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CONTENTS.

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GIRDER BRIDGES FOR MILITARY ENGINEERS.

(*Concluded*).

By Capt. E. N. Mozley, R.E.

PART III.

METHOD OF LAUNCHING RECOMMENDED FOR LARGE GIRDER BRIDGES.

(i.). Ideal Method.

The following description shows the ideal method of launching :— (In the 88′ span bridge (No. 6) under consideration Stage 1 was practically omitted; Stage 2 was more difficult to execute than would usually be the case as the girder had to be rolled up a 1 in 20 incline (on two poles) so as to clear an old cantilever bridge anchorage. Stage 3 was carried out as described, Stages 4 and 5 were carried out as described but with only an 8′ command of sheers block over the far abutment and only one main tackle. Stage 2 and Stage 6 were executed generally as described but the small trestle referred to in Stage 6 was not placed on the cables).

The process may be divided into six stages.

Stage 1.—Carrying the girder bridge (two girders with all wind bracing on) from site of construction to position when front ends of lower flanges *just* overhang gap.

The girders should be 7′ centre to centre, say 8′ out to out. The bridge should be carried by spars underneath and at right angles to the lower flanges 6′ apart, *i.e.* 16 such spars for a 90′ bridge. If the bridge weighs 8,000 lbs. each spar will carry 500 lbs. If each man is to lift 60 lbs. 8 men should lift at each spar, 4 each side of the bridge. Allowing 8′ each side of the bridge for 4 men side by side the spars should be 24′ long. Five-inch diameter fir will be strong enough.

There may be 1 superintendent to every 8 men lifting, *i.e.* 16 superintendents and 128 men are needed to lift easily a 90′ bridge.

They should be practiced in walking with the bridge on the level and if necessary up and down hill before emerging from cover, to carry it to the gap.

In addition to the carriers there should be five side guys on each side of the bridge each manned by 2 men—20 men in all, to prevent the bridge tilting when being carried. These guys should be long in order to keep any lateral pull as horizontal as possible.

With these arrangements the bridge should be carried at the rate of at least 6 yards a minute (allowing for frequent rests). It would probably be possible to increase this rate of advance to 10 yards a minute. In other words if the place of construction were anywhere within 300 yards of the gap and the approach were not too difficult the bridge could be brought up to the gap in half an hour.

Simultaneously with the emerging from cover of the carrying party the following parties would double out to the gap and carry out launching preparations :—

A. *Roller Party.*—30 men. Carry out four spars 30′ long and lay them as in *Fig.* 34.

These four spars should be picketed so as to prevent them shifting sideways, and should be supported by cross logs at the ends close to the gap.

The same party bring up the rollers of which there should be at least four, 18′ long and *not less* than 10″ diameter. Each roller to have a lashing made fast to each end so as to pull it back when it rolls into the gap.

The roller party will assist the anchorage parties when it has completed its work.

B & C. *Cable Parties.*—Two parties each of 20 men. They carry the cables forward, get them simultaneously across the gap and hand them to the cable anchorage parties.

D & E. *Near Side Cable Anchorage Parties.*—Two parties each of 6 men. They carry forward the pickets, log and mauls for making holdfasts for the near side ends of the cables and attach the cables to these holdfasts.

F & G. *Far Side Cable Anchorage Parties.*—Two parties each of 6 men. Duties as for D & E. They, with the assistance of the cable parties, haul the cables taut and take in the slack round the anchorages.

H. *Near Side Cable Abutment Party.*—6 men. They build up two low piers or abutments, if possible 3′ high, for the cables to pass over close to the brink of the gap on the near side. N.B.—If a 12″ spar is available to carry the front end of the bridge on the cables, the cables may be as much as 20′ apart.

K. *Far Side Cable Abutment Party.*—6 men, duties as for H.

L. *Far Side Cable Tackle Party.*—8 men (working in two parties). They carry across the two tackles (already rove) and pickets for two holdfasts for the tackles to pull the cables taut on the far bank. They drive in the pickets, affix the tackles and make the stoppers on the cables to which the tackles are attached.

M. *Far Side Sheers Party.*—20 men. They carry across the sheers (already made, with a cross piece lashed on and suspended from crutch), erect them, make fast the back struts and carry the back guy back to its anchorage.

N. *Sheers Back-Guy Anchorage Party.*—3 men. Place a holdfast for the back guy of the sheers.

O & P.—*Far Side Main Tackle Parties.*—Two parties each of 8 men. They place holdfasts for the main runner tackles, which are attached to the guys which pass through the blocks on the sheers to the forward end of the bridge. They fix these tackle (already rove) and lead the guys (through the blocks if in place) to the near bank again, ready to attach to the bridge when required.

Q. *Side Guy Parties, Near Side.*—4 men, working in two parties. Drive a holdfast each side of the bridge, and make fast "preventers" to the top flange panel points where ordered, as soon as the bridge reaches the gap.

R. *Side Guy Parties, Far Side.*—4 men, working in two parties. Make holdfasts corresponding to those of Q, but on the far bank. The ends of the side guys to be led back across the gap to the near side ready to be attached when ordered.

S. *Rear Guy Party.*—4 men. They place a holdfast in centre line of bridge about 120′ from gap and attach a guy from it to the rear of the top flanges (with a bridle) as soon as the bridge is brought up. They also place two holdfasts (either side of the centre line and just clear of the bridge) to assist in tipping the bridge. These holdfasts to be a distance in rear of the gap equal to half the length of the bridge + 5′. This party also brings up a pole ready to make fast to these holdfasts and attaches two guys to this cross piece the other ends of which will be tied to the top flanges when the rear ends of these flanges are just over the holdfasts and the girder is about to tip.

T. *Excavation Party.*—3 men. They ramp off the near bank between the logs laid down by party A to allow the girder to tip on to the cables without catching the edge of the gap.

U & V. *Abutment Parties, Near Side.*—Two parties each of 4 men. Prepare the seatings for the ends of the top flanges on the near side.

W & X. *Abutment Parties, Far Side.*—Two parties each of 4 men. Carry out the same work for the far side.

All the above parties with the exception of M (sheers party) should, if they understand thoroughly beforehand what they have to do, complete their preparations in ¾ of an hour *if there is no great difficulty in getting men and stores across the gap.* If there is such difficulty, owing to precipitousness of sides of gap or rapidity of stream, a small party must be sent across previously and as secretly as possible to get a line across the gap, pull one cable across and then pass men and stores across on this cable by a carriage suspended from it.

Stage 2.—At the beginning of this stage the bridge is on the rollers with the forward end just overhanging the gap. If the necessary men have been available there will be on the near side 164 men in the carrying party, 30 in party A, 12 in parties D & E, 6 in party H, 16 in parties O & P, 8 in party Q & party S, 3 in party T, 8 in parties U & V, a total of 247: and on the far side 40 men in parties B & C, 12 in parties F & G, 6 in party K, 8 in party L, 20 in party M, 3 in

party N, 4 in party R, 8 in parties W & X, a total of 101. The whole party is therefore 348 men.

Immediately the girder is set down upon the rollers the following will be carried out before launching :—

(1). A prearranged party will lash across and underneath the forward end of the lower flanges a stout pole (from 9" to 12", depending on weight of bridge and distance apart of cables) to convey the weight of the forward end of the bridge on to the cables when it is tipped.

(2). Parties O & P make fast their guys to this pole.

(3). Parties Q & R make fast their side guys and stand to their holdfasts to pay out or take in. Four men will be told off to assist them.

(4). Party S makes fast its rear guy and stands by the holdfast.

(5). Parties M & N continue erection of sheers.

(6). Parties B & F on one main tackle and C & G on the other main tackle prepare to pull the bridge forward.

Parties K, L, W, X on far bank are spare.

Men in pairs (each pair to one handspike) stand each side of the bridge to lever lower flange up if a roller sticks. Two men to be told off to each end of each roller to shift it when necessary. Remaining men on near side stand round outside of lower flanges prepared to shove forward.

When all parties are in position the word is given to launch forward. The bridge will be rolled forward on the rollers. As each roller reaches the forward end of its run it will fall into the gap and be pulled up by the lashing made fast to it and if necessary placed under the bridge in rear.

The main tackle parties on the far side will assist, and the bridge will be pulled forward till it is approximately balanced on the forward roller which should then be within 1' or 2' of the gap.

It should be observed that the number of men here employed are by no means necessary for the actual launching of the bridge. As a matter of fact a 90' girder bridge for infantry two deep can be lifted and carried by 100 men, and can be rolled forward and pulled over the gap by 60 men. The large numbers here given are with a view to *simultaneous* and quick execution of the preparations for launching. It will generally be sufficient to have, say, 150 men to carry the bridge to the gap and 100 to launch it, (60 men on the near and 40 on the far bank).

Stage 3.—*The cables having been pulled up as taut as possible so that the "stretch" is taken out of them,* the bridge is tipped up and the forward end allowed to drop down on the cables as follows (*Fig.* 33) :—

As soon as the bridge is so far forward that it is balanced about the forward roller remove all other rollers except one. Place this one about 5' behind the one on which the bridge is balanced. Now bear

down on the rear end of the bridge, taking in the slack of the vertical lashings made fast between the rear ends of the upper flanges and the pole brought up by party S, which is now lashed to its holdfasts. The front half of the bridge will now rise and the bridge itself will pivot about the rearmost of the two rollers and the other can be removed. Now slack off the rear vertical lashings and the forward end of the bridge will sink on to the cables.

This is a better method than at once tipping the bridge about the foremost roller, as it saves the rear end of the girders from going too high in the air and the tipping is more under control. The whole of this process will not take more than five minutes.

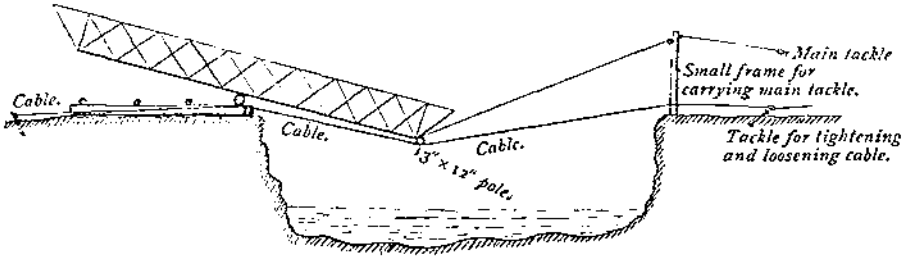

FIG. 33.

Stage 4.—The pulling and rolling forward of the girders is continued and, since the centre of gravity is now descending, the pull will not be a hard one. The cables should have been greased in front of the pole which slides on them.

As soon as ever the sheers are ready, the two forward guys should be lifted up and slipped into the snatch blocks hanging from the cross-piece. This will give somewhat of an upward pull on the front of the girder and prevent excessive sag of the cables. The rear half of the girder moves forward on one roller which is followed up, at not more than 2′ or 3′ interval by another one, so that, when the foremost one falls into the gap, the drop of the bridge on to the one behind will be very small.

This stage, during which the forward end descends, will continue till the forward ends of the lower flanges are about two-thirds of the way across the gap. Then the upward pull from the snatch blocks on the sheers will be sufficient to begin to lift the front of the girders. It will be necessary once or twice to overhaul the main tackles (which should always be overhauled *together* to save time). The slack of the guys attached to these tackles should be taken in where they are attached to the girders and not at the tackle.

During these processes of overhauling the following operations should be performed :—

(*a*). A spar should be *lashed* underneath the rear ends of the lower flanges.

(*b*). A small trestle or crib, previously put together, should be

placed across the cables about 5′ from the near abutment to break the fall of the girders when the rear ends of the lower flanges slip off the abutment. This trestle should have foot-ropes to it secured to holdfasts on the near bank, by means of which it can be allowed to slide down the cables if necessary.

(*c*). The two poles, AB and CD in *Fig.* 34, should be roughly framed together with lashed spars and nailed planks, as shown in dotted lines, so as to enable them to be worked together as a single lever in Stage 6.

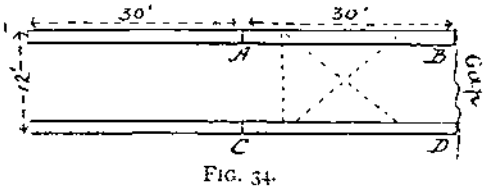

FIG. 34.

Stage 5.—This is merely a continuation of the preceding stage, and only differs from it in the fact that the forward ends of the girders will now begin to rise towards their abutments. As soon as the rear ends of the lower flanges are within 3′ of the near abutment the bridge will be allowed to take its bearing on to the roller which has been lashed to them. The side guys on the far bank may be used to assist in the forward pull.

Stage 6.—As soon as the spar lashed to the rear of the lower flanges comes vertically over the ends of the logs on which it *slides* (*i.e.* over the edge of the gap) the rear end of the bridge must be lowered on to the cables. This is done as follows :—The rear end of the bridge is lifted up a few inches with levers so that the two poles AB and CD on which the lashed roller rests can be slid forward over the gap about 4′. The bridge is then pulled forward again 2′ or 3′ while men bear down on the inshore ends of these poles to prevent them tipping. As soon as the lashed roller is sufficiently far out the poles are allowed gradually to tip up and the rear of the bridge will be lowered on to the cables. Any sudden slip will be caught by the small trestle which has been placed across the cables close to the abutment for this purpose.

As soon as the weight of the lashed roller is brought upon the cables the bridge is again pulled forward till the ends of the top flanges are over their seatings. The tackles attached to the cables on the far side will now be paid out and the cables themselves paid out at the anchorages. The bridge will then be gradually lowered till the four ends of the top flanges rest on the seatings prepared for them.

During this final stage all the side guys must be double-manned as any sudden slip of one lower flange, or extra stretch of one cable will cause the bridge to tilt, which must be at once met by a slackening out of the other cable to bring the bridge level again.

It is for this reason that the cables should be as wide apart as the strength of the rollers and poles will allow, since any difference of level of the cables will have a tilting effect inversely proportional to the distance apart of the cables.

It is necessary to note that, while the sheers will probably lean forward towards the gap when first the tackles are passed through the snatch blocks on its cross-piece, it will subsequently tend more and more to lean backwards, since the resultant downwards pressure of the two parts of the guys will make an increasing angle with the vertical towards the rear. For this reason the back struts must be lashed high up the sheers and must have good footings.

Throughout the operations whistles should be carried by the following :—

1. The officer in charge of operations who will find it best to stand close to the gap on the near side.

2. An officer stationed between the abutments on the far side to judge as to (*a*) correct direction, (*b*) any tilting of the bridge, (*c*) when the main tackles require overhauling.

3. An officer or N.C.O. in rear of the bridge to judge as to any necessity for a cross-lift to the rear of the bridge, either to correct any deviation of direction or to place correctly any roller which may have got askew.

The stopper hitches for the tackles to the main cables on the far bank must be exceedingly well made, as any slip on their part may give the bridge a dangerous tilt.

The cables should not sag, at the most, more than 8′, and the maximum will be reached just before the lift from the sheers is felt (at the end of Stage 4).

There should be plenty of packing and wedges of various sizes laid along each side of the bridge on the near bank ready for use as fulcrums, etc.

It is of little use to place cross-pieces on the cable or on the underside of the lower flanges anywhere except near the abutments, as in any other positions such cross-pieces will fail to convey weight to the cables.

If insufficient men are available on the far bank, secondary runner tackles can be fixed to the running ends of the main runner tackles. By such means eight men have pulled an 8,000-lbs. bridge across a portion of a 90′ gap at the rate of 1′ in three minutes.

The snatch blocks from the sheers should hang 12′ above the abutments, but the bridge *can* be pulled up on to its seatings on the far bank, if sufficient tackle and men are available, with the snatch blocks only 5′ above the abutments.

In the scheme worked out above, two main tackles to the forward end of the bridge have been arranged for. One is, however, quite capable of doing the work though at a somewhat reduced rate.

In the final stage, when the poles, on which the spar lashed to the

rear of the lower flange slides, are used as levers it is important that they should be tipped *together*, so that one side of the bridge will not tip before the other. For this reason they should be framed together as suggested. Their ends should *not* be greased.

The girder seatings prepared by the parties U, V, on the near bank should be kept as low as possible to prevent them fouling the end of the bridge as it drops on the cables.

The operation of paying out the cables in the last stage to let the bridge down on to its seatings is very quick and effective. The anchorages must be so arranged that the slack can be immediately paid out.

In order to prevent (*a*) braces or web planks protruding below lower flanges, (*b*) lower flanges being injured by the levers, the lower flanges should not, if it can be helped, be less than 7″ or 8″ deep, and, if they have cover plates on the underside, such cover plates should be continuous from end to end of the flanges. Bolts passing vertically through the lower flanges should have their heads downwards.

Rollers must be long enough. The distance between the spars on which they roll should be half as much again as the central interval between the girders, and the rollers should overlap each spar by 3′.

Rollers should be kept greased.

Levers *must* be long. 6′ handspikes are little good. 12′ hardwood levers are needed.

Light lines should be stretched across the gap by which stores, side guys, etc., can be hauled to and fro, without having to send men across.

