln in it. But it is the King's land, as it was Church property and purchased by Queen Elizabeth. A warrant to us to seize the lime made in it, would be a great boon as lime is very dear here. — *They must smart for their presumption and bear the charge of mending the fort.*

6. If there is to be a second fort much the best place is the rock right before the North Gate, unless it be at Shandon Cast. which standeth most convenient and which Lord Barry will either let or sell. — *Council of War will decide this.*

7. We think the King's force should take the prison built over the North Gate. It was built by priests, but if manned by the townsmen it might keep the King's forces out of the town. As it is on the wall we conceive it belongs to the King."*

There is also a report by Capts. Pinnar and Noon that they "recommend the restoration of King John's Fort which has been partially demolished by the townspeople. For various reasons they consider the fort of Haulbowline of no purpose. It was intended to watch the outgoing trade, but the merchants of Cork now take their goods overland to Crosshaven, and so defraud the King of his customs. Men could not go to and from it if the weather were stormy whereas a garrison in the mainland fort could always be relieved and would only be seven miles from Kinsale." This new fort was estimated to

* *Conway Papers.*

cost £1,200. No further trace of Capt. Noon has been found anywhere, but there can be no doubt from the above extracts that he was a military engineer regularly employed under the Directors-General of Fortifications. These reports were forwarded to the Council of War by the Lord Deputy on June 13th, 1625, and he wrote again in July "that his Commissioners find that there is an excellent spring in King John's Fort and wishes further orders for the construction of a fort on this site."

But the Government was now in serious financial difficulties and funds were not forthcoming, and on August 25th Pinnar reported from Waterford that "he has just returned from Cork where he has seen that the fortification is proceeding in a most satisfactory way. Nothing has been done that was not necessary, and expense has been much reduced by the use of the squared stones of the old forts. The work is very well forward and a 'portole' of stone finished. Mr. Piercie of Cork has lent him £130. He urges if money be landed, to forward it at once, as people are offering to lay £500 to £200 that the forts will never be finished."

The Lord Deputy complained further that "his power has been so much curtailed that people think he must get orders for everything from England."

Eventually sufficient money was raised to carry on the forts at Cork and Waterford, evidently by means of advances from public-spirited people, like Richard Boyle, the "great" Earl of Cork, who sent the following letter to the Lord Deputy (Falkland), dated May 8th, 1626, who forwarded it to the Privy Council in England on the 11th of the same month:—"I regret your inability to send me money. The half built forts have already suffered much during the past winter. I told your messenger, Capt. Pinner, that rather than see them unfinished I would pawn all my vessel and plate and furnish £500 to bring them to perfection. I am now ready to do this, but as your Lordship knows, I have already spent £500 for the land forces, and this not out of any plentiful estate or store of Money, but will give Capt. Pinner £20 a week till I hear from you. He thinks £500 will be enough to furnish the forts, though not the storehouses in reasonable time. I must ask such security as Lord Brabazon had when he supplied the army, otherwise I must be excused from paying. The Counties of Cork and Waterford are ready enough to contribute, but the other Counties not so." The idea of private individuals pawning their plate in order to get the fortifications finished sounds quaint nowadays, and even Rotheram and Pinnar, as will be seen later, appear to have advanced money in order to get the work done. Accordingly Lord Deputy Falkland was able to report on September 4th, 1626, to the Privy Council in England that "the forts at Waterford and Cork are now fairly tenable. I send Capt. Pinner, who has worked well at them, to tell you what more is wanting for them. I have made him Quarter-master of the Army and hope he may be placed on the new Establishment."

Pinnar accordingly made the following report, dated December 26th, 1626, to the Council of War :—

"I have delivered accounts of the money I have spent on the two forts of Cork and Waterford. The £3,840 I received from Lord Docwra and £500 besides lent by Lord Cork have been spent on them. I have also myself spent £120 on building materials which are ready in the fort in case any occasion arises for their use. If they are not used I shall ask leave to sell them as I bought them at your Lordships' entreaty. The Cork fort is 30 feet high facing the town and elsewhere 20 and 16, all of good lime and stone. The foundation is 10 feet thick and often more and the top of the wall is 6 foot thick where the parapet must be placed. The rampart is 20 feet thick but requires more earth. There is only a wooden blockhouse inside where soldiers keep guard and watch, a gate with no roof, and a secret port in the ramparts for keeping ammunition. I left ten barrels of powder in it and bullets answerable. There are ten guns mounted towards the city. Waterford is also ready to the placing of the parapet. It has a good foundation on flat rock and is well built. The gate is of hewn stone, and there is a good lodging in it with a chimney covered with slate. The wall is of 6 feet of stone and 25 feet of earth and the bulwarks (*i.e.* bastions) filled with earth to the height where the ordnance must be placed. I have made a well, put up the frame of a stone and lime house that will lodge 120 men and taken into the fort three castles of the town walls of which I have roofed two. I have floored three rooms in one and use another for a storehouse, whilst the third (? the roofless one ! !) is a lodging for the officers. I have mounted some guns on a wooden platform and they overlook the town, but there is no moat dug for want of money. I enclose plans."*

Meanwhile Sir Thomas Rotheram was engaged in building the fort at Galway (of which town he was Captain and Governor), and wrote to the Earl of Clanricarde on March 7th, 1626, that "my long silence is not due to want of respect, but to the fact that I have for many years been a stranger to Ireland and Connaught.† Last summer I was employed to build a fort on the west side of the town of Galway, which, by the opinion of experts, has been placed outside the wall, near the bridge. I had also orders to build some houses and make additions to the old fort. I have spent £1,450 in 3 months on the two and have done good work at the price for his Majesty. I paid £200 of my own to forward the work of which two parts only have been repaid. Neither fort is now tenable. The forts at Carrick and Waterford are being continued, but mine I fear will remain unfinished. They are important however and the Artillery should

* These plans are unfortunately now missing.

† From this it may be inferred that Rotheram was out of Ireland between 1619 and 1625.

be mounted. The Mayor and Corporation of Galway have written to the Lord Deputy to beg that the work may be finished." He wrote again on January 12th, 1627, that "the old fort at Galway must be better fortified if it is to be held. Spent last summer in Galway and saw the soldiers mutinous for want of food and clothes. Did not like to punish them severely and did not know if he had power to do so." He again called attention to the weakness of the Galway forts on June 8th of the same year.

At this time there is a draft containing a list of sums due to various officers, including Sir Thomas Rotheram and "Capt. Nichols" (Pynnar) (*sic*) "Overseers of the Fortifications."

In 1630 Pinnar went to England as the bearer of a letter from Lord Wilmot, Commander-in-Chief, to Lord Dorchester; and he also had a letter of recommendation from Sir William Parsons, Surveyor-General. Lord Wilmot's letter is dated from Dublin, April 22nd, 1630, and recommends "Capt. Pinner, the bearer, who has done much good to the forts in Ireland. Although holding a pension on the establishment by patent under the broad seal he was left out of the last establishment. He tells me he knew you well when you were ambassador at Venice. At any rate I beg you to right him." Lord Wilmot continues that "the ordnance of the country is in a wretched condition. Frequently the guns have no gunner allowed to them and we have no carriages or ammunition. The forts had better be demolished than stand so poorly guarded. I am indeed General of an Army by the King's favour, yet have no power to deal with these grievances."

In 1634 Sir Thomas Rotheram resigned his office, and the only subsequent reference to him is in 1641 in a list of "several of His Majesty's Privy Council in Ireland who may lend money," with £500 against his name. The Crown was getting shorter than ever of money.

The office of Director-General of Fortifications was re-granted for life to Capt. Nicholas Pinnar from 13th September, 1634, with a fee of 5s. English a day.* "The fee of 10/- a day being omitted out of y[e] Estab[t] commencing 10th April, 1633, an arrear occurred for 10½ years amounting to £1916-10-0 which being compounded by them for £958-5-0, so also a new grant of y[e] office might be made to Capt. Pinnar with 5/- sterling a day. The King directed the same to be paid and granted."† This looks like a case of taking what you can get and being thankful!

From this date there is little reference to either Pinnar or the fortifications in Ireland. Presumably the Crown had neither time nor money to spend on these things, and was completely occupied with the impending struggle with the Parliament.

* Patent, November 18th, 1634. 10. Ch. I. 1a. pars. d. R. 19.

† Westminster, 12th April, 1634. 10. 2a. pars. d. R. 12.

Sir William Parsons, the Surveyor-General, who had become one of the Lords Justices* in 1641, the year the great rebellion commenced in Ireland, fell from power and was removed from all his offices on 31st March, 1643; and there can be no doubt that Pinnar succeeded him as Surveyor-General, though no definite appointment has been traced. Pinnar died apparently in 1644, for his office was granted provisionally in November of that year by the Marquis of Ormond,† Lord Lieutenant of Ireland, to Capt. (or Colonel) John Payne. At the Restoration of Charles II. the office of "Overseer Director and Surveyor-General of all the Buildings, Fortifications, Plantations, Highways, Bridges, Fords and Passages in Ireland," vacant by the death of Capt. Nicholas Pinner, was granted to Capts. John Payne and John Hullam jointly,‡ thus making it clear that Pinnar had held the office of Surveyor-General; and from this date the office of Surveyor-General was coupled with that of Chief Engineer until the former office was abolished in 1762, when its duties were delegated to the Barrack Board.§

* The Lords Justices General of Ireland are not necessarily Judges. They are Commissioners, usually three or four in number, who perform the office of Lord Deputy (who no longer exists) when the Lord Lieutenant is absent from Ireland.

† Afterwards the "Great" Duke of Ormond.

‡ *Privy* Seal, Whitehall, February 6th, 1660. Patent, Dublin, April 26th, 1661.

§ Privy Seal, St. James', August 11th, 1762. R. 13. Patent, September 29th, 1762. 2 Geo. III. 3a. pars. d. R. 15.

TRANSCRIPTS.

THE MILITARY USES OF SEARCHLIGHTS.

The following is a *précis* of the above interesting work by Capt. Aggermann, which is published by Messrs. L. W. Slidel & Sohn, and printed by Franz Kreisel, Vienna.

Introduction.

Situations often arise in war time which lead to night operations, and as a rule they are directed against an opponent who has taken up a prepared position. The attacker will take advantage of the night to approach near the position, and prepare for the intended attack in the early morning or for a close pursuit of his opponent by night, so as to rout him. Night fighting may also arise in the continuation of an attack begun by day. If an attack by day—on account of the heavy losses which may be expected—appears to serve no immediate end, it may probably succeed if carried out by night.

Especially in fortress warfare the different means for preparing to attack by day must be carried out by night, so that they may be concealed from the view of the defenders, and so that every available hour may be utilized.

It is evident that such kinds of night operations can be interrupted and disturbed if the threatened force succeeds in detecting them at the right time, and electric lights are used in the first line to attain this object.

It is of course possible to conceive that lights will have their value in field operations, but they will play their principal *rôle* only in wars of position and especially in fortress warfare. For field work, lights will only reach some degree of importance when the weight of the carriages can be considerably lessened and teams of horses done away with.

The chief task of electric lights consists in illuminating the foreground for long distances, in order to detect, at the right time, every kind of hostile operation which is taking place within the range of the light. This detection then forms part of the service of reconnaissance, or allows an immediate opening of fire on targets which have been previously located. Besides this chief *rôle* the electrical apparatus can be otherwise utilized, but then the projector would be of no use. We do not intend to treat here with such side issues.

The searchlight is not an independent weapon, and, indeed, if it is to be effective it must be accurately laid on the target, so that it may be possible to either injure it, or, still better, to stop it or to put it out of action. Its chief *rôle* is to be found in the illumination of objects otherwise invisible at night, so that they may be energetically combated, and with the aid of searchlights it is possible to hinder and impede various kinds of night operations of one's opponent, to deprive him of moral, and to upset his plans.

It follows therefore that the searchlight belongs to night operations, in that it affords a prominent "aid" in time of war for long-distance gunfire as well as for close range work. The effective range of the beam should agree with the most effective range for rifle fire at night, and for this searchlights of small diameter will suffice. We must endeavour to obtain a greater range for the light than the rifle, so that the approaching enemy can be viewed before he gets to within effective rifle range, and then the rifle fire can be begun at the most favourable moment. A rifle, for example, with an effective range of 1,100 yards, does not need a searchlight of 3 miles range—one of 1,600 yards would suffice.

PART I.

Part I. starts with a description of the different means by which the necessary electric arc, the source of light, is produced. The dynamo or accumulators, cables and the engine (steam, petrol, paraffin), are described. In the Austrian Army a distinction is made—in the portable application of searchlight apparatus—between the siege corps and the field army. They have also fixed apparatus in fortresses. Each portable set, with its *personnel* and teams, forms the tactical unit, "the Searchlight Section," called after the diameter of the projector.

ORGANIZATION.

One 90-cm. section consists of a 6-horse generator wagon (5,280 lbs. weight), a 4-horse store wagon (3,740 lbs.), and a 4-horse projector wagon (3,520 lbs.).

The *personnel* consists of—

One generator attendant and his assistant	2
One projector attendant with assistant	2
One observer	1
Three telephone men	3
One layer and the non-commissioned officer in charge ...	2
	10

One mounted non-commissioned officer and a driver for each pair of horses.

(*a*). *The Source of Light.*—Minute description of the arc, how produced, distribution of light, temperature, how kept steady, etc., and the automatic regulation of the lamp described.

(*b*). *Carbons* (*Horizontal Lamp*).—These must be very good and of new manufacture; their size, position in the lamp, control, care in burning, etc., are gone into.

(*c*). *The Reflector.*—Function, form, etc.

The silver coating is protected from injury behind by a layer of paper specially prepared. Should be mounted in spring clips.

(*d*). *Distribution of the Light and the Amount of Illumination.*—Butterfly diagram described. Glass absorbs 10 per cent.

(*e*). *Testing of the Reflector.*—A candle at the centre should produce a perfectly even and round reflection. Tests with squared wire netting described.

(*f*). *General Construction of the Projector.*—Cylindrical body, etc., described. Provided with shutter dispersing lens, observation holes, ventilation doors, arc observer, carbon-holder adjusters, motors for traversing, etc.

Directing Details.—The advantages or motor traversing are that the observer himself can direct the light and observe at will. On the other hand the constant attention is tiring, and the uniform speed of traversing is also a disadvantage. For land work therefore it should only be used as the exception.

The advantage of hand-working lies in the possibility of illuminating any particular spot by a sudden movement, the rate being dependent on the gearing fitted. The great disadvantage is having to communicate your intentions to the traverser by telephone, which results in delays, inaccuracies, and misunderstandings.

Graduated circles with pointers also assist observation when using them with guns.

The dousing arrangements (signalling shutter or diaphragm) are also most useful when searching ground.

The double disperser is most useful for close work, but absorbs a lot of light, is heavy and expensive, but tactically sometimes indispensable.

(*g*). *The Cone* (*Beam*) *of Light.*—Although it appears as a sharplydefined cone, many stray rays are reflected from the air and earth, and cause diffused light. Relation of beam to illuminated area is discussed.

The Range is defined as the average distance at which a practised observer under all ordinary circumstances, and from near the projector, can with certainty recognize field (warlike targets) objects, using, if necessary, field glasses.

Aids to Observation.

The best night glasses are very necessary, and should be used to recognize ground formations, hostile detachments, and for general observation. The telescope is also useful for distinguishing more detail. The eyes must be well protected from any outside light (from lanterns, the moon, or the searchlight); this can be very easily done by laying the thumbs against the outside corners of the eyes. Eyes must occasionally be rested by closing them, etc. It is very necessary to have reliefs, as so much depends on detecting the right target at the right time, and constant observation is very exhausting.

Means of Communication.

Telephones, if absolutely reliable, would suffice, but as they are not always to be trusted, other means, such as speaking tubes, megaphone, buzzer, whistle, lamp signalling or orderlies, must be used.

Aids to Sighting.

It is most necessary to know the terrain; time must be allowed for careful reconnoitring of the ground. The tactical value of the ground must be studied with the aid of a map, having regard to the defender's positions and method of fighting, etc. The foreground to be illuminated should be settled and put on a tracing of the map. Then such objects as woods, tree clumps, houses, etc., which would come in the beam, must be identified and put on the map. Objects beyond the searchlight range should be marked and tabulated; objects throwing shadows may have to be cleared.

Distribution of the Gear when in Action.

Four groups are necessary—(1), The engine group; (2), one or more searchlights; (3), one or more observation posts; (4), horse teams.

The *personnel* required besides the mounted officer and orderly are:—

1 non-commissioned officer in general charge.
2 searchlight attendants.
1 observer.
2 telephone men.
2 engine attendants.

With small lights the attendant is the observer. All the numbers should be armed with rifles, and the duties of each can be framed as regular orders. When considering the cover for the engine, care must be taken that the exact and most effective site for the projector is in no way interfered with. If necessary, artificial cover should be provided and constructed before coming into action. It is most important that protection should be provided for the engine wagon.

Site for the Projector.

There is no difference tactically in the best sites for semi-permanent or for field searchlights. The following qualifications are necessary:—

(1). Unimpeded view over the selected section of ground to be illuminated.
(2). No obstruction to one's own fighting forces.
(3). Easy means of access to and egress from the site.
(4). Protection against hostile fire.

As regards (1). This necessitates height of position and flat open foreground, which is not often to be found. The greatest care is therefore to be taken to find the most favourable spot. Clearing where necessary must be carried out. The height of a position tends to shorten shadows and to decrease the extent of unilluminated areas due to undulations in the ground. This height must be provided artificially if not otherwise available, *i.e.*, by erecting towers.

As regards (2):—

(*a*). The beam may unintentionally come in between the rifles and their targets and hinder their view.

(*b*). The beam may increase the difficulty or make it impossible to "lay" the guns owing to its dazzling or screening effect.

(*c*). A light, owing to its position, may mask the fire of a gun or be right in its way.

(*a*) Is caused by giving the searchlight too extended an arc, so that it flanks our own works. This can only be overcome by having several searchlights or by using dispersing lenses. The searchlight must be used directly to its front, and be allotted small sections of foreground only.

(*b*) Is caused by the light being too near a battery, so that either the layer has to look through too much of the beam, making the target indistinct, or the glare may be turned on the sights. To be directly above or underneath and in a line with the direction of the beam is no disadvantage.

(*c*) Is caused by the light being too far beyond the target, generally on one of its flanks, and so masking the guns. This can only be avoided by moving the searchlight, or by relying on smaller ones held in readiness in protected positions within the work.

As regards (3). It is very necessary to have a covered approach, and for permanent works rails are advisable.

As regards (4). The immediate foreground should be unfavourable for bursting shells, *i.e.*, without stones, etc.; not hard, but soft and uneven. Explosions are least dangerous when there is a steep high wall or bank immediately in front of the projector, in which splinters can bury themselves. Searchlights should not be installed in small and weakly constructed works. As the searchlight cannot be used indirectly (except by using plain mirrors to reflect the beam), it is obvious that it must be exposed, and so its keynote is "*First effect, then cover.*"

Projector Position (The Emplacement).

This is described from a permanent point of view. The open emplacement should be used as a rule, and the searchlight on a wagon brought up from the depôt when required. Sometimes a vertical pit is made and the projector mounted on a platform capable of being raised or lowered as required.

The Observation Post.

The observer should be able to see everything which comes into the illuminated field of the searchlight. The further he gets from the projector, the more does the field of view differ from that as seen from the projector itself. As he approaches nearer the projector, the field of view becomes again similar, but the observing less favourable. This is explained in that the observer has to look through more and more of the beam.

With small-sized projectors and at short ranges this disadvantage is not so noticeable. For controlling the projector a close connection between projector and observer is necessary (with small projectors the controller is also the observer). The most sure way is by shouting or using a speaking tube. For observation it is really best to be directly below or over the centre line of the projector. The observer must be careful not to be dazzled in any way either by his own or other searchlights. For long-distance observation an advanced position is necessary, the projector being directed by lamp signals; other means of communication are too liable to errors and interruptions, and take too long to prepare.

The post must be protected from the enemy's fire, and must be large enough to hold three people, with room to lay out the maps, etc. It must be connected by a covered way with the engine station and projectors. In permanent works all this would be included in the original design and protected by armour plating. With portable apparatus the best means attainable must be employed, and should follow that provided for the battery observers.

For one night the simplest preparations should suffice.

THE LIGHTED AREA.