(ii.). REMARKS ON THE ACTUAL LAUNCHING OF THE 88′ BRIDGE (NO. 6) UNDER CONSIDERATION, WITH NOTES ON THE TIME TAKEN.

In order to surmount a local obstacle the bridge had to be rolled up a pair of 55′ poles, laid at a slope upwards to the gap of 1 in 20, and supported at intervals by packing. There was moreover a large tree at the edge of the gap close to the centre line of the bridge, whose branches interfered considerably with the operation. In addition to this the rollers were only 7′ long and therefore kept tending to roll off the poles, and had to be constantly shifted. The tail of the girder also had to be frequently lifted round into the correct alignment. The slope up which the bridge was pulled took it 2′ or 3′ off the ground, where it was more difficult to handle, and the incline greatly retarded the speed of the operation. If these difficulties, which were abnormal, had been absent the process of launching would have been much easier.

107 minutes was taken over Stages 1 and 2 during which the front of the bridge was moved forward from 60′ behind the edge of the gap to 32′ beyond it, when the tipping process (Stage 3) began. Of this

time 66 minutes were occupied in changing rollers and shifting the tail of the girder into the centre line, 18 minutes were occupied in adjusting tackles and placing the front spar, and 23 minutes in actually rolling the bridge forward uphill for 92′.

Stage 3 was carried out, exactly as described, in 5 minutes.

Stage 4, during which the front edge of the bridge advanced from 32′ to 56′ beyond the edge of the gap, occupied 50 minutes; of this 30 minutes was taken up in shifting the tail of the girder into the centre line (the deviation being chiefly due to the shortness of the rollers), and 20 minutes in actually advancing the bridge 24′.

Stage 5, during which the bridge moved forward 18′ till the front end was 14′ from the far abutment occupied 38 minutes, including overhauling the tackle. Ten minutes would have been saved if the rollers had been long enough.

Stage 6, including the remainder of the advance and the lowering of the tail of the bridge till the upper flanges rested on the abutments, took 35 minutes. The arrangements for the lowering were not as perfect as in the scheme which has here been sketched out, and one side of the tail slipped down more quickly than the other; 15 minutes were taken to rectify this.

The actual time therefore, compared with the time which would have been taken if the locality had been favourable and the stores adequate, may be stated as follows:—

Stage.	Advance of Girder in Feet.	Actual Time (Minutes).	Time, if Abnormal Difficulties had been Eliminated.
2	92	107	41
3	—	5	5
4	24	50	20
5	18	38	28
6	14	35	20
Total ...	148	235	114

Four hours may therefore be considered the maximum and two hours the minimum time for Stages 2 to 6 of a bridge of this size. With practice two hours should be sufficient on a favourable site.

To add the time for the other stages, from the time of emerging from concealment to the time the roadway is completed:—

With sufficient men, good organization and fairly favourable ground

Stage 1 (carrying from cover to the gap) should not exceed 30 minutes.* Placing the roadway in the method described, 30 minutes. Therefore the total time of exposure to the enemy would be three hours.

(iii.). STRETCH OF CABLES.

In launching an 8,000-lb. girder bridge it is probable that at no time is the load on the two cables together greater than 5,000 lbs., and this will be about when the bridge is two-thirds of the way across. If 3″ wire cables are used they should not sag more than 7′ or 8′ (less, if the stretch is taken out of them by the tackle before they are loaded). If only 2″ wire cables (breaking stress, say 9 tons) are available, the cables will be safe with a sag of 11′ or 12′, but the lift in the penultimate stage will be heavy if the sag is so great that it exceeds the depth of the girder.

PART IV.

TIME NECESSARY TO MAKE AND JOIN TOGETHER TWO GIRDERS.

As a comparison between the time taken to build nailed girders and bolted girders respectively the following figures are given :—

A 78′ girder bridge for cavalry in single file put together with nails took 296 M.H. (cadet labour). An 88′ similar bridge but put together with bolts and nuts took 369 M.H.†

(If the former bridge had been 88′ long it would properly have taken $\frac{88}{78} \times 296 = 333$ M.H. and if this is so, a nailed girder appears to be rather quicker to build than a bolted girder. It also undoubtedly takes less skilled labour and less accuracy).

If sapper labour were available and if the men had been trained to the work and if nails were used it is probable that a 90′ bridge could be put together in 180 M.H. *i.e.* at 2 M.H. per foot of span.

Not more than 10 men at one time can be economically employed in building the girders. 30 men can lift or turn them. Therefore the least time in which a 90′ girder bridge can be built (exclusive of launching) is probably 18 hours, or including launching and laying the roadway 21 hours, of which only the last three need be under the observation of a possible enemy.

* The following are the results of experiments :—

90 cadets, with difficulty, carried the bridge in the direction of its lengths at 3 yards a minute. The rate was retarded as the lift had to be taken at the lower flanges instead of at cross-pieces under them. The rate could be doubled or trebled with 150 practised men, lifting at cross-pieces.

The bridge can be *rolled* forward on level ground, if nothing such as the lower ends of braces interferes with the rollers, at 6 yards a minute. Allowing for stops for adjustment of rollers, etc., it would be safe to reckon on 3 yards a minute. Of course fewer men are needed.

If the rolling has to take place up a grade of 1 in 20 a rate of 1 yard a minute can be maintained.

† $\frac{3}{5}$ time to build the flanges.
$\frac{1}{5}$ „ „ brace flanges together.
$\frac{1}{5}$ „ „ erect into vertical planes and cross brace together.

Bridge number ...	1.	2 (i.).	2 (ii.).	3 (i.) (ii.).	4.	5.	6.
1. Date of erection	1899.	1901.	1901.	1904.	1904.	1906.	1908.
2. Place of erection	Christchurch.	Chatham.	Chatham.	Herne, Christchurch.	Christchurch.	Kingston, Canada.	Kingston, Canada.
3. Span in feet ..	51.	36.	42.	49.	57.	78.	88.
4. To carry	Cavalry single file.	Infantry in fours.	Infantry in fours.	Cavalry single file.	Cavalry single file.	Cavalry single file.	Cavalry single file.
5. Type of girder ...	Fished beam.	Inverted bowstring.	Invertedqueen post.	(i.) Warren, (ii.) Plate.	Warren.	Plate (triangular section).	Single lattice.
6. Reference to Fig. or photograph.	*Fig.* 5.	*Fig.* 6.	*Figs.* 7, 8, 9.	*Figs.* 10 to 15.	*Figs.* 16 to 22.	*Figs.* 24 to 29 and *Fig.* 3.	*Figs.* 30 to 33 and *Fig.* 4.
7. Roadway carried on.	Upper flanges.	Upper flanges.	Upper flanges.	Lower flanges.	Upper flanges.	Upper flanges.	Upper flanges.
8. Distance between girders, centre to centre.	6'.	10'.	9'.	9' 6".	7'.	4' 6" (top flanges).	7' 4".
9. Depth between flanges, centre to centre.	2' at centre.	5' at centre.	7' 6".	(i.) 6', (ii.) 6'.	5' 6".	6'.	7' 4".
10. Dimensions of one upper flange.	*8" spar.	7 12" × ¾" planks.	2 pieces 12" × 6".	(i.) 4 planks 6" × 2". (ii.) See *Fig.*	*8" telegraph pole.	*8" spars.	5" × 5".
11. Dimensions of one lower flange.	Composite wire.	8 do.	1½" chain.	(i.) 2 planks 6" × 1". (ii.) See *Fig.*	Composite wire.	*10" spars.	5" × 5".
12. Dimensions of web.	See *Fig.*	2" planking.	See *Fig.*	(i.) 6" × 1" planks. For No. in each brace see *Fig.* 10. (ii.) ½" planks (see *Fig.*) and stiffener.	8" telegraph poles and composite telegraph wire.	2" and 1" double planking (see *Fig.*) and stiffeners.	Assorted planking (5" × 3" to 3" × 1").
13. Method of transferring tensional stress at joints in lower flange.	--	Planks nailed to each other and breaking joint.	---	(i.) Dowelled or bolted cover plates. (ii.) Nailed cover plates.	Wires passed through auger holes in feet of compression braces.	Wires passed through auger holes in spars of lower flange.	Cover plates bolted through scantlings of flange.
14. Fastenings employed between flanges and web.	Trenails and lashings (see *Fig.*).	Wire nails and ½" bolts.	Dogs and spikes (see *Fig.*).	(i.) 1⅛" dowels or 1" bolts. (ii.) 2½" cut nails.	See *Figs.* 17--19 for upper flange joints.	6" wire nails.	1" to ⅞" bolts.
15. Bracing between girders (in addition to road transoms).	2 lower cross-pieces.	1 cross-piece at centre of bottom flanges and 2 diagonal braces.	See *Fig.*	Exterior sloping struts fixed to extensions of road transoms	Wind bracing between top flanges, and cross diagonals of wire between girders.	Wind bracing between upper flanges (see *Fig.*).	Wind bracing between top flanges and between bottom flanges, and cross diagonal braces.

* Central.

16. Weight of both girders and bracing (lbs.).	Not estimated.	About 4,000.	About 4,500.	(i.) 1,400. (ii.) 1,600.	5,000.	8,000.	8,500.
17. Method of launching.	Girders singly with 15′ sheers on far bank.	30′ sheers on each bank. Girders slung out singly.	As for 2 (i.), but girder launched in one piece.	20′ frame on far bank and rollers.	2 20′ frames, girders launched together.	60′ derrick on far bank, 35′ frame on near bank, rollers & tackle from far bank.	Slid out on rollers and suspension cables; pulled across with tackle from 8′ sheers on far bank.
18. Remarks on launching.	Girders should have been *first* braced and *then* launched together.	As for No. 1. This bridge had 2 spans	This girder was built and launched upside down, and turned over in the air, a difficult process.	Worked well.	Shallowness of gap impeded operations.	Derrick and frame took too long to erect. Great local difficulty on near bank. Girder had to be launched upside down, which involves turning in the air.	Very successful, but could be further improved.
19. Time in hours of:—							
(*a*). Construction of girders.	13.	29.	13.	50.	21½.	30.	37.
(*b*). Launching of girders.		6.	4.	1.	3.	8½ (longer than usual owing to site).	4 (longer than usual owing to site).
20. Working party for 19 (*a*).	2 R.E.	6 R.E.	16 R.E.	6 R.E.	16 R.E.	10 cadets.	10 cadets.
Ditto 19 (*b*)	14 cavalry.	40 R.E.	40 R.E.	50 R.E. and cavalry.	50 R.E. and cavalry.	60 cadets.	50 to 70 cadets.
21. Total men-hrs. to make the bridge.	208.	414.	368.	350.	492.	823 + 147 for derrick + 50 for frame (see note to 19*b*).	609 (see note to 19*b*).
22. Test	None.	See *Photo*.	See *Photo*.	(*a*) 50 cwt. dead. (*b*) 32 ,, live.	Equivalent to maximum load, slight failure.	4,200lbs. live load, marking time at centre of bridge.	See *Fig.* 23.
23. Observed deflection during test.	—	—	—	Very small.	4″.	3½″. Reverted to 2″ when load was removed.	See *Fig.* 23.
24. Oscillation	—	Very little; none after bracing between girders was put on.	None.	Very little.	Not fully observed.	Some, chiefly due to *single* lower flange.	Very little.

HISTORICAL DOCUMENTS OF MAJOR-GENERAL SIR J. T. JONES, BART., K.C.B., R.E.

A NUMBER of most interesting and valuable papers and MSS. which originally belonged to Major-General Sir John Jones, have recently been kindly presented to the R.E. Museum by his grandson, Sir Lawrence Jones.

As A.D.C. to General Leith, Sir John took part in the retreat to Corunna in 1808-9. In 1809-10 he was in charge of the construction of the lines to cover Lisbon, and later on, as Brigade Major of Engineers, took part in most of the Sieges in the Peninsula. He was severely wounded at the Siege of Burgos in 1812, being incapacitated for the next two years during which time he published his *Journal of Sieges of Spain*. Some years later he compiled a short history of the Peninsular War, and in order that his details should be correct he obtained from many of the generals, who took part in the Campaign, notes and criticisms of the work done by the Divisions, etc., under their command.

The papers presented to the Museum not only include some of the Duke of Wellington's original orders and instructions, but also the whole of Sir R. Fletcher's correspondence on Torres Vedras, memoranda by Sir A. Dickson on the artillery preparation for the sieges of Ciudad Rodrigo and Badajos, and MS. accounts by Sir H. Clinton, Sir C. Colvile and other generals of the work done by their Divisions in some of the principal battles. There are also numerous letters from R.E. officers describing the different battles in which they took part.

Although Sir J. T. Jones has already published the whole of the Torres Vedras correspondence as an Appendix to his *Lines to Cover Lisbon in 1810*, many of the other documents do not seem to have been made use of, and, as they are of considerable historical and Corps interest, it is now proposed to reproduce some of them in the *R.E. Journal*. Practically all of the Manuscripts are in connection with the Peninsular War, and the three published in the present *Journal* refer to the year 1809. The two first letters deal with the rout and destruction of General Loison's Column at the Battle of Vimiera—an incident incorrectly reported in Lord Wellington's despatch. The third document is partly in the handwriting of Sir R. Fletcher and partly in that of Sir S. R. Chapman, and is a copy of Lord Wellington's original memo. and orders for the construction of the Lines of Torres Vedras.

(1). *Copy of a Letter and Memoir from Major-General Sir G. T. Walker to Sir J. Sinclair, Bt.*

HARLEY STREET, *August 4th*, 1816.

DEAR SIR,

Although I had no desire to take advantage of your offer to give publicity to a narrative, now become by subsequent events of little comparative importance, I was yet in hopes for your personal satisfaction to have been enabled earlier than this to furnish you with such explanations as might assist you to comprehend a subject which you have deemed worthy your attention * * * *. But indeed on reference to the Narrative* I inclosed to you, I still feel a difficulty in giving any further details than I have there already done, as to "the Manœuvre practised in the defeat of the French Column at Vimeira." It is there stated that on the near approach of the Enemys Column my Regiment (then formed in line) commenced the attack by a movement to the left in Echellon of Companies of the right wing, while the left occupying a space nearly equal to the front of the Enemy's Column, stood fast. It was then meant on re-forming the Right Wing into a line oblique to the Enemys flank, to charge that, and his front at the same time; but finding that the advance of his Column was becoming too rapid to admit of the delay which this would occasion, I found it necessary as soon as the two left Companies only were formed, to order a Volley and charge of the whole, (the 3 other Companies of the right wing still in Echellon) which, notwithstanding the fire of the Enemy was as great as a close Column so formed could produce, completely effected that route and confusion, consequent upon such a formation when attacked in flank, or rear while its front is occupied. The truth is that the attack in close Column was an invention of the French Revolution, to bring forward undisciplined Troops, against those supposed to be disciplined, and unfortunately however skilled these may have been in tactics and practised in the old and slow forms of discipline, deprived as they were by a long peace of its superintending and pervading spirit, the presence of mind, the quick eye, the prompt decision of the Officer used to Combats, and inspired by a vain confidence built on the recollection only of the skill and success of their fathers, which only served to place them in the way of destruction—astonished and terrified at the unwonted attacks of these enormous masses, it was not unnatural that such Troops should be overwhelmed by them. Bonaparte readily adopted a system suited to the savage character of the Monster, prodigal of blood and with numbers ever at command, in his successive Columns of attack, he

* The one I sent to you being Copy of that on which was grounded the grant made by the Sovereign of the word *Vimeira* as an honorable Badge in the Colours of the 50th Regt.

freely expended the product of his horrid conscriptions, careless of the amount, provided Victory was the purchase, and altho' hardly earned experience began to oppose to him some expedients, the rapidity peculiar to this Man and which characterised all his movements, the horrid and wide wasting destruction all his Armies carried with them, thro' a long unbroken chain of success, added to the want of union and decision in his opponents, occasioned the French Armies to be viewed only through a medium of terror, their progress to be considered irresistible and their tactics perfect. In such a state of things the example set at Vimeira was of an importance that ought not to have been obscured by the Cloud which public opinion drew down upon the subsequent Convention.

It was here that for the first time, beaten and routed, this invincible Column *en masse* fled, and like a flock of sheep, before a British force, not a fifth of its numbers, nor even more has the charm first broken at Vimeira since availed against coolness and discipline. As to giving however any further details of the attack and defence on that occasion as offering a system generally applicable, which appears to be the object of your request, I fear this explanation will have afforded you but little satisfaction. To a Military Man it would be unnecessary to add that such defences must be determined by local circumstances, for although an Echellon on that occasion was employed, and is I believe generally speaking one of the safest and most expeditious manœuvres under fire, various others might under other circumstances become more properly applicable—the object being by an attack on its flank or rear to create alarm in a mass, the greater part of whose members are incapable of being brought into action and where confusion once prevailing neither the judgment or courage of Officer or Soldier can avail ought, the whole being crowded off together. With disciplined Troops then to oppose to it, possessing but due confidence in their Commander, and with coolness, judgment, and decision in the latter it must ever be desirable that our Enemy may persevere in this system of attack.

I have the honor to be, &c.,

(Signed) G. T. WALKER.

SIR JOHN SINCLAIR, BT.