The nature of the ground has a great influence on the extent of the illumination. It may be—

(1). Perfectly open and flat, passable everywhere.
(2). Even but undulating, with high-standing crops, copses and woods, with few cross tracks, but generally passable.
(3). Hilly; otherwise as in (1).
(4). Hilly; otherwise as in (2).
(5). Country as in (1) and (2), but besides intersected by streams and little valleys, so that moving troops are obliged to keep to distinct crossings and paths.
(6). Small mountainous country with steep and difficult or impassable tracks, and along the valley bottom one main L. of C. and the necessary side tracks.

COMPARATIVE VALUE OF THE ILLUMINATED AREAS.

(1) Affords an open and distant view, numerous positions, fields, open spaces, etc., where an enemy can easily be detected. But the searchlight must not be given too large an area to watch.

(2). A restricted view; few points where the enemy may be detected, an unfavourable terrain making the disclosing of moving objects very difficult.

In (3) observation is simplified, because the number of places where an enemy may appear is lessened.

(4) and (5). This ground is more advantageous for detecting objects than (2), and on account of the few favourable positions for the enemy, success is unquestionable.

(6). This ground is easily commanded, and as a rule it is not difficult to discover the enemy.

In all cases the searchlights must of course be sited as high as possible.

Preparation of the Lighted Area.

At times it is necessary to prepare the ground by clearing trees, etc., and increasing the number of open spaces. In thick country large lights are of little use, several small ones being required instead. Clearing should be done for 800 yards to the front.

View and Observation.

It is not easy to see and to observe with searchlights. The inexperienced are apt to be deceived as to their utility, but those who have had practice know their value in time of war.

It is not wise to overrate their capabilities, nor to expect them to perform more than could be done in daylight. We must remember that only $\frac{1}{140}$ of the perimeter in an all-round view is illuminated by the beam. View and observation are influenced by—

(1). The nature of the beam, its intensity and form.
(2). Degree of training in the detachment.
(3). Practice of the observer.
(4). Choice of observation post and search-light site.
(5). Range of view.
(6). Ground formation, colours, shades, the objects themselves.
(7). Effect of the hostile counter-lights.
(8). State of the atmosphere or influence of the moon.

Of these (5) depends on whether the observer is in an advanced position or not.

As regards (6). Objects throw long shadows, and if naturally conspicuous and light coloured, appear, when lit up, much nearer than they really are. Dark objects, when green, reflect few rays of light, and are difficult to make out; they appear further off than they probably are. Hedges and copses cut off the light, and the thinnest mask conceals objects behind it at long ranges. A high site increases the angle of depression and shadows are shortened; where this is not possible we must be contented to use small searchlights at short ranges. Light blue-grey uniforms are most difficult to detect, especially when the background is green fields. The face and hands and arms of a man are the first detected. Detachments in open order, owing to their shadows, often appear double the number they really are. Weapons, tools, helmets, reflect the light and are seen at once. On the other hand, lantern lights, fires, etc., are not very visible when in the beam. Moving objects are more easily detected than those at rest. Sheep's eyes glow like lanterns.

As regards (7). Hostile lights, in their counter-effect, come next to the hostile gunfire in importance. By throwing one beam across another, the latter in its effect is interfered with, and an observer's view is very much impeded when an opposing light shines right on him. The beam of greatest intensity is the first to nullify the effect of its opponent. If a hostile beam shines directly up the line of one's own beam, observation is almost impossible. A screen may be used as a protection to dazzling. Artificially-created clouds of smoke impede vision. Other artificial screens are as a rule impracticable, as they would soon be detected by the enemy.

As regards (8). The atmosphere has a great influence; a dark, clear, dry night with no wind is most favourable to observation. The moon has a disturbing effect, especially if right in front of the observer. Damp air and fine rain are worse than large raindrops or snowflakes. Fog makes the beam useless. Smoke clouds show up brightly, but let no rays of light through. Strong winds make the arc unsteady. With glasses and no counter-influences, it is possible with a 90 cm. to pick up single men at rest at 1,700 yards, numbers of men at 2,200 yards, large bodies at rest at 3,300 yards. Aim can only be taken at a searchlight from outside the beam. It is not easy to hit a projector, and serious harm can only be done when the lamp mechanism is damaged.

Influence of Search Lights on Living Objects.

Observation is affected most when the beam shines directly in one's own eyes. It is of course impossible to look straight at the mirror from near at hand without protecting glasses. When not directly in the beam, the forward movements of any bodies of troops may be hindered by switching the beam to and fro, or by alternative exposure and dousing of the light, or by working it intermittently. This must be properly carried out by exposing on to the target, leaving the beam there until the opponents' eyes have got accustomed to the light, and then suddenly shutting it off. Mounted troops and teams are of course more easily disorganized than dismounted troops. The construction of fieldworks and the like must be suspended, because it is either dangerous to use the tools or else the work is impossible.

The Support of One's Own Troops.

It is possible to screen one's own troops or works by interposing one or more beams between them and the opponent. The beams in this case must remain stationary or work within definite limits, or else they may show up our own troops. This screening is as a rule only possible when the foreground is quite level. In hilly country it is not possible, because the enemy's search lights can easily search above or below one's own beams; and further, lights which it is desired to use as screens must be at least as strong as the opponents. The searchlight may also assist by illuminating the line of march or by lighting up the directing point. It may be used in conjunction with reconnaissance by night or to signal with. Artillery fire can be carried out almost as accurately by night as by day.

PART III.

Handling of the Projector.

The method of controlling the projector depends on—

(1). The construction of the searchlight.
(2). The kind of communication between the observer and the searchlight.
(3). The size of the projector.
(4). The formation of the ground.
(5). The extent of ground to be watched.
And (6). Many other different circumstances.

As regards (1). Whether automatic or hand lamp, motor traversing or hand. Double dispersing lens or shutter.

As regards (2). Whether by telephones or shouting or signalling.

As regards (3). Whether small, medium, or large size.

As regards (4). Open flat country and projector on a height; or close country, low-sited projector; or hilly country.

As regards (5). Arc of observer over or under 90°.

As regards (6); the other different circumstances are badly focussed beam, bad carbons, unsteady arc, bad reflector, poor aids to observation, loss in power, etc.

Personnel.

When using a 90-cm. searchlight with no double dispersing lens and no shutter; with automatic lamp, motor control, flat foreground, communication by call, and in a fixed position an attendant is hardly necessary, except once every three hours to change carbons. We rarely however have such a case, because most searchlights must be provided with "dousing arrangements." Double lenses too are necessary for siege work, and especially on the coast. The automatic lamps sometimes go wrong. Most field searchlights have no motor control and communication is by telephone.

Ground so flat as to afford no cover to moving objects can be systematically searched. It is advisable, if a searchlight has been brought late into action, to first of all search the nearest ground, otherwise the searching is done at the longer ranges first. For this method of searching motor control is a great advantage. One attendant is sufficient in this case (*i.e.*, when using no shutter or disperser).

Where it is required to watch a large area and to suddenly traverse the projector from one edge of the boundary to the other, hand control is necessary. Two attendants and a telephonist are necessary too. When the country is "close" or it is only required to watch a particular spot (if a bridge or dam), the horizontal range of traversing is small and electric motors will suffice. Local circumstances determine whether double lenses and shutters are necessary, and their use also depends on the number of men available. Particular methods for searching work must be practised. The beam must come on the opponent as a surprise, not giving him time to hide. This can be done by traversing the projector "doused" on to the particular area according to the corresponding mark on the horizontal scale, and then by suddenly exposing it. This requires some previous preparation to ensure success, by numbering selected points on the map and noting the corresponding readings on the projected scales (vertical or horizontal).

Carbons should always be allowed to burn for a short time before exposing. The observer then merely gives the number of the point to the light numbers, these traverse the searchlight on to the selected piece of ground and also adjust the elevation if necessary; the observer is notified that all is ready, and when he has adjusted his telescope or glasses, he gives "light" and the shutter is opened. In this case two men and one telephonist are necessary besides the lamp attendant. If the intermediate ground is open, the searchlight may be traversed quickly by hand, and without being doused every time, on to the selected spots. This admits of much quicker searching. It is clear that in this case no electric "controller" can be used, and that the *personnel* are severely tried and will want relieving pretty often. Dispersed beams are of great use at close ranges (about 880 yards), especially where it is possible for an opponent to "surprise" during the night. They must be kept exposed the whole night, and this is very necessary when the enemy has begun his siege works within range of the lights. In this connection it must be observed that constant observation is a very tiring thing, and objects may be missed which should ordinarily be detected.

Small calibre searchlights are light in weight and can be freely directed by hand. One man is sufficient to direct and observe up to 700 yards; beyond this range a special observer is necessary with night glasses. For the successful employment of searchlights it is necessary that—

(1). The observer should have a large amount of practice in the discovery and detection of objects in the beam of a searchlight.

(2). He must have a general knowledge of, and a good eye for country, and especially for the details of the illuminated area.

(3). The searchlight must be expertly handled, *i.e.*, the *personnel* must be highly trained.

(4). The available material be intelligently distributed and sited.

As regards knowledge of the ground and with special reference to the distribution of the material, the searchlight officer (*i.e.*, the observer) must be on the ground at least two hours before nightfall, so that the ground to be illuminated may become impressed on his mind as viewed from his post, and so that he can make a simple eye-sketch of it. Unless he does this he cannot expect to have any definite success. If time and the situation allows, he should examine for himself and make a reconnaissance of the foreground.

THE GENERAL EMPLOYMENT OF SEARCHLIGHT GEAR.

To the defender of a fortress searchlights are indispensable. They are not so necessary to the attacker. Along a coast line where landing is favourable, small calibre searchlights are wanted, and should be used in large numbers.

In frontier (mountain) forts the size of projectors depends on the formation of the ground and the task required of them. Fixed equipment should only be used in permanently constructed works, otherwise mobile equipment should be employed unless there are reasons against it.

In field operations the value of searchlights, especially small ones, is only evident in a position intended to be stubbornly defended, but in such cases they are of very great use.

Other uses are to be found—

(1). In the illumination for working parties of all kinds.
(2). During construction of batteries at night.
(3). In the lighting of enclosed spaces, parks, and yards.
(4). Searching for the wounded after an engagement.

The effective range of rifle fire at night may be taken at 1,100 yards to 800 yards, and a searchlight of 70° dispersion covers at this distance a front of 1,300 yards, *i.e.*, the front of one brigade; under this 800 yards small searchlights are necessary. From this we can determine that at least six large searchlights are required for an infantry division. Choice of calibre depends on the ground formation; generally in a unit one-third should be 90 cms. and two-thirds 35 cms. or 45 cms.