Memoir of that part of the Action of Vimeira Augt. 21st, 1808, in which the 50th Regt. was more particularly engaged.

In Sir Arthur Wellesleys Dispatch where the Position of the Army previous to the Action of the 21st August is described, it may be observed that "General Fane occupied a Hill in front of the whole with the 50th Regt. and his Riflemen." The latter then consisted of

4 Companies of the 95th Regt. and a Battn. of the 60th—this Battalion however when the left of the Line advanced was ordered away for its support and three Companies out of four of the 95th being then employed on Picket or sent to its support in the wood in its front (then attacked by Kellerman's division). The 50th Regt. with a *Single* Company of the 95th were left alone to defend the Hill, supported however by 3 Guns under the immediate direction of Lt.-Col. Robe, R.A., for though (B.-Genl. Anstruther's Brigade having been posted during the night behind the Hill in rear of the right of this Position) the 97th (one of his Regts.) had (as was afterwards learnt) received orders to advance and take up the alignement vacated by the 60th, this movement was not actually executed till some time after the 50th was engaged. The Enemys attack having commenced by an endeavor to force the Pickets in front, B.-Genl. Fane permitted Col. Walker to take two of his Companies to support that of the 50th together with which they were afterwards obliged to retire to a rising ground a little advanced from the left of the Position, where the excellent and incessant fire from this Detachment, contributed in the sequel very materially to the success of the action by attracting the attention of the Enemy to that Flank during the manœuvre performed on the right. In consequence of the absence of these Companies, the others of the left wing were necessarily extended with intervals on the most commanding ground, so as to cover the passage to the Town. Thus situated a massive Column of the Enemy composed of 5 Regts. in close order of half Battns. supported by 7 Pieces of Cannon and under the Command of the General of Division Loison was making a rapid march towards the Hill, and though much shaken by the steady fire of the Artillery, after a short pause behind a height to recover, again continued its advance till Lt.-Col. Robe no longer able to use his Guns, considered them as lost. Till this time the 50th had remained at ordered Arms, but as it was impossible on the ground on which it stood, to contend against so very superior a force, and Col. Walker having observed the Enemy's Column to incline towards the left, proposed to B.-Genl. Fane to attempt turning its Flank by a wheel of the right wing. Permission for this being obtained, the Wing was immediately thrown into Echellon of Companies of about 4 Paces to the left, thus advanced for a short distance, and then ordered to form Line on its left. The rapidity however of the Enemys advance and their having already opened a confused, though very hot fire from the flank of their Column, although only two Companies of the Wing were yet formed, these were so nearly in contact with and bearing upon the Angle of the Column that Col. Walker, thinking no time was to be lost, ordered an immediate Volley and Charge. The result exceeded his most sanguine expectations—the Angle was instantly broken, the Drivers of 3 Guns advanced in front, alarmed at the fire in their rear, cut the

Traces of their Horses and rushing back with them, carried additional confusion among the Enemy, which, by the time the 3 center Companies could arrive to take part in the charge, became general when this immense mass so threatening in its approach but a few minutes before, became in an instant an ungovernable Mob, carrying off its Officers and flying like a flock of sheep almost without resistance, for upwards of two Miles, when on clearing a Wood, Col. Walker observing a body of Cavalry drawn up in a small plain and threatening his flank, deemed it prudent to put a stop to the pursuit, as a party of the 20th Dragoons, which had previously joined in it, had already, by getting entangled in a Wood, suffered too seriously to be capable of affording any further assistance. Having from hence reported his situation and received B.-Genl. Fanes orders, Col. Walker retired with the Regt. to its former position, while the Enemy continued their retreat Eastward in a direction different from their resources.

Strength Embarked ...	3947
Killed	1000
Prisoners	360
Engaged	5307

Exclusive of 1,071 (according to the French Embarkation Return) of sick in Hospital, of Artillery Men and of Officers.

The immediate result of this success of the 50th, including the assistance derived from the Artillery during the advance of the Enemy, and from the 20th Dragoons in their retreat was 1000 Killed, 360 Prisoners and 6 Pieces of Cannon—the Regt. not mustering at the time 900 Men in the Field, the Enemys Column upwards of 5000. Genl. Anstruther's Brigade on the right having been too fully occupied with the attack of Kellerman's reserve to be able to take any steps whatever in the immediate support of the 50th and that it may not be imagined the numbers of the Enemy are here merely stated at hazard, a Copy* of the order of Battle found on a French Colonel killed in action, countersigned by Charlot one of the Brigadiers of this Division, and afterwards acknowledged by him personally, will accompany this Statement, on which it is only necessary to remark, that from his information, and that of General Loison, the subsequent change of Regts. mentioned in the Margin took place early in the morning of the Action. When this Paper is compared with the Embarkation Return† of the Enemy, given in after the Convention, where independant of the Sick in Hospital among which must have been *many* wounded and after all the loss of killed and Prisoners, the strength of the Regts. engaged under Loison remained at 3,947, their numbers in action cannot be said to have been over-rated.

Sir Arthur Wellesley having been occupied with the left Wing of the

* The original of this has been since lost in the plunder of M.G. Sir G. W.'s baggage at Badajos; but a Copy with the changes therein is still in his possession and another original order in the possession of Genl. Fane.

† To be found in the Office of the Secretary of State with the Signature of the Chief of the French Staff. Original Copy lost also at Badajos.

Army during this operation, and separated by a Ravine and woods from the position of the 50th, was not made acquainted with the particulars here detailed at the time his Dispatches were written, having then only learnt generally what he therein states, "that the Enemy were checked and driven back only by the Bayonets of that Corps" but having afterwards heard the whole from General Loison himself (who particularly requested to be made acquainted with Col. Walker) he did him the honor to send for him and express his regret at not having received earlier information, but assured him that he would not fail to make His M. Ministers fully acquainted with the facts; which he afterwards learnt from Lord Castlereagh had been done. The circumstances however though never officially before the public, are so well known to the whole of the Army that full proof of the correctness of this narrative must at all times be easy. M.-Genl. Fane however who then Commanded the advanced Guard is still in England. This Officer saw the whole and can be confidently referred to, or should more be required there can be no difficulty in referring to Marquis Wellington himself where confirmation is certain.

(Signed) G. T. WALKER,
M.-Genl.

WINDSOR, *October 17th*, 1812.

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(2). *Letter from Lieut.-Colonel W. Robe, R.A., to Sir J. T. Jones.*

SHOOTER'S HILL, 18 *June*, 1818.

MY DEAR JONES,

I have with much pleasure read your account of the War in Spain, Portugal, &c., and I am desirous of some alteration or explanation of the statement in the appendix G relating to the manœuvre of discomfiting Columns of attack by Troops in line; because it appears to me that should the statement be left as it now is, in a work of military history; and should it be in future acted upon against great disparity of numbers, it might be productive of very fatal consequences.—The effect produced by the arm under my charge having been mentioned renders it incumbent on me to furnish you with every information in my power, and in so doing I trust I shall not be supposed to intend, in the slightest degree, to derogate from the merit due to the brave and noble conduct of the 50 Regt. or its commander on that day, as it is with unfeigned pleasure I inform you, that from Colonel (now Maj.-Genl. Sir George) Walker and that Regt. I received support and co-operation which I shall remember and be proud to acknowledge while I live.

It would appear by the appendix G that the 50 Regt. under Col. Walker, and three Guns under my orders were the only Troops posted to oppose the advancing French Column, now the fact was that the advanced guard of Sir Arthur Wellesley's army consisting of the 5 Battn. 60th (four Companies) and 2 Battn. 95th (five Companies) Light Troops and the 50 Regt. with a half Brigade of Light 6 Prs. were under Brigr.-Genl. (now L.-Genl. Sir Henry) Fanes orders posted on a rising ground covering the village of Vimieiro, and forming the right of the Army; the two Light Battns. being in advance in some enclosed ground, leaving the 50th supporting the Guns, to which two 9 Prs. of the Reserve had been added in the previous disposition; and the 7th Brigade consisting of the 2nd Battns. of 9th, 43d and 52d under Brigr.-Genl. Anstruther formed in the morning on the right of Genl. Fane, their flank being covered by the 20 Light Dragoons and some Portuguese Cavalry.

The Light Troops of Genl. Fane were engaged with those of the Enemy and retired before superior numbers, and the artillery having opened on the debouche of the Column I went to the spot, when Genl. Fane directed me to bring up what remained of the Reserve viz. one 9 Pr. and one Heavy Howitzer, these were placed by me at the junction of the roads below the knoll and bearing on the Column and the Cavalry of the Enemy. They remained so posted until the inequality of ground hid the advancing column from them, at which time Genl. Fane and Col. Walker came near and remarked to me that the Guns would be in danger; I replyed I was aware of it, and if the Genl. would permit the 50th to show itself they should be taken up the knoll: this was instantly acquiesced in, Col. Walker effectually shewed the support, and the Guns were placed, and opened with the others, every shot from seven pieces of Ordnance passing into and through the Column, and you will know the effect when I mention to you that the point at which the column halted, apparently to deploy, but from whence confusion began, was little more than one hundred yards from the Guns.—The instant was seized.—The Guns ceased firing:—not because "they could no longer be served" for they were on the commanding ground, secure, and in full action; but by Genl. Fanes order to me, that the manœuvre which by his approbation Col. Walker with the 50th made might take place, as its execution placed part of the Regt. in the line of fire.—The Manœuvre was gallantly executed and its effect on the column complete. The French Cavalry formed to support their flying Infantry and received some Shot from the Guns and the Troops on the right, but were immediately in their turn charged by the 20 Lt. Dragoons and a few Portuguese Cavalry under Col. Taylor and driven in confusion through the remains of their Infantry Column.

You will perceive that it is by no means meant to assert that the Artillery alone routed the Column which attacked the right of the

British Army on the day of Vimieiro; but that the natural effect of Seven Pieces of Ordnance well served, upon a column of 5,000 Men within so short a distance was, so to shake that Column, as, together with the appearance of the other Troops ready to act, to enable a gallant Regiment of 900 to make the charge producing the effect described, and which effect was rendered complete by the subsequent charge of Cavalry: And the conclusion which I draw therefrom is, that without such preparation and support it would have been impossible in the instance quoted to have produced any such effect, and might in any future case, lead to fatal error, if a small body of *One* thousand should of itself attempt by disposition or manœuvre to discomfit a Column of *5000* under a front equal to half its own.

To render the Column as an instrument of attack efficient, the first revolutionary French, and afterward Buonaparte, appear to have followed the tactique of Guibert and to have used artillery on all occasions in large Masses, aptly styled "Tete de Marteau" to throw into confusion the part of a line they wished to penetrate and turn; and while the artillery of the opposing armies were little moveable, or frittered away in Battalion Guns the attack by Column was fully successful: But the Column is in itself most defective when Masses of artillery can be brought to bear upon it.—The example of Talavera you have already quoted, and could furnish other examples from the operations you have witnessed, and you well know that in latter instances it was the means by which Buonaparte most frequently attacked the Column.

Though I have thought it right to give you the foregoing statement, I perfectly agree in the conclusion you draw respecting the defectiveness of the heavy close Column for the purpose of attack; and in its being unworthy of the celebrity some time attached to it.—And the result of that part of the day of Vimieiro appears to me to be most satisfactory in a military point of view when taken as an example of what can be effected even by small bodies of determined Troops of different arms, when acting by combined movements under a skilfull leader, and Genl. Officers in whom they have confidence.

The French public dispatch having asserted that the knoll at Vimieiro was found unattackable from entrenchments; It is right for me to say, that no spade had entered the ground except the two with each gun, to level the spot on which it stood; but the general Instruction of the late Lt.-Genl. Sir W. Congreve was strictly attended to, by keeping so much of the knoll in front as, without lessening the effect would in some measure cover both Guns and men; and to this I attribute the smallness of the loss sustained by the artillery on that spot.

Excuse the length of this and believe me ever truly yours

W. ROBE.

(3). *Lord Wellington's Memorandum and Instructions for the Construction of the Lines of Torres Vedras.*

MEMORANDUM, OCTOBER 20TH, 1809, LISBON.*

In considering the relative state of the strength and efficiency of the allied and French armies in the Peninsula, it does not appear probable that the Enemy have it in their Power to make an attack upon Portugal.

They must wait for their Re-inforcements and as the arrival of them may be expected it remains to be considered what Plan of defence shall be adopted for this Country.

The great object in Portugal is the possession of Lisbon and the Tagus and all our measures must be directed to that object. There is another also connected with that first object which we must likewise attend—viz' the embarkation of the British troops in case of a Reverse.

In whatever season the Enemy may enter Portugal, he will probably make his attack by two distinct Lines—the one north and the other south of the Tagus, and the System of defence to be adopted must be founded upon this general basis.

In the winter Season the River Tagus will be full, and will be a barrier to the Enemy's Enterprizes with his left attack not very difficult to be secured. In the summer season however the Tagus being fordable in many places between Abrantes and Salvatierra and even lower than Salvatierra care must be taken that the Enemy does not by his attack directed from the South of the Tagus and by the passage of that River cut off from Lisbon the British Army engaged in operations to the Northward of the Tagus. The object of the Allies should be to oblige the Enemy as much as possible to make his attack with concentrated Corps. They should stand in every position which the Country could afford such a length of time as would enable the People of the Country to evacuate the Towns and Villages, carrying with them or destroying all Articles of provisions and Carriages not necessary for the Allied Army—each Corps taking care to preserve its communication with the others and its relative distance from the point of Junction.

In whatever Season the Enemy's attack may be made, the whole Allied Army after providing for the Garrisons of Elvas, Almeida, Abrantes and Valença, should be divided into three Corps, to be posted as follows:—One Corps to be in the Beira; one Corps to be in the Alemtejo; and the third consisting of the Lusitanian Legion, 8 Battalions of Chasseurs, one of Militia in the Mountains of Castello Branco.

In the winter the Corps in the Beira should consist of Two-thirds of the whole number of the operating army. In the Summer the Corps in the Beira and in Alemtejo should be nearly of equal numbers.

I will point out in another Memorandum the Plan of Operations

* The orthography is as written in the manuscript.

to be adopted by the Corps North and South of the Tagus in the Winter Months.

In the Summer it is probable as I have before stated that he will make his attack in two principal Corps and that he will also push on through the Mountains between Castello Branco and Abrantes. His object will be by means of his Corps south of the Tagus to turn the Positions which might be taken in his front on the north of that River, to cut off from Lisbon the Corps opposed to him and to destroy it by an attack in front and rear at the same time. This can be avoided only by the retreat of the right centre and left of the Allies and their Junction at a point at which from the State of the River they cannot be turned by the passage of Tagus by the Enemy's left.

The first point of defence which presents itself below that at which the Tagus ceases to be fordable, is the River of Castenheira; and here the army should be posted as follows:—Ten thousand allies including all the Cavalry, in the Plain between the Tagus and the hills—5,000 Infantry on the hill to the left of the Plain; and the remainder of the army, with the exception of the following detachments, on the height in front and on the right of Cadafoes.

In order to prevent the Enemy from turning by their left the Positions which the Allies may take up for the Defence of the high Road to Lisbon by the Tagus, Torres Vedras should be occupied by a Corps of 5,000 men; the height in the rear of Sobral de Monte Agraça by 4,000 men, and Arruda by 2,000 men.

There should be a small Corps on the height E. by S. of the heights of Sobral to prevent the Enemy from marching from Sobral to Arruda, and there should be another small Corps on the heights between Sobral and Bucellas.

In case the Enemy should succeed in forcing this Corps at Torres Vedras or Sobral de Monte Agraça or Arruda. If the first, it must fall back gradually to Cabeça de Montachique, occupying any defensible point on this Road. If the second, it must fall back upon Bucellas; destroying the Road over the height of ——. If the third it must fall back upon Alhandra, disputing this Road, particularly at a point one league in front of that town.

In case any one of these three positions should be forced, the Army must fall back from its position as before pointed out, and must occupy one as follows—

5,000 men principally light Infantry, on the hill behind Alhandra; the main body of the Army on the Sierra of Servas with its right on that part of the Sierra which is near the Casal de Portella, and is immediately above the Road which crosses the Serra from Bucellas to Alverca; and its left extending to the Pass of Bucellas. The Entrance of the pass of Bucellas to be occupied by the troops retired from Sobral de Monte Agracia and the Cabeca de Montachique by the Corps retired from Torres Vedras.

In order to strengthen the several Positions it is necessary that different works should be constructed immediately and that arrangements and preparations should be made for the Construction of others.

Accordingly I beg Colonel Fletcher as soon as possible to renew the several Positions.

1. He will examine particularly the effect of damming up the mouth of the Cartanhaira River, how far it will render the river a Barrier and what extent it will fill.

2ndly. He will calculate the labour required for that Work and the time it will take, as well as the means of destroying the Bridge over the River and of Constructing such Redoubts as might be necessary on the Plain, and on the Hill on the left of the Road, effectually to defend the Plain. He will state particularly what means should be prepared for these Works.

He will also consider of the means and time required and the effect which might be produced by Scarping the banks of the River.

3rdly. He will make the same Calculations for the works to be Executed on the Hill in front and on the right of Cadafoes; particularly on the left of that Hill to shut the entry of the Valley of Cadafoes.