In fortress warfare long-distance lights are of undoubted value to the attack, and for the defenders they are also indispensable, and should be augmented by those of small calibre and in large numbers.

When a fortified place has been successfully surrounded, the attackers are still a great way off, but as the siege progresses they get nearer and nearer. If after the defender has been driven out of his advanced positions he wishes to gain some knowledge of the enemy's forward movements at night, he must be provided with long-range searchlights.

Parks, depôts, batteries, and the like are hidden from view or are too far off to be illuminated, and the lights are, therefore, chiefly needed for observation and attack of movable targets and should be easily traversed as well as being very powerful. For this purpose the medium-sized one of 90 cms. is evidently better than the very large and heavy one (*i.e.*, 120 cms., as used on the coast).

To assist in warding off the attack, the small searchlights are necessary; but the larger ones, being used from retired positions, can in conjunction with them afford some assistance in the defence of the advanced works.

As the defenders are driven back within the girdle of forts, these large-sized searchlights may be used both to illuminate siege batteries, depôts, fields, railways, and shelters for material, and to disclose protecting parties, concentration of troops, night marches, etc., and also they may be used to screen sorties made by the defender. The attacker will use his lights to hinder and baulk the working of his opponent's searchlights, to screen his own operations, and to assist the night firing of his own batteries. The defender must avoid bringing his lights too soon into action, so that they may come as a surprise to the enemy.

THE EMPLOYMENT OF SEVERAL SEARCHLIGHTS.

When using several searchlights they must be carefully allotted for watching particular sections of foreground; otherwise beams crossing and intersecting each other will make observing almost impossible. With several searchlights it is possible

(*a*). To illuminate a large fixed area.
(*b*). To increase the visibility of an object by superimposing beams.
(*c*). To keep a few "doused" and to always have some in reserve.
(*d*). To allot some for signalling purposes.

It is useless—and in fact hardly practicable—to concentrate several searchlight sections under one commanding officer. Each searchlight section officer is responsible for obtaining the "most" out of his light, and should be directly under the nearest tactical commanding officer.

The chief *rôle* of searchlights then is to search the foreground for hostile objects, and to so light up these targets that fire can be brought to bear on them.

For long distances, guns are used, for short distances—rifle fire. Guns and searchlights must always work together.

As a rule the long-range projectors are put under the Officer Commanding the Artillery, who is responsible for informing the searchlight officer of what he wants done, and it is the business of the latter to arrange how the order should be carried out.

Besides this however it is the searchlight officer's duty to so handle his lights, that no opponent can approach unobserved. In this matter he is to be considered the specialist. He should be in telephonic communication with the Officer Commanding the Artillery. The actual directing of the search light should never be taken out of the hands of the searchlight officer by the battery commanding officer.

In determining the number of searchlights for any particular situation, such as the defence of a fortified camp, as much of the foreground as possible should be illuminated by long-range searchlights, while the dark intervals are lit by the small ones. Some, too, must always remain in reserve, and two or three sets (portable) must be ready for moving from place to place.

As a rule it is advisable not to expose the searchlights until all one's own troops have finished the reconnaissance work to the front and have withdrawn within the defence line.

The searchlight officer must be kept informed

(1). Of the enemy's situation just before it gets dark.
(2). Of our own situation and any intended night operations.
(3). What terrain is to be illuminated and what are the main points to be watched.
(4). Where the neighbouring searchlights are sited.
(5). Of the general field of fire of the guns.
(6). What time to expose his lights.
(7). The proposed method of "combination" amongst the lights.

(8). Where any information is to be sent or orders are to be obtained.
(9). What the escort is and where situated.
(10). The likely length of the run.
(11). Procedure when bombarded or assaulted.
(12). Ways of retreat.

PORTABLE GEAR.

Duties of the Searchlight Officer before starting the Run.—Having received orders from the tactical commanding officer for the occupation of a certain position, he first examines the position, and studies the map. He then chooses the actual sites for the lights, and for the engines and teams, having regard to the situation on both sides and to the nature of the ground, etc. He notes what measures should be taken for the artificial defence of his lights and detachments. He judges whether he wants extra aid from the working parties. Whether it is essential to build cover, and if it is to be done by night or day. He must then make a very careful study of the section of ground to be illuminated from the actual projector site. He should make an eye-sketch for his own personal use, containing chiefly information which is not on the ordinary map, but which is very important for night work and observation.

This sketch should contain therefore some prominent distant points, all the visible roads and portions of paths, fields with high crops, stone walls, and road crossings, etc. The map need not be to scale, but all important objects should be numbered consecutively. These should be put down in a table and shortly described. He must select sites for the reserve lights and observers, in case of a necessary change of position. He must then give instructions to his relief, to the observer, the projector numbers, etc., and see that the latter know very decidedly the number of their position. About 1½ hours before dark the gear should be brought up and installed. The engine numbers make all necessary preparations. Just before dark the projector and observing parties go at once to their places, having in the meantime laid out the cables, telephone lines, etc. When night comes on everything must be ready and the light started with the shutters closed; instructions must be given to all concerned as to the way the work of searching the foreground is to be carried out.

DUTIES DURING RECONNAISSANCE AND SEARCHING FOR TARGETS.

Lights are started up at the hour ordered. The area of ground is swept successively with the beam, with the object of amplifying the table by locating and disclosing and fixing all range marks and likely targets. To detect moving objects the method described further back should be used. In difficult country especially, the searchlight officer must calculate when the enemy ought to appear at certain spots, and must in his calculation include the distance of the target, the rate of march, and the rate of traverse of the projector. He must not only pay attention to the large targets, but to the small detachments and even to single men, so that he may determine the intentions of the enemy as to his bigger movements. He must be able to recognize the deceptions which the enemy are likely to impose on him. He must give the closest attention to all, and even the least important, approaches. In case of an expected "dazzling" by the enemy's searchlights, he must be careful to have ready all protective means. He should inform his tactical commanding officer of all his more important observations. If ordered to keep his lights on a particular object, he must keep them there as long as the firing requires it.

Summing Up.

A few words are here necessary on the advantages and disadvantages to be met with in the illumination of foreground.

If an attacker or defender wishes to carry out night operations without any aids to illumination, it is easy to see that, of the two, the defender is at a disadvantage.

The attacker can choose his course of action, and can carry out at will his intentions, while the defender has to await decision in order to form his counter-plans. The defender in the first line is thus forced to use such means as will make it possible to see at a great distance in order to discover the intentions of his opponent. The attacker can carry out his operations at night without the help of distant illumination. It is sufficient for him to hinder the illumination of the defender. Of all known means for the artificial illumination of foreground, the electric searchlight is incontestably the best. The lighted area is comparatively large. The beam of light can at will be kept fixed on the object, or be made to suddenly change its position and direction. It is often easier to fire at an object illuminated at night, than during the day. The "gear" lasts a long time, is as a rule easily procurable, and can be kept stored. The source of light is a very difficult target. The beam can dazzle and considerably delay or hinder the movements of an opponent. It can also be used for signalling purposes, or be made to serve the purposes of a screen. The disadvantages are that—

(1). Electrical apparatus is expensive.

(2). A highly trained and carefully selected *personnel* are necessary.

(3). The effect of the searchlight is very dependent on the configuration of the ground and the state of the atmosphere.

(4). When small lights are used, a very large number are necessary.

The reproach from all sides that searchlights assist a force to determine his opponent's position and aid him in his advance, arise from peace manœuvres. It is natural that a searchlight can never have good results on unsuitable ground, but on favourable ground it is different. The position of the defenders' works must be known very accurately to the attacker before he plans night operations, and without having first been given away by the searchlights. When during his advance he gets into the beam, instead of being able to fix his whereabouts, it is more likely that he will lose himself and become exposed to the effective fire of the defender, and this can be increased by changing the positions of the lights or by introducing reserve lights. By siting searchlights near "works," hostile fire which may be really intended for the searchlights only is drawn to them. This circumstance must be carefully considered when choosing sites for searchlights.

R. Walker.

WIRELESS TELEGRAPHY.

Translated from a Lecture by Major Ferrié, of the French Military Telegraph Department, in the *Annales des Ponts et Chaussées.*

WIRELESS telegraphy furnishes an almost unique example of a scientific discovery arrived at solely by previous theoretical reasoning.

Maxwell having mathematically proved that the properties of light could be compared to those of an electro-magnetic vibratory motion, Hertz sought to verify this statement experimentally, and succeeded in creating electrically a vibratory motion possessing all the properties of light.

Wireless telegraphy—optical telegraphy's first cousin—had been discovered; it was only some years later however, thanks to other scientists, Tesla, Lodge, Popoff, Branly, and last, but not least, Marconi, that this invention was practically made use of.

Before therefore describing wireless telegraphy at its present stage, it may be as well to call to mind the properties of Hertzian waves.

A.—HERTZ'S EXPERIMENTS.

If a condenser be connected to the terminals of a source of high-tension electricity, and also to two small metallic spheres, it is found that, if the spheres be brought within a certain distance of one another, the gap between them is bridged by a spark, due to the discharge of the condenser. This discharge is not a sudden neutralization of the electricities of opposite sign on the spheres, but a series of oscillations of the electricity in the discharge circuit, *i.e.*, an alternating current is produced in this circuit, which dies out more or less rapidly according to the resistance of the circuit and of the spark. The frequency of this current is very great and varies with the capacity of the condenser, and with the size and shape of the wires connecting it to the spark gap. Frequencies greater than 1,000 million alternations per second have been produced, *i.e.*, vibratory motions having a wave length of less than 1 centimètre, but they cannot compare with the vibrations of light, the wave length of which is about $\frac{1}{2000}$ millimètres.

These electrical vibrations are transmitted through the atmosphere by means of waves, known as Hertzian waves, which can be reflected, refracted, or polarized just like light waves. They have the property of being able to generate in any metallic circuits they meet alternating currents similar to those produced in the original circuit. This phenomenon can be experimentally illustrated as follows:—Electrical oscillations or alternating currents of high frequency are generated in a circuit consisting of a source of electricity, a condenser, a spark gap, and a few turns of wire wound round a core. A second circuit consisting of a condenser of adjustable capacity, a few turns of wire, and a detector is fitted up (*Fig.* 1).