4thly. He will examine and report upon the means of making a good road of Communication from the plain across the Hills with the Valley of Cadafoes, and the left of the proposed Position, and Calculate the time and Labour it will take.

5thly. He will examine the Road from Otta by Abrigola, Lebougeira to Merciana, and thence to Torres Vedras; and also from Merciana to Sobral de Montegaçia.

He will also examine and report upon the Roads from Alenquer to Sobral de Montegaçia.

6thly. He will entrench a Post at Torres Vedras for 5,000 men. He will examine the Road from Torres Vedras to Cabeca de Montachique; and fix upon the spots at which to break it up might stop or delay the Enemy, and if there should be advantageous ground at such spots he will entrench a Position for 400 Men to cover the retreat of the Corps from Torres Vedras.

7thly. He will examine the Position of Cabeca de Montachique, and determine upon its line of defence, and upon the Works to be constructed for its defence by a Corps of 5,000, of which he will estimate the time and Labour.

8thly. He will entrench a Position for 4,000 on the two heights which command the Road from Sobral de Montegaçia to Bucellas.

He will entrench a Position for 400 men on the height of St. Ajuda between Sobral and Bucellas to cover the Retreat of the Corps from Sobral to Bucellas; and he will Calculate the means and the time it will take to destroy the Road at that spot.

9thly. He will construct a Redoubt for 200 men and three guns at

the Windmill on the height bearing E. by S., and E.S.E. from the height of Sobral de Montegaçia; which guns will bear upon the Road from Sobral to Aruda.

10. He will ascertain the points at which and the means by which the Road from Sobral to Aruda can be destroyed.

11*thly*. He will ascertain the time and labour required to entrench a Position which he will fix upon for 2,000 men to defend the Road coming out of Aruda towards Villa Franca and Alhandra.

12*thly*. He will fix upon the spots at which the Road from Aruda to Alhandra can be destroyed with advantage.

13*thly*. He will construct a Redoubt on the Hill which Commands the Road from Aruda, about one league in front of Alhandra.

14*thly*. He will examine the little rivers at Alhandra and see whether by damming them up at the mouths he could increase the difficulties of a Passage by that place—and he will ascertain the time and Labour and means which this Work will require.

15*thly*. He will fix upon the Spots and ascertain the time and Labour required to construct redoubts on the hill of Alhandra on the right and prevent the passage of the Enemy by the High Road—and on the left and in the rear to prevent by their fire the occupation of the Mountains towards Alverca.

16. He will determine upon the Works to be Constructed on the Right of the Position upon the Serra de Serves as above pointed out to prevent the Enemy from forcing that point, and he will calculate the means and the time required to execute them. He will likewise examine the pass of Bucellas, and fix upon the Works to be constructed for its defence and calculate the means, time and Labour required for their execution.

17*th*. He will calculate the means, time and Labour required to construct a work upon the Hill on which a Windmill stands at the Southern Entrance of the Pass of Bucellas.

18*th*. He will fix upon the Spots on which Signal Posts can be erected upon these Hills to Communicate from one of the Positions to the other.

19*th*. It is very desirable that we should have an Accurate Plan of this ground.

20*thly*. Examine the Island in the River opposite Alhandra, and fix upon the spot, and Calculate the means and time required to construct Batteries upon it, and play upon the approach to Alhandra.

21*stly*. Examine the effect of daming up the River which runs by Loures; and Calculate the time and means required to break the Bridge at Loures.

THE REPORT OF THE ROYAL COMMISSION ON COAST EROSION.

By COLONEL W. PITT, LATE R.E.

THE Royal Commission on Coast Erosion has recently issued its Report. This is a very interesting publication which should be in the hands of every R.E. officer who is responsible for the maintenance of the foreshore of War Department property. It can be obtained from Messrs. Wyman & Sons, 109, Fetter Lane, E.C., for the small sum of 3s. 5d. including postage.

The Report is divided into parts dealing respectively with the following subjects :—Physiographical and Geological Considerations, Extent of Erosion and Accretion in recent years, Engineering (Sea Protection Works), Administration, Reclamation of Tidal Lands, and Grants from Public Funds. It is signed by the whole of the members of the Commission subject to reservations on certain points, appended by four of them.

It is proposed in the following notes to give a brief review of the Report and recommendations under each of the heads mentioned above, and to deal somewhat more fully with that part relating to engineering questions, as this is what especially bears upon the protection of the foreshore.

I contributed a paper on "Coast Erosion and its Prevention" to the June issue of the *R.E. Journal*, 1908. The facts and opinions therein put forward are in close agreement with those to be found in the Report of the Royal Commission.

Part I. of the Report opens with a consideration of the recent changes of level of land and sea, using the term recent in its geological sense. The raised beaches found in many places and submerged forests in others clearly show that such changes have taken place; moreover the sea lochs on the west coast of Scotland and the inlets on the west coast of Ireland are all drowned valleys, similar to the Norwegian fiords but on a smaller scale. There is not sufficient evidence to enable us to say whether movements causing these changes are in progress now or are likely to recur. A brief description is given of the geological conditions affecting the coast and the way in which erosion is caused by weathering of cliffs and the action of the sea. This part of the Report is in agreement with what was stated in my paper in this *Journal* but not being subject to limitations as regards space is naturally fuller. There are, however,

some remarks in para. 42 (1) of the Report which call for comment. It is stated that the supply of beach material derived from the sea bed may be regarded as negligible. As evidence against this opinion may be quoted the great quantities of coal washed up on the north-east coast of England sufficient to make it worth while for people to collect it in baskets and take it home for use. This coal must come from an outcrop in the sea bed, and if coal can be washed up why not shingle and sand? The following is an instance of shingle apparently coming from below low water mark. About two years ago the sea wall in front of the King's Bastion at Portsmouth, extending from the Clarence Pier towards the entrance to the harbour, failed owing to the sea breaking over the top, washing out the filling behind, which had no covering of asphalt, and scouring out the foundations already exposed by denudation of the beach. The wall was repaired and four groynes constructed in front of it on the steep beach. This would seem to be a most unpromising place for the erection of groynes. There can be no travel of shingle from the south because it cannot get round the pier, nor from the north because, although there is plenty on the beach between Forts Monckton and Blockhouse, it cannot get across the mouth of the harbour. Yet beach material has accumulated and the ends of the groynes at the toe of the sea wall are now covered with shingle. This certainly appears to have come from below low water mark, except a small quantity which was replaced by hand from the accumulation drifted up against the pier.

The Commission bring to notice one point which is not referred to in my paper for the sufficient reason that it had not occurred to me. The supply of beach material is derived from erosion of cliffs. This material is subject to the wear and tear of travel, the sand is carried out to sea in solution and the pebbles are worn away gradually by friction. It is obvious therefore that were we able absolutely to check erosion at all points the source of supply would be cut off, and in course of time the beach material would disappear. This is however such a remote contingency that our regard for the interests of posterity need hardly lead us to restrict our protective measures because of it.

After describing the formation of "Accretions" the Report goes on to give in considerable detail an account of the geological features of the entire coast line of England and Wales, Scotland and Ireland. This occupies 16 pages of the Report and need not be referred to here. At the end of Part I. the Commissioners give a number of "conclusions." Two only of these call for notice; one, that "there is no evidence that any changes in the relative levels of land and sea are now in progress except possibly a slight submergence on the coast of Northumberland, in the extreme north of Scotland, and on the south and west of Ireland"; the other that it is important that

artificial structures erected on the shore should not arrest the flow of shingle to the detriment of the shore on their leeward side. This latter point was referred to in my paper.

Part II. of the Report deals with the extent of erosion and accretion in recent years. Investigations into this question can only be carried back with any degree of accuracy for about 60 years owing to the lack of reliable maps of an earlier date. Old maps showing the coast line are frequently very misleading. My paper already referred to was accompanied by a reproduction of a map of Romney Marsh, compiled by Colonel Hickson, D.S.O., showing the coast line at different periods. According to one of the maps consulted by him high water mark in 1736 was half a mile inland of Dymchurch, an obvious impossibility. Old maps should be treated with suspicion unless supported by other evidence.

Colonel Hellard, C.B., late Director-General of the Ordnance Survey, prepared for the Royal Commission a statement of the losses by erosion, and gains by accretion, in the United Kingdom during the last 35 years. It appears that the losses have amounted to 4,692 acres, and the gains to 35,444 acres, making a net gain of 30,752 acres. This last total includes the area of artificial reclamations. Viewed as a financial transaction the balance would possibly be the other way. Land lost by erosion had mostly a fair market value; that gained by reclamation should be valued at the difference between the cost of the necessary works and the price obtainable for the land reclaimed, sometimes a negative quantity. Land gained by natural accretion has very little value until it has been for several years out of reach of the tide, and even then it is sometimes covered with sandhills and is worth nothing except to let for rifle ranges.

Thirty-five pages of Part II. of the Report are devoted to an abstract of a vast amount of evidence giving details of the erosion and accretion in progress round the coast of the whole of the United Kingdom, and the steps taken in each case to protect the foreshore.

Part III. deals with "Engineering (Sea Protection Works)." The opening paragraphs describe the action of tides, waves, and winds in almost the same words as will be found on page 346 of the *R.E. Journal*, June, 1908. The facts of course were well known. There is a statement in para. 8 of this Part which seems open to question. It is said that "offshore winds cause beaches to heap up in the vicinity of high water level" and that inshore winds flatten the slope. This statement is presumably made on evidence given before the Commission but it sounds rather doubtful.

Evidence was taken regarding sea walls, and the relative merits of various profiles, vertical, battered, or curved. The Commission came to the conclusion that a battered face is best but gave no opinion as to whether the face should be smooth or stepped. It is

generally, I believe, considered that a wall should be built in steps with very small treads, in order to break up the backwash.

Sea walls, if successful, protect the feet of cliffs from erosion but in no way prevent them from falling and slipping. As has already been pointed out the loss is usually primarily due to this cause, and it is therefore necessary to slope and drain the cliff to prevent its softening and slipping forward due to the action of land water. This it may be remarked is sometimes a very difficult operation. Reference was made in my previous paper to the new Marine Drive round the Castle Hill at Scarborough. The cliffs at the back of the drive are slipping badly. On the top of the hill is a depression in which are two small ponds. Soakage from these undoubtedly finds its way to the face of the cliffs and, until the ponds are done away with, slipping is bound to go on.

The subject of Groynes is next dealt with but unfortunately it is treated in a rather cursory manner. This is the more to be regretted as there are such extreme divergences of opinion amongst engineers as to the relative merits of high and low, long and short groynes, of timber and concrete for materials, as to the distance apart at which they should be constructed, and whether they should be at right angles to the beach or inclined. Mr. Wheeler, the author of *The Sea Coast*, gave evidence with regard to "Case" groynes. These were strongly advocated by the late Mr. E. Case. The principle of them is that they are of timber, long and low, and raised gradually as the beach makes up. They are described in my earlier paper. Mr. Wheeler said "Case groynes are no use where you want to protect shingle * * * Where there is shingle the groyne must be much stronger and much higher, because shingle will collect 5 or 6 feet on one side, and, of course, the groyne must be sufficiently strong to stand the shingle pushing against it." With the greatest deference to such a high authority as Mr. Wheeler it is submitted that the shingle should not be allowed to collect 5 or 6 feet high against a groyne. The object in view should be to get a beach with regular contours parallel to high water mark, and not a series of zigzags. This can only be attained by making groynes low in the first instance so that the sand or shingle can drift over the top of them and thus raise the whole beach gradually. As the level of the beach rises more boards should be put in until the desired profile is obtained. As I pointed out in my earlier paper there are on the South Coast of England some glaring examples of the evils of high groynes, notably at Eastbourne. Shingle may be seen piled up against timber groynes, 15′ higher on the windward side than the leeward, and to keep up this enormous weight huge timber struts are required. High groynes accumulate in one place more shingle than is required, and keep it away from places where there is a deficiency. However the authorities at Eastbourne appear to realize the mistake made, as the

Borough Surveyor of that town gave evidence before the Commission to the effect that the Corporation had recently been constructing low groynes "leaving the piles sufficiently high to build up the groyne as the beach accumulates." Some witnesses advocated the provision of scupper holes to allow the shingle to drift through, and the Commissioners rather endorsed this recommendation but it seems doubtful whether it would answer.

It is satisfactory to note that the Commission recorded an opinion that in many cases groynes have been constructed unnecessarily high, and consequently injuriously affected the coast to leeward of them, and caused excessive erosion. The perfectly sound principle is laid down that "the most effective groynes are those which produce the least differences, generally, in the beach level, on the windward and leeward sides."

As regards length of groynes it is recommended that they should extend from the shore to the vicinity of low water spring tides, and occasionally even further seaward. The distance apart should generally be about equal to the length.

The witnesses examined differed considerably in their views as to the angle to the shore at which groynes should be constructed. The conclusion arrived at was, that a direction at right angles to the shore or pointing slightly to windward would be most effectual.

There was also a great difference of opinion amongst the witnesses as to the life of groynes. Those of concrete are said to be practically permanent. This seems rather optimistic; it is questionable whether any structure which the sea can get at should be regarded as permanent. Timber groynes of oak, jarrah and softer woods have varying lives dependent not merely on the material of which they are constructed, but to a great extent on local conditions. On the South Coast ferro-concrete is being tried. The objection to this material is that applying to all concrete groynes, viz. that they cannot conveniently be raised as the beach material accumulates.

It was stated that on the east coast timber groynes had been known to last 30 years. On the south coast, where there is more shingle and less sand the life of oak groynes was said to be from 15 to 20 years. This question is one which materially affects Corporations and other similar bodies because at present the local Government Board will only allow 10 years for the repayment of loans for the construction of timber groynes and 20 years where concrete is used.

The Commission took a great deal of evidence as to the cost of groynes. Concrete is of course the most expensive material. At Hastings the cost was about £3 a foot-run, and the upkeep of 64 groynes at the same place averaged over £17 each per annum. At Brighton concrete groynes cost on the east side £4,818 each, and in

the west £3,000 each. The length varied from 255 to 465'. These were however enormous structures 24' high above the chalk foundation and carried up 12' above high water mark.

As regards timber groynes some witnesses gave the total cost without stating the length, a useless piece of information. The Borough Engineer of Eastbourne gave 25s. per foot-run. Other witnesses 26s. 6d. at Sandgate and St. Margaret's, 22s. to 23s. at Dover, and also at Dover £1 to 30s.

In my previous paper I referred to Mr. Wheeler's quotations of 16s. 9½d. *per yard* for low groynes and 19s. 2½d. *per yard* for "Case" groynes. These estimates are far below those given before the Royal Commission, and are probably too low.

The report calls attention to the fact that in many places on the coast the cost of adequate protection by groynes would exceed the value of the land liable to be eroded. This is not a consideration which need as a rule trouble R.E. officers, though there may be exceptional cases where land is not worth protecting, and its loss would not affect defence works.

The "conclusions" given at the end of this part of the Report have mostly been embodied in the foregoing remarks. It is pointed out in addition that it is necessary that there should be some central authority controlling defence works, with power to prevent local authorities from unduly holding up beach material to the detriment of their neighbours.

A Committee of the Commission examined the foreshore defence work in Holland and Belgium and plates are given in the Report illustrating some of them. It was considered however that the circumstances in these countries are so different that these works do not afford examples to be followed.

In Part IV. of their Report the Commissioners consider questions of "Central and Local Administration." The matters dealt with are to a large extent of a legal nature and as is usually the case the more a mere layman studies the questions raised and the evidence given the less it seems possible to arrive at a clear understanding of what the law really is. Take for instance the question of the ownership of "accretions." I defy any owner of land adjoining the foreshore who may have an "accretion" fronting his property to ascertain from what is said in the Report whether he can legally claim the accreted land or not. Should such a case arise with reference to W.D. property I should advise the officer in charge to take steps to get the land brought on his "Property Statement" and set up boundary stones. Any other person claiming it would then have to make out a better case. This is an important matter because if no such steps were taken we might have fishermen's huts built on an accretion and obstructing the fire of a battery or view from a

P.F. cell. When buildings are once erected it is difficult to get rid of them.

The various sections of Part IV. deal with the law relating to the foreshore, the respective powers of Government departments and local authorities, and the changes in the law which appear to be necessary. Space does not admit of more than a few brief references to this portion of the Report which moreover, though of considerable interest, does not much concern officers who have charge of W.D. property with a sea frontage.

The first point brought to notice is that the word "foreshore" has different meanings in England, Scotland, and Ireland. In England the Courts have decided that the landward limit of the foreshore is high water mark at medium tides, no seaward limit being defined. It has never been decided whether this is applicable to Ireland so that the foreshore is there an unknown quantity legally. In Scotland it extends from high water mark at ordinary spring tides to low water mark of the same tides. Primarily the foreshore is the property of the Crown; part is under the charge of H.M.'s Commissioners of Woods and Forests and part under the Board of Trade, but a great deal of it has been permanently alienated. In many cases the War Office has had to pay to private owners preposterous sums for the right to fire over the foreshore in front of batteries. In England and Ireland the only rights vested in the public are those of navigation and fishing. There is no right of way at low water. In Scotland there appears to be a right of way.