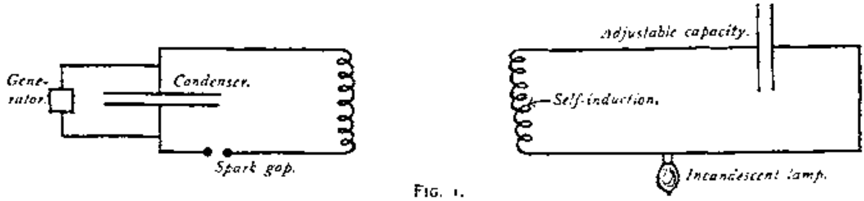


FIG. 1.

Now were this second circuit connected to the source of supply, the frequency of the alternating current generated in it would depend on the capacity of the condenser and the number of turns of wire (*i.e.*, the inductance); so that we see that the two circuits, as fitted up, can be "syntonized," or got in tune, by varying either of these factors. If the two circuits be placed close enough together, an ordinary incandescent lamp can be used as a detector; it will then be noticed that the lamp becomes very brilliant for the value of the factors, which is such that

$$\text{Inductance of No. 1 Circuit} \times \text{capacity of No. 1 Circuit}$$
$$= \text{Inductance of No. 2 Circuit} \times \text{capacity of No. 2 Circuit},$$

i.e., when the circuits are syntonized.

The time of duration, T, of an electric oscillation in a circuit of capacity, C, and self-induction, L, is given by the formula

$$T = 2\pi\sqrt{L \cdot C}.$$

The wave length of the vibratory motion produced, *i.e.*, the distance travelled by the vibration whilst the oscillation lasts is given by

$$\lambda = V \cdot T,$$

where V = the velocity of light.

The experiment just described explains the theory of wave meters, that is to say instruments for measuring the wave length of the electric oscillations due to the discharge of a condenser. A wave meter generally consists of a circuit containing an adjustable capacity, an adjustable inductance, and a detector (generally a thermal ammeter). Each apparatus has a reader giving the wave lengths corresponding to various values of the capacity and inductance, from which the desired result is obtained.

Yet another characteristic of alternating currents of high frequency is their power of propagating themselves in open circuits. Thus, if the second circuit of the above experiment be replaced by a straight stretched wire, the centre of which is only a short distance away from the generator circuit, the following phenomena may be observed :—

(1). The vibratory action induced in the wire travels to its extremities and is then reflected.

(2). The incident and reflected vibrations interfere with one another, and if the length of the wire has been properly chosen, it is possible to observe by means of suitable detectors, the production of electrical waves and depressions similar to the vibrations in a stretched string.

Now the distance between the summits of two consecutive waves or the bottoms of two consecutive depressions, is equal to the wave length of the vibration, so that, provided it is not too long, we have a second method at our disposal of measuring wave lengths.

As soon as Hertz's experiments were known, several scientists declared that if sufficiently powerful waves could be produced, they could be used for the transmission of telegraphic signals. Marconi, when aged 19, was however the first man who made any real attempt to put the Hertzian waves to practical use, and his success is due to the use of a vertical conductor, termed aerial, which increased the distance the waves could travel.

No attempt is here made to describe in detail Marconi's experiments, or the means by which he brought wireless telegraphy to its present state of perfection; it is only intended to give a rough outline of the various forms of telegraph now in use.

B.—Wireless Telegraphy.

The problem of wireless telegraphy can be divided into two quite distinct parts—(*a*) the transmission and (*b*) the receiving of signals.

Transmission is accomplished by producing at a point long and short series of Hertzian waves, combined so as to reproduce the letters of the Morse code. To ensure that the waves will travel some distance, they are generated in a vertical conductor or aerial—either directly or by induction—from a special circuit.

Direct generation of the waves in the aerial was used from the beginning by Marconi; now however it is almost entirely in disuse. In this system the aerial formed one plate of a condenser, whose other plate was the earth. The secondary of an induction coil was connected to this condenser, a battery and key in the primary circuit being the means of signalling. Two metallic spheres at the terminals of the secondary circuit formed the spark gap (*Fig.* 2).

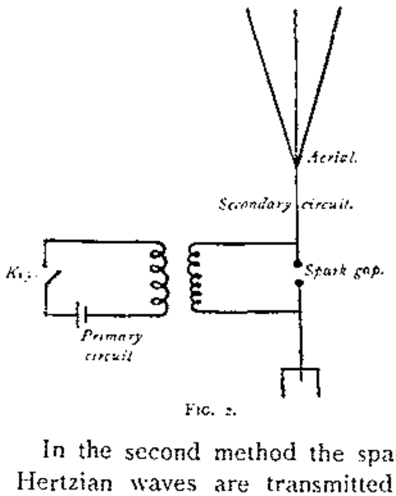


Fig. 2.

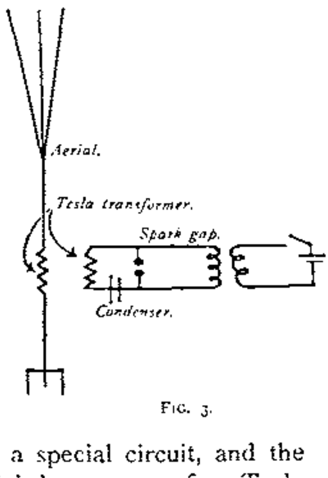


Fig. 3.

In the second method the spark gap is in a special circuit, and the Hertzian waves are transmitted to the aerial by means of a Tesla transformer (*Fig.* 3). The condenser in the special circuit can be charged either by an induction coil, or by means of the secondary circuit of an alternating current transformer, of proper size for the frequency of the current and the capacity to be varied. A key in the primary circuit is used for "sending."

Experiment shows that the "range" of the waves increases with the height of the aerial, or, in the case of an aerial consisting of several wires joined at their base, with the area covered.

The waves travel along the surface of the ground, but how, is as yet not well understood. They go round obstacles like sound waves, or rather by a phenomenon similar to the diffraction of light. When they meet an aerial similar to that by which they were produced, they create in it electrical oscillations similar to those which existed in the transmitting aerial. These oscillations are very feeble; they become most intense when the two circuits have the same period of vibration, *i.e.*, when they are syntonized.

The presence of these weak oscillations is detected by making them act on a wave detector either directly or by means of a specially calculated little transformer.

The commonest types of detectors are the Branly coherer, the Ferrié electrolytic detector, and the Marconi magnetic detector. The last two are the most commonly used forms, and are about equally good as regards sensitiveness and ease of use.

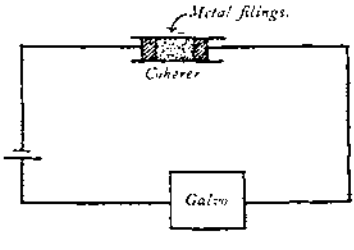


FIG. 4.

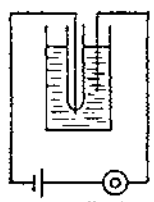


FIG. 5.

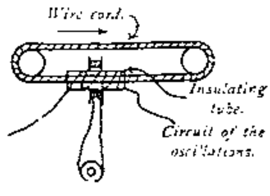


FIG. 6.

The Branly coherer (*Fig.* 4) consists of a glass tube containing metallic filings, between a pair of metallic electrodes. If this coherer be connected in series with a battery and galvanometer, it will be seen that no current flows through the circuit. When however Hertzian waves are produced near the coherer, it becomes a conductor, and remains so after the waves have ceased, but the very slightest tap is sufficient to "de-cohere" it again. It will thus be seen that this apparatus, if provided with a suitable tapper to "de-cohere" it, can be used to receive the dots and dashes from the transmitting station and pass them on to the ordinary telegraph apparatus for the reception of messages.

The electrolytic detector consists of a platinum wire soldered into a glass tube, so that only about $\frac{1}{100}$ millimètres of the wire project beyond the glass into a jar of acidulated water. The wire is connected in series with a battery telephone receiver with a return to the water (*Fig.* 5). As soon as the current flows, the short wire gets polarized and the current stops. Hertzian waves depolarize the point, the current flows, and a noise is heard in the receiver; when the waves cease, the reverse process takes place. Telegraphic signals can thus be read "by ear" in the receiver. The Marconi magnetic detector is based on the effect of the Hertzian waves on the magnetization of a cord of thin wire. This cord passes through an insulating tube wound with wires carrying the waves. A coil connected to a telephone receiver is placed round the tube (*Fig.* 6). When the cord is moved in the proximity of a magnet placed near the coil, noises are heard in the receiver. They are due to the currents induced by the changes in magnetization of the cord, under the influence of the electric oscillations.

Other detectors are Fleming's valve and the carborandum detector. The latter is especially useful for transmitting continuous waves. The process described above only produces very much damped vibrations, which begin afresh with each spark, and the reception of signals is not always as clear as might be desired; thus for short distances untuned receiving stations often receive messages not meant for them, even from stations emitting waves of a different wave length to their own. This constitutes one of the disadvantages of wireless telegraphy.

Attempts have been made to obtain good results at receiving stations by means of undamped vibrations, on the following principles:—When a condenser is connected to the terminals of a continuous current arc lamp (*Fig.* 7), it is found that an alternating current, whose frequency depends

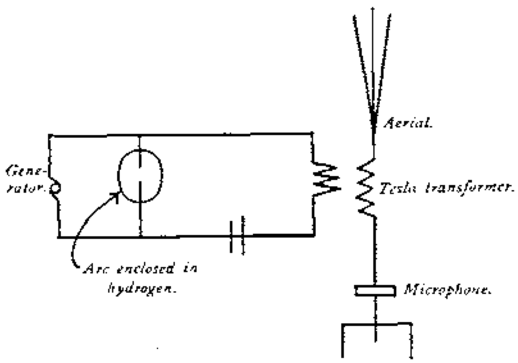


Fig. 7.

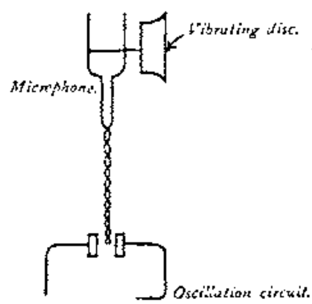


Fig. 8.

on the capacity of the condenser, exists in the condenser circuit, and by giving the capacity the proper values, Hertzian waves of the right strength for signalling can be produced. The best results are obtained when the arc is enclosed in an atmosphere of hydrogen or lighting gas, and when placed in an intense magnetic field.

Attempts have also been made to construct alternators generating high-frequency oscillations direct, but hitherto apparently without any very great success.

C.—Wireless Telephony.