The Board of Trade exercises jurisdiction over the foreshore as regards navigation and its consent is required to the construction of any groynes, piers, or similar works, which may affect navigation. It is not clear that the Board can interfere where the foreshore is not Crown property, but however that may be the War Office invariably asks for the Board's authority to construct groynes even where the foreshore has been acquired. By Act of Parliament the Board of Trade can issue an order prohibiting the removal of stone, shingle, etc., from the foreshore anywhere in the United Kingdom.

Many pages of the Report are devoted to a detailed account of the local authorities "having powers and duties in relation to the regulation of the foreshore or to sea defence." They are Commissioners of Sewers, Drainage Boards, Harbour Authorities, County and Borough Councils, Urban and Rural District Councils, etc., etc. Their name is legion, and their powers and duties as varied as it is possible for them to be. I referred briefly to this subject in my paper in this *Journal* for June, 1908, and do not propose to say any more about it here beyond remarking that there are large stretches of dangerous foreshore for which no one is responsible but the adjacent owner. This gentleman may neglect his sea wall and imperil hundreds of acres of his neighbour's property with impunity. I quoted a flagrant

instance of this close to Dymchurch Redoubt near Hythe. The "Recommendations" of the Commission are lengthy, but some of the more important may be mentioned. It is proposed that all Crown foreshores should be controlled by the Board of Trade; and that a right of way over all foreshores should be granted to the public. As regards sea defence it is recommended that the Board of Trade should be constituted the "Central Sea Defence Authority" for the United Kingdom, with the necessary powers of control over existing local authorities, and with power to create new authorities where required. The working out of this scheme is given in the Report in considerable detail. It is also recommended that it should be made illegal to remove any material from the foreshore without the consent of the Board of Trade.

In Part V. of the Report consideration is given to the Reclamation of Tidal Lands. It is pointed out that reclamations are of two kinds, viz. those undertaken for commercial purposes such as making docks, etc., and those carried out with a view to obtaining agricultural land. In the first case a large expenditure on the necessary works is usually justified by the results to be obtained. Where however the object in view is the reclamation of land for agricultural purposes the cost to be incurred is a matter for very careful consideration, and the operation is to a large extent of a speculative nature. The value of agricultural land has for some years been on the down grade and there is every indication that the decline will be progressive. It is indeed highly questionable whether there is any land which could be reclaimed at a cost which would not exceed the value of the acreage gained.

The estimated cost of reclamations as put before the Commission by different witnesses varied remarkably. A farmer from Fingringhoe, near Colchester, said that 600 acres could be reclaimed in his parish for £2,500. On the other hand works in Morecambe Bay necessary to reclaim from 400 to 500 acres were estimated at £1,500,000. It should be stated that in the latter case the object in view was primarily to prevent sea water percolating into mines. The scheme has not been carried out. Evidence was given as to many other reclamations proposed in different parts of the country. Few, if any, of them held out an alluring prospect to the cautious investor.

The Commission next proceeded to consider the question of utilizing the labour of the "unemployed." This *Journal* is not concerned with economic problems of this kind and it will therefore suffice to quote the "conclusions" of the Commission.

As regards industrial reclamations the Commissioners were of opinion that these are matters which may safely be left to the Corporations or other bodies proposing to undertake them. In the case of schemes for agricultural reclamations they considered that the

State should facilitate the carrying out of such works with a view to lessening unemployment; but that the evidence tended "to show that such reclamations would not be profitable from a financial point of view." With reference to the "unemployed" the opinion is recorded that the utilization of their labour would increase the cost of the work to be carried out, but that on the other hand it would have the effect of saving men from being supported out of the rates. It is suggested that the Board of Trade should, in conjunction with the Development Commissioners, frame schemes, and that the latter body should advance the necessary funds.

Part VI. deals with the legal question as to whether it is, or is not, the duty of "the Crown to defend the coast of the Kingdom from the inroads of the sea." It was contended by the "National Sea Defence Association" that the responsibility "rests primarily upon the nation at large." The Town Clerk of Lowestoft appeared on behalf of the Association and stated the grounds on which their contention is based, in a lengthy legal argument going back to feudal times.

The solicitor to the Board of Trade presented the opposite view of the case. The opinion of the Commissioners is that they cannot adopt the principle that there is a responsibility for sea defence resting primarily upon the nation at large; and that all they can do is to consider whether there are special reasons from a national point of view which would justify the making of grants from public funds in aid of defence works. Their conclusion is that there is no justification for such a course.

The Report is signed by the whole of the Commissioners, but subject to certain reservations on the part of four of their number.

One member has appended a lengthy statement on the question of the liability of the Crown to protect the realm from the sea, and contends that this obligation is imposed on the Sovereign by his Coronation oath, and has been so imposed ever since the Magna Charta of Henry III. This member records his opinion that the Sovereign is just as much bound to protect his dominions from the inroads of the sea as from invasion by an enemy, and that consequently sea defence is a national service and should receive national aid.

Two members have signed a "reservation" disagreeing with the recommendation made in Part IV. that it should be illegal to remove material from the foreshore without the consent of the Board of Trade. This they consider too drastic a measure.

The third "reservation" does not take exception to anything in the Report but advocates legislative action regarding the definition of the term "foreshore" so far as Ireland is concerned with a view to the adoption of the limits in force in Scotland. This Commissioner would like to see the same course adopted as regards England and Wales but admits that the legal obstacles are insuperable. In Ireland

there has never been any decision by the Courts and consequently there is nothing to upset.

I took up the Report of this Royal Commission with much curiosity as to whether it would be necessary for me to modify any of the statements of fact, or opinions, or recommendations, put forward in my paper written three years ago. Having carefully studied the Report I do not see that it is in conflict with anything in my paper but on the contrary it supports all that I said. The only alteration I might feel disposed to make is one touching the cost of timber groynes. Reference is made above to Mr. Wheeler's estimates quoted in my original paper. These seem to be too low, but I recommended that in all cases detailed estimates should be prepared as the only reliable means of arriving at the cost of a groyne.

ECHOES FROM THE ENGINE ROOM.

(Continued).

By "INSPECTOR."

ECHO NO. 12.

FLYWHEEL *v.* NON-FLYWHEEL PUMPS.

In connection with some correspondence regarding pumping machinery with one of the leading British firms manufacturing such plant "Inspector" received a letter containing the following paragraphs :—

"You will notice that we have proposed to use Rotative Engines, *i.e.*, engines provided with flywheels, in every case. There is no doubt that where water is within suction distance pumping engines of this class are the best.

"Because 1. The flywheel contains a store of energy, so that the engine will finish up the stroke even after the steam has been cut off, so that the steam can be used expansively and therefore economically."

"Because 2. The flywheel engine fitted with a crankshaft and connecting rod makes a constant stroke irrespective of the care of the attendant, and therefore, the losses through clearance, while always less than with a Non-Rotative engine, such as a "Worthington" or one of our own Differentials, are constant, and are not liable to be increased through short stroking, which almost always takes place at times with non-rotative engines."

"Because 3. The flywheel engine is on the whole safer than the non-rotative type, since there is no liability to strike the covers in the event of a burst pipe causing loss of head."

These remarks are of great interest, and their value is the greater since they emanate from a firm who have done most of their business in "Straight Line" pumps.

The majority of the pumping plants visited by the writer in his *rôle* of inspector are of the "Worthington" type. In nearly all these plants short stroking is the rule under ordinary working conditions,

and a similar state of affairs has been observed in the case of other Worthington pumping engines visited. A reason for this may be assigned. Short stroking tends to safety, as the chances of the moving parts striking the end covers is thereby lessened. Speaking from personal experience it is found that if the pump is made to run at full stroke it will under ordinary circumstances shortly do one of two things. If the boiler pressure rises, even but a little, (an increase of 5 lb. on 100 lb. will suffice), the pump will begin to strike the end covers; if the boiler pressure falls the pump will run at a shorter stroke. With a flywheel pump the corresponding changes would be either an increased or diminished speed, but the length of stroke would remain constant. Now even under test conditions, when the supervision is more strict than can be economically provided in every-day work, it is not easy to keep the boiler pressure quite steady with any but first-class firemen, nor is it practicable to always keep a man on the engine stop valve. Hence there is some excuse for the ordinary attendant to run his straight line pumping engine somewhat below its full rated stroke. If the pumps are in good condition it has been found practicable during inspection tests of some hours duration, to run Worthington pumps even somewhat above their full rated stroke, and it is under such conditions alone that the most economical results in steam consumption are obtained. However for the reasons above stated, it would seem that the flywheel pump is more likely to live up to its guaranteed behaviour than is the "Straight Line" pump, in everyday work.

Since the length of stroke in a "Straight Line" pump is subject to alteration due to variation in steam pressure, this alteration will also occur if the load on the pump varies. If the load is increased above normal by undue friction (caused for instance by screwing down the piston and pump rod glands too tight) the efficiency will fall whether the pumping engine is of the flywheel or non-flywheel type, but in the latter case the length of stroke will also be reduced, and this tends to a still further loss of efficiency in consequence of the increased clearances in the steam cylinders. It should, however, be remarked that although the tendency to variation in the length of stroke is an inherent characteristic of the non-flywheel type, the actual offence *can* be prevented by attention to steam pressure, and by controlling the steam stop valve and the cushioning valves on the engine, or, in other words, by careful attendance. In large plants, working long hours, where it is justifiable to employ a highly skilled staff such attention can be reasonably looked for. Under those circumstances the straight line type is far more likely to, and does, hold its own as an economical performer.

The following extract from the '91 edition of Tangye's catalogue of pumping machinery has also a bearing upon this question :—

"It may be worth while to explain why the principle of expanding steam cannot be used in ordinary direct[9] acting pumps to the same extent and with the economical results obtained with rotative engines. In pumping, the load of resistance is practically constant. In an ordinary direct acting pump, steam is admitted to the cylinder during almost the entire stroke, the driving force is thus also constant, and the pump works satisfactorily. Immediately an attempt is made to work expansively, the driving force is either excessive at the beginning of the stroke, sending the piston forward violently in a manner quite unsuited for pumping, or if the force is right at the beginning of the stroke it is too weak towards the end, the pump fails to complete its stroke and stops, or short stroking results; neither defect can be tolerated, and expansion must be sacrificed to certainty of action."

Compromise is necessary in many engineering schemes; having therefore formulated a case *against* the "Straight Line" type of pumping engine let us see if there is nothing to be said on the other side. Another extract may be taken from the letter already referred to :—

"Where water is to be pumped from deep wells or boreholes the first function of the flywheel, that of providing a store of energy, is performed by the weight of the rods, and steam can be used expansively without the use of a flywheel."

Now it is not to be supposed that steam is not used expansively in a straight line pumping engine. In a single cylinder engine of that type the amount of expansion is negligible, or at the best, very small. But in compound, and triple expansion engines the amount of expansion made use of is considerable even if the full pressure of steam is carried for nearly the whole of the stroke in the H.P. cylinder, and in triple expansion engines may amount to about 11 expansions by volume, depending on the ratio of the various cylinders, and on the point of cut off in the H.P. cylinder.

In a flywheel engine the rotation of the flywheel calls for a certain amount of power, or in other words the flywheel does not give back all the energy put into it. In the straight line pumping engine there is no "waste" of this kind, and the result is that the mechanical efficiency is higher than with the flywheel type, amounting to as much as 94 per cent. or more even in engines of 80 P.H.P. The mechanical efficiency of the large 400 P.H.P. flywheel pumping engines supplied for the Rand Water Board is given in the published reports as a trifle over 92 per cent., based upon the water actually pumped.

As regards ease of transport the advantage probably lies with the

[9] This term here means what are defined as "Straight Line" pumps in these notes.

straight line type; this is so in the case of Worthington pumping engines as these are invariably made duplex, as has been already mentioned, and the consequence is the weight of the individual parts is less. There is moreover no relatively heavy flywheel or crankshaft to be dealt with.

Similarly as regards erection. The parts to be handled are smaller and lighter in the case of duplex pumps and no greater in other cases, and it is hard to imagine anything less difficult in the way of erection than the putting together of a straight line pumping engine.

In the case of borehole pumps (*vide* Echo No. 8) where a long stroke (*i.e.* long compared to the diameter of the bucket) is required, and there are in addition other factors to be considered, *e.g.* pausing at end of stroke, the straight line pumping engine has undoubted advantages. But just as there are many ordinary cases where straight line pumps have been installed for some reason in preference to flywheel engines, so also there are many instances of borehole pumps operated by engines of the latter type.

It is difficult to generalize as regards cost. Although manufacturers work to standard sizes, pumping engines, proper, as opposed to "Trade" pumps, are not made for stock. On the contrary, every order is a special one unless the requirement can be met either by a trade pattern or by assembly of stock parts. In the case of a duplex pump it must be remembered that this means duplication of all the principal parts, and this probably means a relatively high price. On the other hand if a "simplex" (as opposed to duplex) pump will meet the requirements of the case, a "Straight Line" pump will almost certainly be cheaper in first cost than a flywheel pump for the same duty.

In so far as a personal expression of opinion is permissible the writer has a decided preference for pumping engines of the flywheel type for all ordinary requirements, especially so where skilled supervision is costly, and when the size of the plant does not justify the employment of an expensive staff. In justice to the "Straight Line" type it should be stated that the many plants of this type already referred to have been in operation for several years, without, so far as is known, anything approaching a serious disablement, except in the case of one of the largest pumping engines which developed a cracked water end. (Reason not known; possibly water hammer set up in the long rising main by improper manipulation of valves. Probably nothing to do with the type of pumping engine). Nevertheless it does not follow from this that flywheel engines would not have given equally satisfactory service, and it is contended that they would have been more economical in steam (and fuel) consumption; no more costly in maintenance; and probably less expensive in the first instance (*i.e.* less costly than duplex "Straight Line" pumps).

Echo No. 13.

WORTHINGTON PUMPS.

Although straight line pumps have already been mentioned and Worthington pumps have been referred to in general terms, the latter pumps call for some additional remarks.

The combination of duplex straight line pump in which the valve motion on one side is operated by the pump motion on the other side is believed to be due to H. R. Worthington. Be that as it may, pumps acting in that manner are often colloquially known as "Worthington" pumps although such pumps are nowadays made by many different firms. The most generally known form of "Worthington" pump is the ordinary duplex pump used for boiler feeding. The smaller sizes of such pumps are made with only one cylinder on each side and they are exceedingly simple in construction. In the larger sizes each side of the pump is made compound and is generally arranged with the L.P. cylinders nearest to the water end and the H.P. cylinders at the "back."

The next development was introduced in connection with pumping engines for water supply purposes and consisted in making each side of the pump triple expansion, the L.P. cylinders being still placed nearest to the water end and the H.P. cylinders at the "back."

This arrangement of steam cylinders was reversed in later designs in order, presumably, to simplify the working of the expansion valves referred to below.

All the foregoing pumps were fitted with D valves, but the triple expansion pumps were in addition provided with a Meyer expansion valve upon the back of each H.P. valve, the expansion valve on each side being operated directly off the piston rod on its own side.

In the double cylinder pumps (*i.e.* one cylinder on each side) the valve face has five ports viz. a central exhaust port and two other ports on each side of the centre. In the compound pumps the H.P. cylinders have only three ports in the valve face, but the valve faces in the L.P. cylinders are as above described. Similarly in the triple expansion pumps the L.P. cylinders have five ports in the valve faces but the valve faces of the I.P. and H.P. cylinders have only three ports. Further, in both the compound and triple expansion pumps the L.P. cylinders are fitted out with "cushioning" valves for controlling (to some extent) the length of stroke, and such valves are sometimes fitted in single cylinder straight line pumps.

Of the five ports above referred to the two outermost ports are connected by passages to the extreme ends of the cylinder and serve as steam supply ports only; dependent upon the position of the valve

they are either covered by the valve or are open to steam; they never are, and cannot be, connected to the exhaust.

Of the other three ports the centre one is the exhaust port simply, and the two inner ports on either side of it are alternately connected to exhaust by the agency of the valve. They are either in the position of being connected to exhaust or covered by the valve; they never are and cannot be connected to steam. The passages connecting these two ports to the cylinder enter it at some little distance from the ends so that they are alternately closed by the piston before it reaches the end of its stroke. Considering one cylinder only it will be clear that when the piston starts on its forward stroke its valve will be right forward. In that position the outermost forward port will be covered by the valve, the other forward port will be connected by the valve to the exhaust port, the outermost back steam port will be open to steam, and the other back port will be closed by the valve; the valve remains in that position until the piston almost reaches the end of its stroke; in so doing, the piston closes the only passage by which the steam can escape from the forward end of the cylinder and a certain quantity of steam is thereby trapped in that end of the cylinder to serve as a cushion to arrest the motion of the piston.