The use of continuous waves and of the "singing arc" have also been employed for the purposes of wireless telephony. The apparatus used is as follows:—The aerial is excited by means of damped waves, an arc lamp replacing the spark gap. The microphone is either in series with the aerial or in shunt with the Tesla transformer in the aerial. The best form appears to be a water microphone. This consists of a vibrating disc, which is fixed to a glass funnel terminating in a sharp point (*Fig.* 8). Acidulated water falls from the funnel; when speaking, the vibrations of the voice induce vibration in the liquid, and the conductivity between the two contacts varies. As these are in the oscillating circuit, variations in intensity can be noticed and the human voice reproduced.

D.—Directional Wireless Telegraphy.

The first attempts made to direct the waves by means of large mirrors, in the foci of which the aerials were placed, met with little or no success.

The use of horizontal aerials, giving a maximum intensity in the opposite direction to that towards which the aerial points, was next tried, but was only useful for short-distance signalling.

Now experiments are being made with a view to utilizing the phenomena of interference by the use of two or more aerials. The results are as yet incomplete, and only allow of a maximum effort being made in one direction and a minimum in the others, and not as in wire telegraphy, of all the effort being made in one direction—along the wire.

E.—Applications of Wireless Telegraphy.

The Navy has most profited by the invention and development of wireless telegraphy. Stations all along the coast communicate daily with the steamers, some of which even edit a daily newspaper with the latest political and commercial news.

The Marconi Wireless Telegraph Company has attempted to compete with the Trans-Atlantic Cable Company, but the service is somewhat irregular on account of atmospheric variations.

It is interesting to note that the military station on the Eiffel Tower at Paris receives all the telegrams exchanged between Canada and Ireland, although 5,000 kilomètres distant from the former country.

In the Colonies and for communicating with lighthouses and lighthouse boats, wireless telegraphy is invaluable, and in any future war it will certainly play a large *rôle*, as has been shown by the French operations in Morocco.

In a word, everywhere where ordinary telegraphy cannot be used, or where it is too expensive, wireless comes to the rescue. It must however be remembered that it has come not to replace but to help its predecessor where hitherto it has been powerless.

A. H. Scott.

WELLS IN SENEGAL.

From the *Revue du Génie Militaire*, September, 1908.

BETWEEN the Senegal and the Gambia there are no rivers of drinking water in the dry season; there are only small streams, which disappear in the sand after a course of a few miles.

Nearly all the water necessary for the population is extracted from the ground, which contains water in variable quantities and at variable depths. These water-bearing strata have been studied methodically since 1904; the results obtained have been classified, and in time a hydrological chart of the country will be available. The knowledge of the location of these water-bearing strata is of great use in forecasting the amount of digging that will be required, but it is also necessary to consider how this can best be done. To obtain water it is obviously necessary to dig a hole; this hole varies in shape and depth according to the resources of the constructor.

The shepherd, who has but a rudimentary stock of tools, prefers to settle near the rivers; he only leaves them when he can no longer find a living for himself or his flocks. He then settles near the pools; when they dry up he digs a hole to follow the descending water level; these holes become deeper and deeper, until the rains come to raise the water level. In Senegal these holes are called "*céanes*."

The *céanes* are nearly always dug in a soft and sandy soil, and when they are more than 6′ deep they are dangerous; they fall in, and there are many accidents. Necessity is the mother of invention, and some natives try to revet them with branches. The *céanes* are generally in the low country, though there are some exceptions. Winter destroys them, and every year they have to be dug afresh.

In some parts a large proportion of the population is exclusively employed in digging these pits. If the amount of labour employed is calculated, it will be seen that this method, which at first sight appears cheap, is in reality expensive, and the construction of wells on the site of these *céanes* would confer great benefit on the natives. They need be only a few feet deep, and the cost would be less than one year of the present labour.

The wells now being sunk in the neighbourhood of Dakar can be taken as an example. Here the natives have dug wells and reveted them with antproof wood from the forest, and some of them have been in existence for more than 50 years. Now that the white man has conquered the country, he has attempted to help the natives by lining the wells, and has found that they may be divided into those in sand, those partly in sand and partly in rock, and those entirely in rock.

In Longa, Tivaouane, and Thiès the soil is all sand—in many places to a depth of 130′. When a pit is dug in such soil, it must be lined to a greater or less depth. The classic method is to use wood as far as the water-bearing stratum, and then to build a masonry lining on a wheel and lower it by digging below to the required depth. The masonry usually has a thickness of $15\frac{1}{2}''$ and the wood of $7''$, so that for a well of $4'\ 6''$ diameter the pit must be $4'\ 6'' + 2' \times 15\frac{1}{2}'' + 2' \times 7\frac{1}{2}'' = 8'\ 4''$ wide.

The wooden lining gets too dry in the sand and decays; a safer method is to use iron, but this is expensive. The estimate for a well at Longa, 110′ deep, was £690, or £6 per foot. Those at Pont cost £4 a foot, and at Thiès £3 13s. per foot. This method is too expensive for use in Senegal, where more than 100,000 wells would be required to satisfy the needs of the population.

Sheet-iron cylinders were next used, without any masonry. This method has many advantages—among others, that the diameter of the hole to be dug can be reduced. The cylinders can be rolled to the place where they are wanted, the work is easier, and the results better.

This method became general in 1904, but it is not without its disadvantages. The first is its expense. The cylinders cost about 27s. per foot-run in France; wells of 60′ depth cost about £2 a foot. This is a great improvement on masonry, but it is not cheap enough, as the wells have to be built not by the foot, but by the mile.

The reduction of the cost is of vital importance, and the solution has been sought by the substitution of reinforced concrete for sheet-iron cylinders. The former cost about a quarter as much as the latter. This appeared to solve the problem, but we shall see that the solution is not yet a perfect one; and to do this we must go into details of the making of wells with cylinders.

All the methods can be reduced to three, which are quite distinct from one another.

First Method.—When the soil is solid enough to stand without lining. In rocky ground a well is dug without any protection, but when it is clayey, the bottom portions have to be lined with wood or sheet iron, as the water eats away the sides and makes them dangerous.

Second Method.—If the soil is friable, a hole about 6′ deep is dug, two or three sections of the cylinder are joined together and placed in it, and packed round with loose soil; they are then weighted on the top, and descend by gravity as the soil is dug away from inside. Other sections are added at the top and the process repeated. There are two objections:—(1), It is difficult to make the shaft vertical, and if it is not vertical a bucket cannot be lowered into it; (2), the cylinder jams and will not go lower. In this case another cylinder of smaller diameter must be inserted to continue the work; this lessens the available width, and the provision of several different sizes complicates supply. In point of fact, the diggers never use the smaller size—they go on without lining, with the natural result that the well only lasts a few years.

Third Method.—It is however possible to line the whole required depth with cylinders of one diameter. This is done by using sections of the cylinder made, in two halves, of steel which is springy enough to admit of their being lowered down the jammed sections and then put together in a space excavated below. Of course the earth must be sufficiently solid to stand up while this is being done. The lower sections inserted by this method hang from the upper ones, which are jammed. The two first methods can be used with reinforced concrete, but not the third one, as it is inelastic. It was easy enough to obtain cylinders of reinforced concrete, but very difficult to place them. Experiments however proved that it was possible to make even sand stand vertically long enough to apply a coat of cement. This affords the possibility of making the cylinders on the spot without moulds. The cylinders can be given the desired thickness, and the bars, which are normal to the walls, bind the layers of cement together. At first two layers of iron, ·31″ thick, and 4″ of cement were used; gradually this was decreased to a layer of reinforced concrete 2″ thick, with the metal forming a trellis of 4″ mesh, made of ·16″ iron, which was very easy to adjust. Many wells lined in this manner have lasted two winters without any damage. Practically it has been found that the first section lined in this way has sufficient friction against the sides to remain in position when the next section is excavated; this can then be lined, and so on to the desired depth. With very slight training, natives who have never handled a trowel can be taught to make wells in this manner up to a depth of 40′ without European supervision.

Cost of the Wells.

The factors affecting the cost are:—

1. *Pay of Natives.*—Generally a native foreman at about 2s. and three labourers at 1s. 3d. a day are employed. Food supply has to be arranged for, as the work is generally far from villages.

2. *Materials.*—The expense per foot-run works out at about 125 lbs. of cement for 4s. 2d. and 6 lbs. of wire for 1s., a total of 5s. 2d.

3. *Transport* (per foot-run).—By rail, about 1s. 7d. a mile; by camel pack, very variable, but about 2s. 6d. a mile.

4. *Supply of water* costs about 10s. a day, by camel pack, when the work is carried on up to 20 miles from the point of supply.

5. *Necessary Tools, etc.*—Very variable. If the wells are shallow, very small; perhaps 2s. per diem.

6. *European Supervision.*—It is necessary to ensure European inspection every two days or so. The expense of course depends on the proximity of the parties to each other. The ordinary civil pay is 8s. 6d. pay and 8s. 6d. travelling allowance.

7. *Administrative Expenses.*—About 1s. 4d. per party per diem.

E. G. Godfrey-Faussett.

NOTICES OF MAGAZINES.

ARTILLERISTISCHES BLATT.

13th March.

GUNS FOR THE ATTACK OF AIRSHIPS.—The first gun manufactured was mounted on a motor car, had 5-cm. bore, and was 30 calibres in length. The maximum height of the projectile fired was 2,400 mètres.

Krupp have also manufactured another gun 6·5-cm. size, which fires "Brand" shot only. With this kind of shot it is hoped to set fire to the gas of the envelope and to explode it. Their latest gun is 7·5-cm. size, with central pivot mounting. It can be used on board a ship or mounted on a motor car protected by armour. The recoil of this gun is taken up by compressed air, and has been reduced to a minimum.

THE NEW ARMOURED BULLET.—This has been designed for the attack of shielded artillery. Trials have shown that at a range of 600 mètres these bullets can pierce a field gun shield 6 mètres thick. The bullet weighs 10 kgs., and has an initial velocity of 850 mètres per second.

THE NAVAL AMMUNITION MAGAZINE OF THE UNITED STATES, ON THE ISLAND OF JONA, IN THE HUDSON RIVER.—Some detailed information about this is given, with illustrations.

NATIVE MILITIA IN FRENCH TONG-KING.—This native militia was first organized in 1884. At the present time it numbers 7,000 men, whose duties are to ensure protection in the interior, to act as escorts for wheeled transport, as guards in administrative buildings, to man the prisons, and to provide the street police. They are organized now in brigades, each consisting of four sections of 50 men, one brigade being allotted to each district. They are located in posts throughout the districts, and in each province the Resident is allowed a mounted guard of 20 men. These carry lances and swords, whilst the dismounted rank and file are armed with a rifle of 1892 pattern and carry 90 cartridges. These native guards are said to serve very loyally and bravely, and have been known to lay down their lives for their commanders. The existence of this small local force is hardly known, but it gives one some idea of what France is doing in Indo-China.

NOTES.—Germany this year is going to carry out submarine mining operations in conjunction with the fleet.

Trials are also being made at Kiel with acetylene shells, which it is said will replace search lights. The shells are filled with calcium carbide; when they alight on the water and sink, the water runs in through a tube, and soon a bright light appears on the surface, which burns for three hours. The actual details which cause the lighting of the gas, etc., are not described.

Acetylene Signalling Lamp.—A description is given of a new lamp made by Bittner & Co., of Vienna. The size is $7\frac{3}{4}'' \times 3\frac{3}{4}'' \times 3\frac{3}{4}''$. It is fitted with a shutter worked by a key as easily as a telegraph instrument. It can also be used as a hand lamp. A small pocket is included for taking telegraph forms and pencils. The box is divided into two compartments by a partition, of which one is for the water and the generation of the gas; the other contains the burner, a silver reflector, and a bull's-eye lens. It is fitted with a substantial handle, which, when not in use, folds into a prepared socket.

Fighting Motor Car.—This is constructed so as to have a clearance off the ground of 16″ and a total height of 36″ only. The drive is directly on the hind axle, the engine being mounted in rear. A machine gun is mounted in front on a pivot, has an all-round fire, and can be elevated if required. The ammunition is stored in the point of the car and is protected by nickel steel. Wheels are made to be fitted with double solid rubber tyres.

R. Walker.

Journal des Sciences Militaires.

June 15th, 1909.

French Manœuvres.—The second part of the Russian staff officer's comments on the French manœuvres treats in more detail of the various arms. He considers that the uniform of all arms is on the whole much too conspicuous. The only improvement is an experimental chrome steel bullet-proof cap for the artillery. Lighter packs and greatcoats for the infantry are under consideration. The infantry march well and cheerfully, but keep little order. Their tactical instruction is better when stationed at a distance from Paris. They do not pay much attention to the use of ground, which may in part be due to the bright-coloured uniform, and besides this the officers expose themselves unnecessarily. The Reserves during an action stand up and watch the enemy. The large percentage of reservists considerably affects the efficiency of the whole.

The cavalry have excellent horses and look after them well. They are not trained for dismounted action and probably shoot badly. For mounted work they are well trained, but do not always seize the best moment for attack.

The artillery is excellent in every respect. At these manœuvres only field guns were employed, whereas the Germans employed 6″ howitzers and 8″ mortars. The French are numerically inferior, but they claim equality on account of a superior organization and method of fire.

Machine guns are of the latest Hotchkiss type. Their tactical employment leaves something to be desired, and, as usual, they make poor use of the ground. Fire is opened at too long a range, and they unmask themselves prematurely without gaining any advantage by so doing.

The Press takes great interest in the manœuvres, and—quite contrary to the German plan—practically nothing is kept secret.

The officers are decidedly superior to the Germans in general knowledge, but the latter surpass them in military matters. On account of the clear dividing line between those who have risen from the ranks and those who have obtained their commissions in the ordinary way, there is not the same moral unity as in Germany. The generals, though very learned theoretically, lack practice in the field. The men are not at first prepossessing, but improve considerably on further acquaintance.

Automobilism.—The final article on "Automobilism" sums up the advantages and disadvantages, and suggests that a committee should enquire into the whole subject, and definitely lay down the requirements of motors for military use. Opinion as to these requirements is still divided, and the experience at the 1908 manœuvres was inconclusive owing to the light test of the motor transport employed.

Training of Officers.—The question of a training common to all officers has been raised in Italy. Its supporters claim better combination between the various arms would be obtained by this means, and they also wish to better the prestige of the infantry in the eyes of the nation. The first claim is not of much value. The Italian cavalry and infantry officers already have a common training, yet there is a deep gulf between the two arms. A better solution would be to attach officers to other arms of the service, for short courses after finishing instruction in their own branch. It is hardly likely that the second idea would be realized. The engineers and artillery would need special courses after the combined course was done, and by these special courses would be differentiated as strongly as ever.

H. L. Woodhouse.

Kriegstechnische Zeitschrift.

May, 1909.

The Distant and Close Attack in Fortress Warfare.—By Lieut.-Colonel Frobenius.—Brialmont, in his writings, has recorded his opinion that the technical improvement in the manufacture of destructive weapons, and particularly the progressive development of artillery, has favoured the defence rather than the attack, and that as these destructive weapons continue to improve the defence will grow superior to the attack. The truth of this theory is supported by the generally admitted fact that the defence, owing to better preparation, can get greater effect from their artillery, and can also protect themselves more completely from the hostile artillery fire. This advantage is most conspicuous in the permanent defences of a fortress, in the construction of which every technical appliance is available and time is of little consequence.

It has always been due to the growing strength of the defences that improved means of attack have been devised, and as soon as these means had transferred the superiority to the attack, it became the object of Engineers to adopt these improved methods to the advantage of the defence, and at the same time to shield the defenders from the effect of these improvements when used by the attack. As however the old fortresses became worthless and the construction of new works took considerable time, there were always periods in which the superiority lay with the attack. It was impossible that every development in the attack should be forthwith nullified by an improved type of permanent fortification, and in this fact lies the explanation of the surrender of a large number of fortresses without adequate resistance.

The great increase in range and power of artillery, due to the introduction of B.L. and rifled guns, was answered by surrounding the kernel of a fortress with a girdle of works instead of a continuous parapet. This not only conferred on the defence an increased power to manœuvre and counter-attack, but, by adopting the improved artillery for the defence also, it forced an early deployment and distant investment upon the attack, and thus brought into being what is now known as the distant attack. Thus the increased range of artillery which the attacker thought would be to his advantage became only a further obstacle to him, as it enabled the defence to prolong their resistance.

This consequence however was not generally recognized. It was thought that the works of the defence could be destroyed at long ranges, and the defenders themselves so weakened that the close attack of former days could be dispensed with, and that the infantry could advance in a series of long rushes without suffering many casualties. The only obstacle deemed worthy of consideration was the artillery of the defence, and it was hoped that, as soon as the attacking artillery was in position, a short duel would reduce this to silence. This theory was advanced with great confidence by artillery officers, and even officers of Engineers were inclined to believe that the *rôle* of permanent fortifications had been played out.

It does not appear that any serious basis for this theory was ever advanced, and the disillusionment at Port Arthur was so sudden that even now there are many in the German Army who think that the German artillery would have produced very different results.

Undoubtedly the prospect of at once procuring the downfall of a fortress by bombardment alone was very alluring to German strategists. Their ideal was at any rate to overcome the fortress by distant attack only, making the close attack quite superfluous. Their sanguine views on the subject resulted in the entire attack of a fortress being divided into the two following parts:—

(*a*). The artillery, or distant attack, in which the fortress artillery was to be so damaged that the infantry could march at once to the assault.

(*b*). The infantry assault.

The infantry were to advance in rushes, and in a few days the works would be captured.

As no one doubted the ability of the artillery to do all that was required of it in a very short time, the work of the infantry was regarded as extremely simple, and no instruction was considered necessary in peace time.

All need for the slow and costly methods of the close attack being thus happily removed, it naturally followed that the technical troops instructed in these methods were deemed superfluous. Technical instruction was to be devoted solely to the service of the artillery.

In Austria, indeed, the proposal was seriously made to transfer all pioneers, aeronauts, telegraphists, to the artillery, as their activity in fortress warfare would be confined to the service of the artillery. Recent experiences however have entirely destroyed these hopes, and have confirmed Brialmont's opinion that the improvement in artillery is in favour of the defence in fortress warfare.

In Port Arthur, indeed, the Russian artillery was very inferior in quality and numbers, and was also badly sited. Thus what was considered to be the chief obstacle to the attack was in this case peculiarly weak; but with the aid of field artillery and infantry fire it conferred such a superiority on the defence that even in the case of hastily constructed temporary works the attacking side were compelled to adopt the last resources of the close attack, which was so slow in its progress and so productive of heavy casualties that it excited universal astonishment. Supporters of the "Distant Attack" theory endeavour to account for this by stating that the Japanese had not enough heavy guns, and especially howitzers.

This contention is of little value because the defensive works were not heavily protected, and according to previous assertions of artillery experts, should not have been able to resist the artillery which the Japanese actually employed.

The truth however is that the distant attack, far from obviating the necessity for a close attack, is not even able so to support the latter as to bring it to a rapid conclusion. Moreover the improvement in firearms has given to a fortress the power of compelling the attack to begin at greater distances, besides forcing on the attacker a double attack, *i.e.*, distant and close.

With the increased extent of the field of fire, and with the greater freedom of manœuvre conferred upon him, the defender is now much nearer the attainment of his ideal—to hold the fortress till the end of hostilities. This conclusion, drawn from actual experience in fortress warfare, seems to be corroborated by recent examples of field campaigns, where the development of the attack is a much more gradual process than it used to be. The character of the close and distant attack in fortress warfare has changed entirely. It is no longer correct to regard the distant attack as synonymous with the artillery combat and the close attack as equivalent to the infantry assault. We ought rather to divide the infantry attack into two periods, the first of which should include all operations against advanced positions up to the moment when the besieged are forced to abandon these entirely, and the attack then begins operations against the main position and comes under the effective fire of the fortress girdle.

The second period would include the further advance, including the final assault.

No period can be set aside as the artillery attack, as the artillery will be invaluable throughout in supporting the infantry advance.

The Distant Attack.—It has long been recognized that artillery cannot expect to come into action under some 4,000 yards of the fortress girdle, and many authorities maintain that at the first investment 7,000 yards will be the minimum range. It will be the object of the attack to deploy his artillery as soon as possible, as without its support the infantry cannot advance. Before the artillery is deployed, the infantry will endeavour by their fire to protect and mask the siting of the guns; if this is successfully accomplished, the delay, before the infantry advance can begin, will be considerably diminished.