Mention has however been made of cushioning valves. When such valves are fitted the two steam passages, referred to above, at each end of the cylinder are, respectively, connected together by a passage which is controlled by a screw down valve. Under the conditions above described it has been assumed that this valve was shut. If, however, the valve had been open the trapped steam would have been able to escape *viâ* the outer passage, through the connecting passage and so *viâ* the inner passage to exhaust. Under those circumstances the cushioning effect would be eliminated, and under certain conditions the piston would hit the end of the cylinder. The valves controlling the connecting passages described are called "cushioning valves" for sufficiently obvious reasons. By their judicious manipulation the piston may, on the one hand, be prevented from hitting the ends of the cylinder and, on the other hand the cushioning may be so controlled that the pump is enabled to make a full stroke. This matter has been dealt with at some length because this arrangement of steam control is common to all duplex straight line pumps, and moreover it appears that the use of the cushioning valves is often but little understood. The description will, it is hoped, be intelligible if a sectional drawing of a Worthington pump is referred to such as appears in a Worthington pump catalogue or in *Plate* XII. of the *Water Supply Manual* published by the War Office in 1909.

In every steam engine the internal length of the cylinder must be

somewhat longer than the actual stroke of the piston. The excess of cylinder length over piston stroke should, generally speaking, be equally distributed at each end of the cylinder, and it will be convenient to call the excess at each end the "clearance length." In a flywheel engine the travel of the piston is definitely controlled by the throw of the crank, so that it is possible to make the clearance length quite small. It may be as small as $\frac{1}{8}$" for a piston stroke of 12". On the other hand in a straight line pump the internal length of the cylinder must be appreciably greater than the rated stroke of the piston, and a clearance length of $\frac{1}{4}$" for a rated stroke of 10" is quite usual. In other words the maximum possible stroke in such a pump—called the "contact stroke"—would be $10\frac{1}{2}$", whereas in actual working the travel of the piston would probably be somewhat less than 10". From this it will be clear why the clearance volume at each end of the stroke in a straight line pump is greater than in a flywheel pump. Further, although a flywheel pump may work stiffly and uneconomically due to a variety of causes, *e.g.* badly packed glands, the clearance volume is not altered. Similar causes in a straight line duplex pump will emphasize the want of economy in working by curtailing the length of stroke on each side and thereby increasing the clearance volume.

Most people who have to do with steam engines seem to know more or less how to set an ordinary D-valve operated by an eccentric. But although the setting of the valves of a Worthington pump of the type already referred to is a simpler matter, it does not appear to be equally well known to those who use such pumps. In these pumps there is always more or less "lost motion" in the valve work, and as the pins and other points of connection get worn the lost motion increases. The tendency of this increase is to lengthen the stroke of the pump, but provided this tendency does not become excessive, the slackness of the joints may be ignored until it is convenient to overhaul the pump. By "lost motion" is here meant the distance a valve rod can move without moving the valves, or in other words the "backlash" between the valve and the thing that moves it. The procedure for setting the valves is described in the general catalogue of the Worthington Pump Co. Briefly the method is as follows:—Place each piston in the middle of its contact stroke. Set each valve in its central position on its seating—in this position the valve will just cover the outer ports since these valves have no outside lap. Adjust the nut, or nuts, on each valve rod so that the lost motion is equally distributed on each side of each valve. The total lost motion will be about $\frac{3}{8}$" *i.e.* when the setting is correct each valve should have a movement of about $\frac{3}{16}$" on each side of its central position without moving the piston on the opposite side of the pump. If on putting the pump to work (it is assumed to be in good order) the stroke is

found to be too short the lost motion may be increased, and conversely. These instructions apply to single cylinder, compound, and triple expansion pumps with D-valves, but in the case of pumps fitted with cushioning valves it should be remembered that the length of stroke can be controlled by these valves to a considerable extent independently of the lost motion. Also, if expansion valves are fitted the length of stroke can be regulated by their manipulation as well.

In *Plate* XII. of the *Water Supply Manual* already referred to is given a section of a compound Worthington pump. The object of the compensating cylinders illustrated on *Plate* XII. is described in the *Manual* and will not therefore be further referred to in these notes. Such cylinders are only fitted to pumps of large power. The pump illustrated has 5-ported valve faces on both H.P. and L.P. cylinders, and, as shown, the valves have considerable outside lap. The lap may be an error in the reproduction, but as regards the other point it is usual to have the double passages to each end of the L.P. cylinders only. "Inspector" has however come across one station containing two compound duplex Pearn pumps in which both H.P. and L.P. cylinders have the double passages, and each cylinder has also a pair of cushioning valves. This complication seems quite unnecessary.

The next variation to be referred to is the substitution of Corliss type valves for the D-valves in triple expansion Worthington pumping engines. The largest sizes of these pumps have entirely separate valves for steam and exhaust but such pumps do not come within the scope of these notes.

The ordinary D-valve has such well-known merits it may perhaps seem strange why it has been replaced by the Corliss valve. It is not necessary to discuss that point here. The valves in question work in liners forced into the cylinder castings and behave similarly to the corresponding D-valves except as mentioned below. The I.P. liners have three ports but both the H.P. and L.P. liner have five ports, and the L.P. cylinders are fitted with cushioning valves as already described. In place of the Meyer expansion valves, each H.P. cylinder has two entirely separate expansion valves, one for each end of the cylinder. The arrangement is clearly shown in the accompanying plate; this figure has been prepared from a blue print supplied by Messrs. J. Simpson and Co. The ports in the H.P. liners behave in the same way as do the ports in the L.P. liners, but whereas in the latter case the two ports on each side of the centre one are both connected to the L.P. cylinder direct, in the H.P. cylinders only the inner port is connected to its end of the cylinder, each outer port being connected to its corresponding expansion valve, and in this way, although admission and release are both controlled by the

main valve, cut-off is governed by the expansion valves, if they are correctly set.

As regards the L.P. valves the figure is partly diagrammatic. The three ports shown in section, together with the valve covering them, behave exactly as do the corresponding parts in an ordinary D-slide valve, and in this respect the L.P. valve is similar to the I.P. valve. Actually each of the small ports "PP" is in line with the main steam port on its corresponding side and would not appear separately on a cross section through the valve chamber. The valve is so made that these small ports behave similarly to the outermost ports of a 5-ported valve face in the manner already described, *i.e.* each port "P" is either open to steam or covered by the valve, it cannot be connected to exhaust. Hence if the cushioning valves "V" are closed some steam is trapped at each end of the cylinder in turn, on the exhaust stroke, and cushioning occurs. If the valves "V" are open the cushioning effect is more or less eliminated according as the valves are more or less opened. Whether the valves "V" are open or shut steam is admitted to the extreme ends of the cylinder in turn through the corresponding port "P," and, after the piston has moved a little, steam is also then admitted through the other (main) connecting passage at the end of the cylinder affected.

As in the case of the "ordinary" Worthington pump the main valves of one side are operated off the piston rod on the other side of the pump, but the expansion valves are worked by the piston rod on their own side. Each valve is operated by a short arm keyed on to the valve spindle, and each valve has a travel of about 30° to 60° of arc depending upon the amount of lost motion allowed. As regards the expansion valves, when the valve is in the middle of its travel, its arm points upwards and outwards about 15° out of the vertical and cut-off occurs when the arm is inclined outwards at about 30°. The arms of all the other valves should point vertically downwards when the valves are in their central position.

Except as regards the expansion valves the setting of these Corliss valves, is, theoretically, no more difficult than is the setting of the D-valves. It is only necessary to put each side of the pump in the middle of its contact stroke and then to adjust the valve rods so that the valves are central with respect to their ports. There are however difficulties, which, although they need not be detailed here, are nevertheless sufficiently serious to justify a brief description of the procedure which has been found to give good results in practice, more especially so as no reference can be given to any literature dealing with the subject. It is assumed that each cylinder is fitted with indicator cocks, as should certainly be the case in a pump large enough to be built triple expansion.

To set the Valves of a Worthington Pumping Engine fitted with Corliss Valves.

1. Put each side of the pump in the centre of its contact stroke. Insert chocks of wood to prevent the pistons moving.

2. Leave the expansion rod in position, but remove the expansion links and all valve rods.

3. Consider one side of the pumping engine only. Open the indicator cock to one end of the H.P. cylinder, and place the main H.P. valve to admit steam to that end of the cylinder. Turn on a very little steam, move the corresponding expansion valve by hand as required and so ascertain its point of cut-off; mark the position.* With the expansion valve open, similarly ascertain and mark the point of cut-off of the main valve. This should be the central position of the main valve, as these valves have no outside lap. Repeat for the other end of the cylinder; the mark for the point of cut-off of the main valve should coincide with the mark previously obtained, if it does not then the central position of the valve must be assumed to be midway between the two marks.

4. Turn the arm of the main H.P. valve vertically upwards so as to allow steam to pass straight to exhaust and so to the I.P. cylinder. Ascertain the central position of the I.P. valve in the way described above.

5. In a similar way ascertain the central position of the L.P. valve.

6. Repeat for the other side of the pumping engine.

7. The point of cut-off can be adjusted while the pump is running, but not so readily as in the case of a Meyer valve. Each expansion valve should cut off steam when its arm is inclined outwards at about 30 to 35° from the vertical; as a trial position place the expansion valves with their arms inclined outwards at about 15° to the vertical, this will give a cut-off at about 0·8 of stroke if the valves, spindles, etc., are as they should be. Fit on the expansion links making them all of equal length, the valves should then be symmetrical with reference to the cut-off points. In some pumps the expansion rods are adjustable and they may need alteration in order to bring the expansion valves symmetrical.

8. Eliminate the lost motion at the forward end of the H.P. valve rod, adjusting the screws so that the bolt which secures this end of the rod is in the middle of the slot.

* See above as to approximate position of the valve arm when cut-off occurs. If cut-off occurs only when the arm is in some very different position a reversed valve or badly twisted valve spindle is probably the cause.

9. The length of each of the valve rods is adjustable. Place all main valves in their central positions and adjust the rods so that they all then fit on to the arms of the valves correctly, without moving the valves.

10. Remove the chocks referred to in "1" above, and move one side of the pump off its central position. If this is not done the pump will not start when steam is turned on as all the main ports are just covered by the valves.

11. It is desirable to put marks upon the pump on each side indicating the ends and middle of the contact strokes. The pump can then be readily "centered" when required and moreover when the pump is working it is easy to see how nearly the pump is making full stroke.

12. After setting the valves it is preferable to start up the pump without any lost motion. As has already been mentioned an increase of lost motion leads to a longer stroke and therefore it is safer to work without any lost motion until the behaviour of the pump has been observed. Moreover, dependent upon the work to be done relatively to the design of the pump, it may be found that better results are obtained without any lost motion. However if it is found that full stroke cannot be got after the pump has thoroughly settled down to work and is working at a suitable speed it will then be necessary to gradually give lost motion. The lost motion should ordinarily be adjusted symmetrically. Do not be in a hurry to fiddle about with the setting arrived at as above. Give the pump time to settle down and go easy. Make sure that both sides of the pump are alike in every way as far as possible, particularly as regards the packing of glands, etc.

13. As an alternative to the above procedure relating to the main valves the front covers of these valves may be removed, and the valves wedged temporarily in their central positions. The covers are then replaced and the valve rods adjusted to suit. Rods and covers are then again removed without altering the lengths of the rods, and then, after the valves have been freed, the parts may be finally assembled.

Some of the triple expansion pumps referred to have a separate steam stop valve on each side of the pump, and there are also valves whereby the exhausts from the two H.P. cylinders can be interconnected, and similarly as regards the exhausts from the two I.P. cylinders. The suitable adjustment of these various valves will often materially improve the running of the pump, but if the valves have been correctly set the best results are obtained by having all these valves wide open and controlling the steam supply by a single valve in the main supply pipe. The more modern pumps

known to "Inspector" only have one single stop valve for the pump.

It is hoped that this Echo will enable anyone who has to do with any Worthington pumps of the types referred to, to take an intelligent interest in their working. It is not possible in a written note to deal completely with all difficulties that may arise, but a steam engine is a long suffering servant, and it is extraordinary how persistently a Worthington pumping engine will continue to push water notwithstanding adverse conditions. Nevertheless economical results can only be attained if the pump is kept in good order and is worked properly.

(*To be continued*).

Maj-Gen Sir John Hills KCB, FRSC
Late Royal Engineers

MEMOIR.

MAJOR-GENERAL SIR JOHN HILLS, K.C.B., F.R.S.E., ROYAL (LATE BOMBAY) ENGINEERS.

By Colonel R. H. Vetch, C.B.

Jack Hills, as he was generally called by his friends, was a member of a family well known in India for a long time back. His father, James Hills of Neechindapore in Bengal, son of Archibald Hills of Harestanes near Jedburgh and Ancrum in Roxburghshire, was one of the largest landowners and indigo planters in Bengal, and throughout a residence of over half a century gained the esteem and respect of both Europeans and natives in so large a degree that his name is still held in revered memory. He married a lady, half Italian and half French, Charlotte Mary Savi, daughter of John Angelo Savi of Elba, and granddaughter of General Corderan, commanding the French forces at Pondicherry. By her he had a family of six sons and four daughters:—

Archibald, the eldest son, was a cadet at the Hon. East India Company's Military Seminary at Addiscombe from 1850 to 1851, when he gave up the prospect of a military career in order to join his father in Bengal as a planter. He maintained the high reputation for probity, generosity and fairness and other qualities which had endeared his father to Europeans and natives alike. He was reckoned the best pigsticker of his day, and in consequence was especially invited to meet H.R.H. the Duke of Edinburgh at the Pigsticking Camp on the occasion of His Royal Highness's tour in India.

James, the second son, is better known under the double name Hills-Johnes, which he took on his marriage. He has had a distinguished career, passed his examination for Engineers but became first artilleryman of his term at Addiscombe, was commissioned in the Bengal Artillery on the 11th June, 1853, won the Victoria Cross during the Siege of Delhi and is now Lieut.-General Sir James Hills-Johnes, V.C., G.C.B., etc., late Royal Artillery, and Deputy Lieutenant and Justice of the Peace for Carmarthenshire. His services in the Mutiny, in Abyssinia, in Lushai and in Afghanistan are well known and are to be found in many books of reference.

John, the subject of this Memoir, was the third son.

George Scott, the fourth son, was commissioned from Addiscombe in the Bengal Engineers on the 8th June, 1855. He retired as a colonel in March, 1887, having served in the Indian Mutiny (1857–8), the Bhutan Expedition (1864–5), and the Afghan Campaigns (1879–80). For many years he was employed in engineering the roads of Assam, especially those to Shillong, the headquarters of the new province of Assam. He distinguished himself in early life in active pursuits. He was a good billiard player and an excellent fencer and boxer. He died on the 11th May, 1892.

The two younger sons, Robert and Charles, were in business in Calcutta where they were well known in social and sporting circles.

It is a noteworthy fact that the three soldier sons of James Hills of Neechindepore were all mentioned in the same Honours Gazette (1881) for their services in Afghanistan: James was created a Knight Commander of the Bath, John a Companion of the Bath, and George was promoted to be a brevet lieutenant-colonel.

Of the daughters the eldest married Lieut.-General Jenkin Jones, Royal (Bombay) Engineers; the second married Colonel William George Cubitt, V.C., D.S.O., of the Indian Army; the third married Lewis Pugh Pugh of Abermaed, M.A. (Oxon.), J.P. and D.L., and some time M.P. for Cardiganshire, Barrister-at-Law, Advocate-General, Bengal, and Member of the Governor-General's Legislative Council in India; the youngest married Sir Griffith Humphrey Pugh Evans, K.C.I.E., of Lovesgrove, Wales, M.A. (Oxon.), Deputy Lieutenant and Justice of the Peace for Cardiganshire, Barrister-at-Law and for over 20 years Member of the Governor-General's Legislative Council in India.

JOHN HILLS, the third son, was born in his father's house at Neechindepore in Bengal on the 19th August, 1834. Sent home at an early age he was educated at the Edinburgh Academy and at the Edinburgh University, where he distinguished himself in mathematics and gained the Straton Gold Medal and Scholarship. He entered the Hon. East India Company's Military Seminary at Addiscombe on 6th August, 1852, and on leaving it was awarded the Sword of Honour, and received a commission as 2nd lieutenant in the Bombay Engineers on the 8th June, 1854.

After two years of professional instruction at the Royal Engineers Establishment at Chatham, John Hills went to India, arriving at Bombay in August, 1856. He was at once posted to the Bombay Sappers and Miners, and, having passed in Hindustani, etc., in December, was reported eligible for employment, and appointed, on 14th January, 1857, Assistant Field Engineer with the Second Division of the Persian Expeditionary Force, commanded by Lieut.-General Sir James Outram. Hills was present at the capture of Mohamra on the 26th March, receiving the medal and clasp.

At the end of the campaign ill-health compelled him to go on furlough.

He was promoted to be lieutenant on the 5th November, 1857, and while at home was elected on the 21st March, 1859, a Fellow of the Royal Society of Edinburgh at the early age of 24 years, the youngest Fellow on record.

Returning to India Hills was, for a time, employed in the Public Works Department as Garrison Engineer at Fort William, Calcutta, but in January, 1862, he was transferred to Oude as Assistant to the Chief Engineer in that province. Promoted captain on the 1st September, 1863, he was sent two years later to Rajputana as Executive Engineer.