When the infantry advance is progressing, it is the duty of the attacking artillery to relieve the infantry from the fire of the hostile batteries, in the first place by drawing the fire on itself and finally by silencing it entirely. Their efforts in this direction may bring about a preliminary duel, in which the opposing batteries seek to silence each other by artillery fire only.

The prospects of a speedy termination to such an engagement are however so remote that such a course of action can only be regarded as a waste of an enormous amount of ammunition.

The duties of the attacking artillery are so manifold that no attacking force will have sufficient artillery at disposal to attempt to carry them all out simultaneously with any prospect of success. It is therefore of great importance that the batteries at disposal should not have their resources squandered against a target better concealed than themselves, unless it is absolutely necessary. It is the first duty of the artillery to select as their target that portion of the defensive line which offers the greatest obstacle to the attack, and which is the greatest source of danger and injury to the attacking infantry.

It is impossible to provide every battery with a separate airship or balloon to observe its fire, but if the fire is concentrated on the most important targets, such means of observation will generally be available.

The Siege of Port Arthur gives us no idea of the great obstacles the infantry advance will meet with, before coming under the fire of the fortress girdle proper, because the Russians precipitately abandoned the most important advanced positions, including the Wolfsberg—which was invaluable for the deployment of the attacking artillery—and withdrew into the fortress itself.

When on July 28th, 1904, they were forced to abandon the Laotsuschan-Jupilasa position and to retire to the line Louisa Bay-Wolfsberg, they thought plenty of time would be available to fortify the new position. Thus this line, which was the most important advanced position, was not properly prepared for defence, and consequently the defending force, which was very weak for so extensive a line, was quite unable to withstand the sudden and overwhelming assault delivered on July 30th.

The Russians now held only Dagushan on the right and Schuishiyin on the left of the north-east front, although the ground generally was favourable to a gradual and stoutly contested retirement.

Parallel to the line of permanent works and some 1,000 yards to the front there is a slight undulation in the ground, and when the Japanese had captured Dagushan, which enfilades this position, it formed an ideal base for the close attack. In order that the close attack should envelop the left flank however the Japanese had to get possession of the Schuishiyin works (Kuropatkin and Temple Redoubts), and the difficulties and casualties involved in this operation form the only example which the siege affords of the infantry distant attack.

The Kuropatkin Redoubt lies some 1,600 yards from Fort Erlungshan, and it is commanded by the Wolfsberg at a distance of 3,500 yards. As the Japanese had established their artillery on the latter hill, the garrison of the redoubt was not very favourably placed for an obstinate resistance. Yet it maintained its position until the 20th September, and until then the Japanese were unable to begin the close attack against Forts Erlungshan and Sungschushan.

We are therefore justified in concluding that the close attack would have been seriously delayed had the Russians occupied the whole of the rising ground on the Jaho, instead of only two posts on the flanks. As even the unfavourable position of Schuishiyin compelled the Japanese to resort to regular covered approaches, it is improbable that the distant attack of the infantry, even when the attacking artillery has soon obtained a superiority over that of the defence, as at Port Arthur, will be able to progress by a series of rushes.

In the French official instructions the distant attack is described as a series of desperate encounters leading to pitched battles, and this description is much more likely to be correct. If the defence has been properly organized, every suitable advanced position will have been utilized to increase the difficulties of the distant attack and to prolong its duration; consequently for the distant attack alone considerable time will be required. This time cannot be lessened by increased artillery fire alone; the distant attack can only be brought to a successful conclusion by an overwhelming infantry attack closely supported by the artillery.

Because in the past the attacking force has been able to proceed to the attack of the main position with little delay, it must not be thought that this will occur again. On the contrary, it is to be expected that in future a fortress garrisoned by an energetic army under a capable commander will consist of a series of advanced positions, each one of which will only be captured after heavy fighting.—(*To be continued*).

C. OTLEY PLACE.

BOOKS RECEIVED.

Lectures on the Strategy of the Franco-German War, 1870, up to the Battle of Sedan. By Brevet Major W. D. Bird, D.S.O. Hugh Rees, Ltd., 119, Pall Mall, S.W. 6s. net.

An Introduction to Military Geography. By Brig.-General E. S. May, C.B., C.M.G., G.S., Irish Command. With maps and sketches. Hugh Rees, Ltd., 119, Pall Mall, S.W. 8s. 6d. net.

An Introduction to the History of Tactics from 1740 to 1905. By Capt. A. F. Becke, late R.F.A. Hugh Rees, Ltd., 119, Pall Mall, S.W. 3s. 6d. net.

The French Conquest of Algeria. By Major G. B. Lawrie. Hugh Rees, Ltd., 119, Pall Mall. Price, 6s. net.

Molesworth Metrical Tables. By Sir Guilford L. Molesworth. E. & F. N. Spon, Ltd., 57, Haymarket, S.W. 2s. net.

Handbook on Tacheometrical Surveying. By C. Xydis. E. & F. N. Spon, Ltd., 57, Haymarket. 6s. net.

The B.I. Handbook. British Insulated and Helsby Cables. B.I. Cables, Ltd., Prescott, Lancashire. 7s. 6d. net.

The Frontiers of Baluchistan. By G. P. Tate. Witherby & Co., 4, Newmans Court, E.C. 12s. 6d. net.

Theory of the Recoil of Guns with Recoil Cylinders. By Prof. F. Rausenberger. With three plates. Specially printed from *Artilleristische Monatshefte*. Translated by Alfred Slater. Crosby, Lockwood & Son, 7, Stationers Hall Court, Ludgate Hill. 10s. 6d. net.

The Manufacture of Explosives. Twenty years progress. Four Cantor Lectures delivered at the Royal Society of Arts in November and December, 1908, by Oscar Guttmann. With 11 illustrations and coloured frontispiece. Whittaker & Co., 2, White Hart Street, Paternoster Square, London, E.C. Price, 3s. net.

Spon's Architects' and Builders' Pocket Price Book, 1909. Edited by Clyde Young and revised by Stanford M. Brooks. E. & F. N. Spon, Ltd., 57, Haymarket. Price, 3s. net.

Notes on Magnetism and Electricity. By J. S. Iredell, A.S.C. Gale & Polden, Ltd., 2, Amen Corner, Paternoster Row, E.C. Price, 3s. 6d. net.

La Marine. Le Haut Commandement Ses Fautes, sa Réforme. Par "L.M.V." et Capitaine E. Liron. R. Chapelot et Cie, Paris. Price, 2f. 50.

The "Times" History of the War in South Africa. By L. S. Amery. Sampson Low, Marston & Co., Ltd., 100, Southwark Street, London, S.E. 1909. Vol. VI. Price, 21s. net. Vol. VII. 10s. 6d. net.

Chaudières Marines et Accessoires. Avec notes de résistance des matériaux et de Thermodynamique. Par L. Jauch et A. Masméjean. J. Alté, Editeur, Quai Cronstadt, Toulon. Price, 22f.

The Indian Mutiny, 1857–58. Selections from the Letters, Despatches, and other State Papers preserved in the Military Department of the Government of India. 3 vols. Calcutta Military Department Press.

The Services of the Bengal Native Army. Calcutta Government Printing Office. Price, 4s. 6d.

A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet. By Colonel S. G. Burrard, R.E., Supt., Trig. Surveys, and H. H. Hayden, Supt., Geological Survey of India. Part IV. The Geology of the Himalaya. Calcutta: Supt., Government Printing, India. Price, 2 Rupees.

CORRESPONDENCE.

TENSION BRIDGES.

SIR,

I notice in the May number of the *R.E. Journal*, an account by Capt. Mozley of "A Proposed Tension Bridge." It is an excellent form of bridge.

About the year 1899, I built a bridge on these lines whilst training recruits at Chatham. No doubt the drawings and calculations are still in the archives of the Training Battalion. The only important difference was that I retained the old form of frame, and did not use shears instead; but that does not affect the principle of the bridge at all. I am not aware of any such bridge having been built previously, although probably this has been the case.

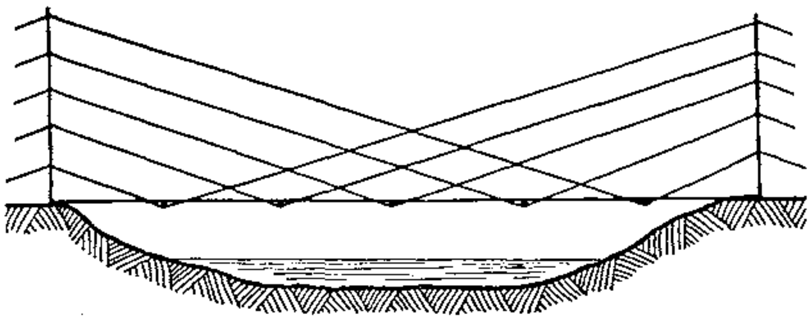
I am surprised that Capt. Mozley finds it necessary to use more wire than for a similar ordinary suspension bridge, for it was the economy of wire in the bridge I constructed, which first made me think of the method.

There was at the time a good supply of 2½" steel wire rope, but no large cables available. It was the usual practice to stop three parts together and erect an ordinary type bridge. I separated them and used three intermediate transoms, each supported by one 2½" rope at each end. I was also able to use much bigger frames than for a suspension bridge. In the result, the bridge in question carried infantry crowded at a check, whereas the ordinary form with the same span and the same ropes, only permitted infantry in file crowded, and the bridge was very free from vertical oscillation.

The reasons why Capt. Mozley found it necessary to use more wire, appear to be two in number: In the first place straight inclined ties under the bridge are quite unnecessary to prevent vertical oscillation. In the second place frames or shears much higher than 30' should be used for a 200' span, in order to realize economy of wire. If you double the height you almost halve the amount of wire required.

Although for a distributed load no advantage accrues from increasing the lengths of the bays, this is no longer so with a concentrated load. I found over 20' advantageous. If I recollect rightly this allowed the same strain for the heaviest vehicle, short of siege ordnance, as for infantry crowded at a check. Of course it resulted in a heavier roadway, but that is not an unmixed disadvantage. The unloaded bridge was heavy enough to make the cables very nearly straight lines, and the further straightening caused when a load came on was trifling.

I found no difficulty in adjusting the bridge without using any traveller, which appears to be an unnecessary complication.



The accompanying sketch shows an alternative arrangement which, whilst complicating the frames and anchorages, has the advantage of complete symmetry, and an absence of fore and aft strain on the frames.

G. E. SMITH,
Major, R.E.

The Editor, *R.E. Journal.*