In 1867 Hills was selected for service with the force to be sent to Abyssinia under Major-General Sir Robert Napier, afterwards Field Marshal Lord Napier of Magdala. He was at first employed as Field Engineer at the camp which had been formed at Kumeyli at the foot of the mountains, to which place a railway was in course of construction from the base and port at Zula which was 10 miles away, in Annesley Bay on the Red Sea. At Kumeyli Camp he was chiefly occupied in obtaining a good water supply, by sinking wells and Norton tubes and in carrying out other engineering work at this large depôt. But his principal work was, a little later on, in the construction of roads. He was Field Engineer at Senafeh, a distance of over 50 miles from Kumeyli, the road rising in that length to a height of 7,400′, and having several bad defiles requiring skilful engineering. The road when completed to Senafeh had a breadth of 10′. Huge granite boulders had to be removed and in some parts it was necessary to cut the road out of the rock of the mountain side. Beyond Senafeh for some 37 miles to Addigerat a rough cart road was made but beyond Addigerat to Magdala the road was only a track passable for laden mules and elephants. Hills was mentioned in despatches and received the medal.

At the end of the campaign Hills returned to India and resumed duty in the Public Works Department as Executive Engineer at Lucknow. At the end of 1871 he was appointed Commandant of the Bombay Sappers and Miners at Kirkee and held the command for the next 12 years, bringing the Corps into a high state of efficiency. Meanwhile he was promoted major on the 5th July, 1872, lieut.-colonel on the 1st October, 1877, and brevet colonel on the 1st October, 1881.

During the Afghan War of 1879–80 and while still holding the post of Commandant of the Bombay Sappers and Miners, Hills was Commanding Royal Engineer of a division of the Kandahar Field Force in 1879–80 and of the South Afghanistan Field Force in 1881. He took part in the defence of Kandahar and distinguished himself on several occasions. For his services in this war he was mentioned

in despatches, created a Companion of the Bath, Military Division, on the 22nd February, 1881, and received the medal.

After a furlough the next and last appointment which fell to Hills was that of Commanding Royal Engineer at headquarters of the Expeditionary Force to Burma in 1886–1887 when he saw more war service. He retired on the 31st December, 1887, with the honorary rank of Major-General. In May, 1900, Hills was promoted in the Order of the Bath to be a Knight Commander.

He was an all-round sportsman, a good cricketer, a powerful swimmer, a fine swordsman, an expert boxer and an excellent shot. Many tigers fell to his gun, it is said they numbered over one hundred. In 1900 he published an account of the work of *The Bombay Field Force in 1880*, with plans, in an octavo volume. He was a great lover of the horse and was a diligent student of that noble animal in its finest breeds for 30 years. He was engaged in correcting the proofs of an elaborate book entitled *The Points of a Racehorse*, when illness seized him. This work, published by Blackwood in 4to. form in an *edition de luxe* in 1903, gives the results of his experience and study. The book is dedicated to the Duke of Portland, and a fine plate of the late King Edward's Derby winner Persimon with His Majesty standing near forms the frontispiece. With a clear brain and a strong will he continued the correction of the proofs until within an hour or two of his death from heart failure, which took place at 50, Weymouth Street, London, on Wednesday, 18th June, 1902, after some weeks' illness. He was buried in the family vault at Kensal Green on the 21st.

Sir John Hills was never married. As his brother and two married sisters lived in Wales he was a frequent visitor to the principality where he made many friends and where some of his happiest days were passed. *The Carmarthen Journal* in an obituary notice of him says: "His powerful reasoning, his quiet sense of humour and gift of witty expression, his broad views, his kindly heart and ready sympathy brought a bright and invigorating element into his intercourse with friends."

The Secretary of the R.E. Institute has called my attention to the fact that Sir John Hills had the unique distinction of being the only officer of the Bombay Engineers who ever attained the honour of a Knight Commandership of the Order of the Bath, although the Bombay Corps had a larger proportion of Companions than either the Bengal or Madras Corps.

TRANSCRIPT.

NEW ZEALAND FORCES.

(Extracts from a Report by Col. E. S. Heard, I.G.S., on the Training Camp at Tauherenikau, 7th January to 17th March, 1911).

THE training camp at Tauherenikau was instituted for the following purposes:—

1. To train a sufficient number of officers, destined for the New Zealand Staff Corps, to fill appointments on the Staff of the Defence Force, and as Adjutants of Territorial units.

To train the required number of N.C.O.'s as Sergeants-Major in charge of areas and Sergeants-Major of units.

Scheme of Instruction.—The scheme of work was of such a nature as to develop the powers of instruction in each individual, fit all ranks to take part in the training of the Territorial Forces, and carry out the necessary duties of registration and organization in the areas and area-groups.

Drill.—With this ideal in view, it was necessary to start everyone from the beginning, and give all ranks a thorough grounding in drill, progressively, from squad drill as recruits up to battalion drill and company training in the field. This progressive training was also carried out as regards mounted drill. Thus it was hoped that the officers and N.C.O.'s under instruction would be taught to be able in turn to instruct the recruits and trained soldiers of the Territorial units in their military duties.

This instruction in Infantry drill was handed over to the supervision of Capt. Hamilton, Grenadier Guards, Camp Adjutant, who was kindly lent to the Defence Department by His Excellency the Governor. As instructors under him, Capt. Hamilton had the assistance of the following N.C.O.'s of the Permanent Staff:—Staff Sergts.-Major Dovey, Cheater, Redmond, and Walker.

Progressive Training.—The scheme of training of all ranks was progressive—that is to say, everyone began at the beginning as recruits, no matter what their training or experience was in the past.

Squad Drill.—The officers and N.C.O.'s were divided into four Infantry squads, each under an instructor, and they began as recruits to be instructed in the correct manner of standing at attention, marching, turning,

saluting, etc.; in short, how to carry themselves smartly with a properly soldierly bearing. All this preliminary part of the drill was without arms.

When they had sufficiently mastered the rudiments, and had in turn taken the part of an instructor, giving all the necessary explanations and words of command, they passed on to the next step, which is squad drill with arms. In this they were taught the proper method of handling their arms with precision and smartness both while marching and at the halt.

Communicating drill, which consists chiefly in the practice of using the voice properly in giving words of command, and in repeating the explanations and commands in drill, was made a special study, and was attended with good results. A great deal depends, in drill, on the manner in which a word of command is given. Some who have no proper command over their voice or manner of giving an order fail to produce smart movements in drill, while others who have the habit of command can do anything with their men. To obtain full value out of communicating drill the squad should be commanded from a considerable distance.

Company Drill.—After squad drill, the next step was company drill, and in this, as before, each individual took his turn in commanding squads, sections, half-companies, and the company, so that all should be familiar with every detail of company drill.

Battalion Drill.—When sufficient progress was made in company drill, battalion drill under the Adjutant or Commandant, was taken in hand. Owing to the lack of numbers, each company in the battalion was in single rank. The battalion was composed of six companies only. Officers took it in turn to perform the mounted duties of senior Major and Adjutant and of Commander of a Company, and occasionally one or other was called out to drill the battalion. The officers and N.C.O.'s had paid so much attention to their drill from the start that their movements in battalion drill, and the manner of handling their arms, left very little to be desired, and would have done credit to a battalion of Regulars. Their steadiness in the ranks was particularly noticeable.

Company Training.—Besides drill, company training in the field was undertaken. The officers and N.C.O.'s under training formed a company, at war strength, between 120 and 130 of all ranks. The training included attack and defence practices, advanced, flank, and rear guards, and outposts. As many as possible took it in turn to command squads, sections, half-companies, and the company. It must be noted that the officers and N.C.O.'s took their places together in the ranks, and were trained just as if they were ordinary privates in the company.

Field Engineering.—Instruction was also given in the construction of fieldworks under the supervision of Capt. Duigan, Headquarters Staff.

The time devoted to fieldworks was necessarily limited, but every officer and N.C.O. had a good grounding in the elementary principles of the work, and did his share of the actual digging, etc.

The work carried out was mostly of a practical nature, and consisted of:—

Construction of a fire trench.
Loopholes.
Overhead cover.
Concealing trenches.
Cover lying down.
Cutting brushwood and clearing the foreground.
Tracing trenches.
Types of traverses for protection from enfilade and oblique fire.
Stone sangars.

The system of detailing working parties was thoroughly explained to all, and the principles of construction, effect of fire, handling tools, and siting trenches explained in a lecture.

I have no hesitation in saying that every officer and N.C.O. who was instructed in the above knows how to instruct his unit in the work carried out.

Mounted Duties.—All ranks, whether they formerly belonged to the mounted branches or not, were instructed in mounted drill. At first the instruction was given on foot, and the movements were thoroughly learnt in this manner. After this grounding was satisfactorily absorbed, the officers and N.C.O.'s were put through the drill on horses. At first the mounted squads learnt how to ride and handle their horses in the *manège*, as in riding schools. After this they carried on with troop and squadron drill, with and without arms. Paucity of horses and unsuitable ground prevented mounted work in the field being carried out, but as much training as possible in this direction was done on foot.

Capt. Spencer-Smith, Staff Officer to the G.O.C., undertook for a time the supervision of the mounted drill, assisted by Staff Sergts.-Major Dovey, Walker, and Redmond.

Thus all ranks, without distinction, were thoroughly instructed in infantry and mounted drill, so that each individually could undertake the duties of instructor in either branch, as Adjutants, Area Sergeants-Major, or Sergeants-Major of units.

Musketry.—In addition to drill and field training all ranks went through as thorough a course of musketry instruction as the time would admit, under the supervision of Major Hughes, Assistant Commandant, assisted by Staff Sergts.-Major Rose and Henderson. In this course it was intended to show how the recruit should be instructed, and for this purpose all those under instruction began at the beginning as recruits and were carried right through the course. They were shown the special points to observe in the instruction of recruits, and the method of conducting the standard tests. Great stress was laid on the care of arms, a very important matter, since in this country an alarming number of rifle-barrels are condemned every year through want of proper care on the part of those in possession of arms as Volunteers. Judging distance, also very important, was frequently practised. Great stress was also laid on the importance of fire discipline and control. The extreme usefulness of work on a miniature

range was illustrated, and all the various methods of fire and specimens of targets were shown. Methods of testing the firers' errors in aiming, by grouping practices, and the errors in sighting of rifles also formed part of the instruction. As in the drills so in musketry, all ranks were practised in imparting instruction as to recruits, etc.

The whole course was very useful, and was ably carried out under Major Hughes and his assistants.

Examination.—Periodical examinations in drill, musketry, Commandant's lectures, and Adjutants' and N.C.O.'s duties produced very satisfactory results on the whole, testifying to the efficiency of the instruction given. The seniority of both officers and N.C.O.'s in passing out was determined in great measure by the results of these examinations.

Semaphore Signalling.—Semaphore signalling with flags was taught to all ranks, under the supervision of Capt. Duigan, Headquarter Staff, and all had to pass an examination in this branch. The training was very thorough, and the majority of officers and N.C.O.'s reached a very satisfactory standard of efficiency. Flag drill was not hurried, and the detail was grounded into all.

Many of the officers who were under instruction are proficient in Morse, which will be of great value to them in training the signallers of their units.

Physical Training.—Capt. R. O. Chesney supervised the instruction in physical training, which was undertaken by Corpl. Gallagher, R.N.Z.A. Certain exercises were selected from the Imperial Handbook on the subject, and all officers and N.C.O.'s have been given copies of those selected.

Lectures.—Frequent lectures were delivered by all the members of the Instructional Staff on various military subjects included in the course of instruction. Amongst these were lectures by the Commandant on attack, defence, protection, discipline, scouting, etc. Major Hughes gave a very useful and instructional series of lectures on musketry. Capt. Hamilton lectured on drill, duties of Adjutants, etc.; Capt. Duigan on fieldworks. Capt. Browne gave instruction in the fitting of saddlery. Capt. Reid, N.Z.V.C., on horses and horse-mastership. The latter is very important, and very much required in this country.

Special instruction was also given in the duties of Area Sergeants-Major.

Camp.—The camp was laid out by Capt. Browne, Headquarters Staff, Camp Quartermaster, and the excellent health of all ranks was due to his careful supervision, and the extreme cleanliness of the camp and its surroundings, which was always insisted upon.

Sanitation.—The latrines were on the pan and dry-earth system, and their contents were buried daily.

Soak-pits were dug for the reception of water used in washing utensils for cooking.

All refuse was burned in the incinerator, and empty tins and indestructible matter buried after passing through the incinerator.

At intervals, behind the tents, receptacles were placed, into which scraps of paper and litter were thrown and afterwards burned. Thus the camp was kept clear of all rubbish.

Water Supply.—The water supply, duly tested and found pure, was obtained from a creek behind the camp, and pumped up to tanks by a hydraulic ram. A plentiful supply of water was thus obtained for all ranks, and shower-baths in sufficient quantities were erected.

Lighting.—All the mess marquees were lighted with acetylene gas laid on from a generator erected under the water-tank. This method of lighting was considered cleaner, safer, cheaper, and better than by oil-lamps. As a great deal of work, reading up manuals, etc., was done at night, it was necessary that the light should be good and adequate.

Horses.—For instruction in mounted duties 40 horses were purchased, and were placed under the care of Capt. Browne, Camp Quartermaster. These horses were kept in a paddock between the camp and the Tauherenikau River, and were looked after by a certain number of the R.N.Z.A. The Inspecting Veterinary Officer, Capt. Reid, in veterinary charge of camp, reported that their condition was very good, and showed great improvement since their purchase, which reflects credit on the care that was taken of them. Only one horse was cast, and this was sold after the camp was closed. The remainder were distributed among Area Sergeants-Major, as far as they would go. These N.C.O.'s will in some districts have to cover long distances in the execution of their duties, and therefore it is considered necessary that they should have a horse for the purpose.

Fatigues.—The necessary fatigue duties in camp were executed by a detachment of the R.N.Z.A. and a few civilians engaged for the purpose. These duties were carried out entirely satisfactorily, and all worked hard with commendable zeal and energy.

Situation of Camp.—The camp was situated on the south-east side of a belt of bush which stretched from behind the racecourse to the Tauherenikau River. The site was ideal, as the bush sheltered the camp very efficiently from the north-west wind, which frequently sweeps down from the hills with much violence. As stated above, the water supply was close behind the camp, and the Tauherenikau River close to the horse-paddock. This river was used for watering the horses, and a bathing-place was made in it for the use of the camp.

The ground on which the camp was pitched is part of the property of Mr. Quinton Donald, who very generously placed it at the disposal of the Defence Department for the purpose.

Daily Routine.—The daily routine of work in the camp was as follows:—Work commenced at 8.30 a.m., and went on till 1 p.m., with a break of half an hour from 10.30 a.m. till 11 a.m. After lunch, at 1 p.m., work recommenced at 2 p.m., and finished at 4.30 p.m. Saturday was a general holiday, and on Sunday a church parade was held in the morning.

Discipline.—Discipline in camp left nothing to be desired, and the

smartness and soldierly bearing of all ranks is a matter for congratulation. The zeal and energy displayed by all officers and N.C.O.'s under instruction was extremely creditable. From first to last everyone showed a very commendable desire to learn all he could, and a great deal of work, both practical and theoretical, was done during hours supposed to be devoted to relaxation, and even late in the night. This soldierly spirit gives good promise for the future success of the Territorial Forces.

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Conclusion.—In conclusion, it was noticed that though the native-born of this country pick up field training and manœuvre very quickly indeed—a fact that is no doubt due to their outdoor life and habits of independence—drill and discipline does not come so easily to them. It is obvious, therefore, that a great deal of attention must be paid to the latter. At this school of instruction, as soon as they had been taught to drill, to skirmish, and to do as they were told, the rest came easily. In England, on the other hand, the soldier picks up drill and discipline quickly, but is slower in learning the principles of modern field training.

The camp was struck on the afternoon of the 17th March, and all ranks were despatched to their destinations by the same evening.

NOTICES OF MAGAZINES.

Revista del Genio Civile.

July, 1911.

Electric Traction on Swedish Railways.—Sweden is one of the poorest countries in the world in coal which is only to be found in a very few places in the south, and consequently most of the coal used is imported. The State railways alone burn annually nearly £400,000 worth of English coal and those owned by private companies consume an almost equal amount. The country is however very rich in waterfalls, the power of which has hitherto remained idle, and for some time past the Government has been considering the introduction of electric traction on the railways. It was resolved to experiment with it in 1902, and during the years 1905, 1906, 1907 electric locomotives were employed on the Tonteboda-Värtan and Stockholm-Järfva lines. These tests aroused considerable interest all over Europe, as they represented the first attempt to use 20,000 volts on a live wire. The results were so successful that it was resolved to use electric traction on the Kiruna-Riksgränsen line, which carries very heavy traffic, connected principally with the transport of ores. The length of the line is 129 kilometres.

Steam traction, it is considered, will be unable in the future to cope with the traffic on this line, which is estimated to increase from 1,600,000 "tonnes" in 1908 to 3,200,000 in 1913 and 3,850,000 in 1918.

Were steam traction adhered to, it would be necessary to double the line in certain places, buy heavier engines, etc. With electric traction, on the other hand, the problem is solved by the fact that the trains will consist of 40 instead of 28 trucks—each carrying 35 tonnes—that the speed will be increased from 50 to 60 k.m. per hour instead of 40 as at present and further that this speed will only go down to 30 k.m. per hour on the maximum gradient ($\frac{1}{100}$) instead of 12.

The expense of changing to steam traction is £1,200,000, and the work will be carried out by a local firm and Siemens Schuckert of Berlin. The saving after transformation will amount to £2,344 per annum, to which figure must be added the money saved by not doubling the line.

It is interesting to note that this line is the most northerly of the whole world, being in all its length north of the Polar circle. From the point of view of defence against snowfalls, it can be divided into two parts; in the southern one no special measures are needed, but in the northern branch, which is 30 kilometres long, overhanging galleries of ferro-concrete are necessary in places to protect the line from avalanches, whilst in others a "scatterer" on the principle of centrifugal force is required.

The power is supplied by the waterfall of Porjus 120 kilometres south of Kiruna; its flow is at present 23 cubic metres per second and this can be increased fivefold so as to supply an average horse-power of 65,000 (chevaux de force) per annum.

The water of Lake Porjus is led by means of a canal 45 square metres in section and 525 metres long into a distributing reservoir, which serves to equalize the level of the water. Thence five vertical pipes lead the water to the turbines in an underground machinery room, which can hold five turbines of 12,500 chevaux de force each. Three of them are coupled up to alternators (5,000 vols. periodicity 15) and feed the railway. The monophase current is boosted up to 80,000 volts at the switchboard, and thence goes on overhead lines to four sub-stations, where it is transformed back to 15,000 volts, at which potential it is fed direct to the contact wire over the line and thence to the engine.

The contact wire is supported on wooden posts 30 metres apart with hollow steel crosspieces. Arrangements are made to allow for expansion and contraction of the wire under varying conditions of temperature, and also to leave a little vertical play.

The engines for goods trains are in two identical parts, each of which contains a monophase motor which is coupled direct to the driving wheels. The engines are of the 0-6-0+0-6-0 type. The engines for passenger trains are of the 4-4-4 type, are in one part instead of two, and have only one motor which is coupled to the four centre driving wheels. The first type weighs 100, the second 70 "tonnes."

The goods trains consist of 40 trucks, or a total weight of 2,050 "tonnes"; their speed must not exceed 50 k.m. per hour or go below 30 k.m. per hour on the maximum gradients (1 in 100) or on the steepest curves (500 m. radius). The engines must be able to start on the ruling gradient and steepest curves and exert a tractive force of 31,200 kilos. The average annual run of goods engines will be 90,000 kilometres, that of the passenger train locomotives whose maximum velocity is restricted to 100 k.m. per hour, 100,000 k.m.

A. H. SCOTT.

REVUE MILITAIRE DES ARMÉES ÉTRANGÈRES.

July, 1911.

THE JAPANESE IMPERIAL MANŒUVRES OF 1910.—A long and detailed account of these manœuvres is given in the June and July numbers of this magazine; the following are extracts from the remarks on them:—

Two remarkable features were, firstly, the great detail in which they had been worked out by the general staff, and secondly, the intense spirit of the offensive displayed on every possible occasion. Although it is possibly a disadvantage to work out manœuvres too much in detail, it makes them all the better practice for the subordinate ranks. This seems to be the opinion of the Japanese staff, who consider that the

higher commanders are best prepared for their duties by the study of military art and the carrying out of staff rides, and not by being given an entirely free hand on manœuvres.

As regards the offensive spirit, it was shown in every movement and in every order issued. Even if the order to retreat was given, it was stated that this was merely a preliminary to the attack. Troops were never to be found waiting to be attacked in entrenched positions, the main fight between two opponents almost invariably took place half-way between their positions.

The attacks were carried out with extreme vigour, at the double, in many cases at a fast run, and they invariably ended with a hand-to-hand engagement. There was but little use of entrenching tools in the attack, their use is contrary to the spirit of the Japanese regulations which state that they tend to tie the men too much to the ground; the main object is to get up to the enemy and decide the battle with the bayonet. The use of entrenching tools is only justifiable in cases where the attack is checked, so as to prevent the troops from being driven back.

Reserves were small in number, consisted mainly of infantry and engineers, with cavalry for those units not situated on the flank of an attack, and were invariably pushed home to the very last man. The use of heavy artillery to support the mountain or field artillery is considered normal—the proportion of heavy to field artillery being 1 to 5. The heavy artillery are armed with 4·5″ and 6″ howitzers and 4″ guns. They have eight-horse teams.

The advanced guards were composed of about one-third to one-quarter of the infantry of the whole force, as much cavalry as was available, two or three batteries per division, engineers, a medical corps detachment, and later on a section of the bridging train was added.

The fronts occupied by divisions, contrary to the practice of 1909, were restricted to 3·5 to 4 kilometres.

Great importance was attached to the adoption of a preliminary formation before the attack when some 2 to 3 kilometres from the enemy. This formation was generally taken up at night so that the offensive could be assumed at dawn.

The fire discipline of the troops was excellent.

The troops bore hardships without any signs of discontent, although they were made to bivouac out on two or three very cold nights, and in certain cases had to attack through ditches which wet them up to the waist.

By no means the least satisfactory feature of the manœuvres was the interest taken in them by the inhabitants of the districts in which they were held, and the great enthusiasm they evoked.

MILITARY NEWS OF DIVERS COUNTRIES:—

AUSTRO-HUNGARY.—*Re-organization of the Army.*—The terms of service to be adopted are 2 years with the colours except in the following cases:—(1). 3 years with the cavalry or horse artillery. (2). 4 years in the navy. (3). 1 year for specially qualified people. (4). 10 weeks instead of 8 for those people dispensed of service or for the "ersatz-reservists."

After this period of colour service the troops will be disposed of as follows:—

Two-year men:—10 years with the reserve, which includes 4 periods of service or a total service of 14 weeks.

Three-year men:—7 years in the reserve, including 11 weeks training in 3 periods. They are exempted of 2 years in the Landsturm.

Five-year men:—5 years with the reserve, exemption of 5 years Landsturm service.

One-year men:—Mostly become reserve officers; undergo 4 subsequent training periods of 4 weeks each.

Ten-week men:—12 years reserve service, 3 periods of training of 4 weeks each.

The increase of the peace strength of the army from 103,000 to 159,500 men will be spread over 3 years, at the end of which time the forces will be divided as follows:—Austria 91,313 men, Hungary 68,187. Of these, 134,500 will be 2-year, 19,000 3-year and 6,000 4-year men. This strength is liable to be modified after 12 years.

The privilege of serving for one year only, has been restricted to those who:—(1) Have studied in a secondary school; and (2) Have undergone the necessary government examination to qualify for this privilege. (3) To schoolmasters, or to university students.

Those one-year men who are not at the end of their time considered fit to become reserve officers will be given lower rank. One-year volunteers need not serve at their own expense except in the cavalry, horse artillery or train.

The choice by ballot of the people who become "ersatz-reservists" is suppressed, they will be chosen for reasons of health, family, or professional interest.

Only students in Holy Orders, landed proprietors who till their own lands, and supporters of families are dispensed from military service.

The Honved is also to be reorganized:—

(1). It will be increased from 94 to 97 battalions, and each regiment will be given a second machine-gun detachment. The strength of a company will be 80 instead of 50 men. (2). The strength of the squadrons will be raised from 63 to 100 men; each regiment of hussards will be given a machine-gun detachment, and the 10 cavalry regiments will be organized into two divisions. (3). Each of the 8 infantry divisions will be given an artillery brigade of 8 guns or howitzers, and a horse artillery brigade of 3 batteries will be allotted to each cavalry division. (4). The peace strength of the Honved will be increased yearly so as to reach 25,000 in 3 years.

Supply of Ammunition and Bayonets to the Cavalry.—The cavalry are in future to carry 80 rounds instead of 50. Of these 30 are to be carried on the man, and 50 on the horse. A horse is also allotted to each squadron to carry ammunition. A short bayonet is shortly to be issued to the cavalry.

Steps are being taken to instruct officers of the Hungarian Army in German, so that they may follow with full advantage the instruction given in the German-speaking military establishments, viz. the Staff College,

and School of Construction, of telegraphy. Subaltern officers must also be perfectly acquainted with the language of the regiment with which they are serving; this knowledge is to be tested by severe examinations.

Combined Manœuvres of the Army and Fleet in 1911.—These are to take place this year in Dalmatia, the land forces consisting of a brigade of mountain troops with some cavalry and mountain artillery, and the sea ones of 6 battleships, 7 cruisers, 18 torpedo boat destroyers, 12 torpedo boats and 12 submarines. These manœuvres will not consist merely of embarking and disembarking troops, the general idea being that a part of the Istrian coast is being attacked by a portion of the fleet, which is defended by the land forces and the remainder of the fleet. Similar manœuvres have not taken place since 1906.

GERMANY.—27,278 horses were submitted to the remount commissions in 1909, of which 14,047, or somewhat over 50 per cent. were purchased. Their average price was 1,331 francs, an increase on the prices of the two previous years. The highest price paid was 2,125 and the lowest 1,000 francs.

The report issued at the end of 1910, showing the age of officers, calls forth the remark that the time spent in the ranks of captain, major and divisional general has increased since 1909. The promotion is very slow at the present moment, especially in the infantry where officers are often promoted as supernumeraries and do not get the pay of their rank till two years later. This is not so marked in the cavalry and engineers. The youngest brigadier is 52 years old—the oldest 57. The divisional generals average 54 or 59, the difference in age being accounted for by the fact that officers who have served on the staff are promoted more rapidly than regimental officers. At the present rate of promotion it is impossible for the senior majors ever to reach the rank of general, and even the juniors will not become colonels before they are 53 years old. The question of quickening the promotion of officers is at present being gone into in Germany.

SPAIN.—*Regulations on Aviation in the Army.*—Regulations have recently been issued on the training of officers as aviators. The aircraft are all under the direction of the Engineer Experimental Committee. The aerodrome is under the command of a field officer of engineers, who will record the experiments carried out and the flights made by each officer. The civilian professors come from the firms which supply the machines.

The conditions to be fulfilled by would-be aeronauts before selection are:—(1). They must be pilots of spherical balloons in the corps of engineers. (2). They must have some theoretical knowledge of aviation, and a practical and theoretical knowledge of motors. (3). They must be accustomed to drive fast motor cars, or to ride motor cycles.

The qualifications for the certificate as pilot are:—(1). To make two flights of over 5 kilometres in the aerodrome, and to "ride the machine on either rein." (2). To be able to raise their machine to a height of at least 50 metres: this can be tested either in one of the first two flights or in a third one.

As soon as there are sufficient pilots, they will be employed to replace the present civilian professors.

ROUMANIA.—A new rank has just been created in the army, viz. that of

army corps commander. This is at present, however, merely a rank with no corresponding appointment.

RUSSIA.—It has been decided that 12 officer aviators will take part this year in the manœuvres. Russia at present possesses 30 flying machines, and 12 new ones are daily expected.

The Army Estimates.—There is a large increase in the 1911 estimates; the chief causes being: New barracks, 5,000,000 roubles; calling out of reservists for training, 5,000,000 roubles; transformation of the field artillery, 3,000,000 roubles.

22,028 roubles are devoted to the Aircraft Section and the Aeronautical Experimental Committee; 25,000 roubles for the organization of aviation tests; and 6,506 roubles for the upkeep of the new wireless telegraph stations.

A. H. SCOTT.

RIVISTA DI ARTIGLIERIA E GENIO.

June, 1911.

DETAILS OF PERMANENT FORTIFICATION.—In a long and exhaustive article Lieut.-Colonel Zunino of the Engineers enters very fully into the above subject, dividing it into ten parts, viz.:—(I.) On the installation of Gardner's mitrailleuses with vertical loopholes, or in barbette and with horizontal loopholes. (II.) On a concealed metallic caponier for resisting the fragments of artillery projectiles. (III.) On movable shields for protecting windows from projectiles. (IV.) On metal covers to be used in peace time for preserving armoured towers and turrets from the effects of the weather. (V.) On camp beds to fold up against the ramparts. (VI.) On drawbridges, and armoured gates of ingress capable of resisting the fragments of projectiles. (VII.) On a special arrangement of chains for regulating the various positions of drawbridges. (VIII.) On armoured shields with loopholes for protection of windows from artillery projectiles, and from rifle fire. (IX.) On an indirect method of access to an unguarded work in time of peace, when the drawbridge is raised. (X.) On a method of preserving caves or underground works from the dropping of water from the roof. Considerations on the action of frost on mortar, and on the plaster at the base of cemented works.

All these protective methods are very fully described with excellent plans, diagrams and photographs.

VISUAL SIGNALLING IN THE GERMAN COLONIES IN AFRICA.—The German periodical *Kriegstechnische Zeitschrift für Offiziere aller Waffen* of March and April, 1911, publishes a valuable article by Hermann Thurn on the employment of visual signalling. It is divided into two parts. The first treats of the use of visual signalling at manœuvres, and requires no particular comment as this branch of the service in the German Army has been fully developed and leaves nothing to be desired.

The second part is of an essentially descriptive character and contains an account of the evolution of visual signalling from its commencement in Africa up to the present time. The first record of the use of visual signalling in the German colony dates from the year 1901 in the pro-

tectorate of Eastern Africa. At that time a department of instruction in signalling was formed at Dar-es-Salam with one officer and two European non-commissioned officers, with a certain number of natives who could read and write; this detachment made use of the heliograph exclusively. In the exercises which took place in the hinterland of Kilva and Kilimanjaro the detachment took part for the first time and initiated the sending of telegraphic messages by means of the heliograph up to a distance of 90 k.m.; these experiments at first were not successful owing to the mist, and the masses of vapour which collected after the rainy season. It was not until the summer of the same year that they succeeded in overcoming a distance of 200 k.m. joining the station of Kilimatinde on the Dar-es-Salam–Tabora road with the military post of Mikalamo in Issansu.

In 1904 and 1905 the experiments assumed greater proportions, and a network of stations for extensive visual signalling was established. Moreover a line was established from Kilimatinde in a north-east direction towards Ussandam (67 k.m.), and the first intermediate station was established at the military post of Kwa Mtoro. From Ussandam other lines were determined towards the north-east to Turu (37 k.m.) to Ijambi (53 k.m.) and to Mkalama-Issansu (37 k.m.). The trials on these lines lasted for two and a-half months. The signalling on this network of lines worked very well and was only impeded for short periods during the rainy season. The stations were at considerable altitudes, 1,200, 1,450 and 1,850 m. respectively but the system was sensibly impeded by clouds, as had happened at the mountains of Kilimanjaro and Meru at inferior heights of 1,400 m. At distances beyond 80 k.m. they succeeded, in favourable conditions of the atmosphere, in establishing communication, but were not able to guarantee the security of the service.

In the year 1904 a section for visual signalling was attached to the Commission for the delimitation of the Anglo-German boundary between the Lake Victoria-Nyanza and Kilimanjaro. The heliographs on this occasion besides being employed for the transmission of messages were also used to render visible very distant trigonometrical points, and were of great assistance to the Commission.

From December, 1904, to February, 1905, the signalling detachment established communication between Muansa on the south bank of Lake Victoria, and the military posts of Schirati on the east bank, and Ikoma in the plain of Massai. This communication was rendered necessary owing to the frequent raids of the Massai. The communication by heliograph was also of assistance as a guard at Muansa, and to the before-mentioned posts in case of alarm. The distances between Muansa and the two posts at Schirati and Ikoma were 192 and 196 k.m. respectively. The signalling line devolved from Muansa over the Gulf Speke, towards the mountain Kiruwiru (86 k.m.) and from this mountain proceeded for 67 k.m. towards the mountain Tschamliho, from which it separated into two lines, the first to the north-west, for 53 k.m. towards the mountain Ujamgirodi, and from this for 46 k.m. towards Schirati; the second line ran to the south-east from Tschamliho for 61 k.m. towards Ikoma. At the same time communication was established between Ikoma and the Orgoss posts situated 56 k.m. to the south-east.

The network described above worked regularly from February to the end of May. Commencing in June, and during the dry season, the Gulf Speke remained covered with mist so dense that the lines Muansa-Kiruwiru and Kiruwiru-Tschamliho, which were above the water of Lake Nyanza, were interrupted. On the contrary the lines from Tschamliho that communicated respectively with Schirati and Ikoma, which were over the land, remained permanently in action.

Later on in January, 1907, when the political situation in the Portuguese Protectorate of East Africa became complicated and rendered the permanent location of colonial troops in Kionza necessary, this point was joined heliographically with the last station, distant 61 k.m. from the permanent telegraph line in the south at Mikindani. Afterwards the signalling detachment established communication by heliograph between Lindi and the posts of Ssassavara, distant 350 k.m., with four intermediate stations, and this also worked well during the rainy season as on five days only in the middle of the month were the transmission of messages impossible. This result was the more satisfactory when one reflects that the permanent electric telegraph lines were frequently interrupted, not only owing to atmospheric influences but also to damage caused by vegetation and animals.

To ensure a quick and accurate visual signalling service in case of necessity, the heliograph detachments should fix at once the more important lines of communication, the points at which the transmission of messages can be guaranteed and which are adapted to a permanent occupation. The indispensable conditions for the last are an ample supply of drinking water and means of subsistence, and reliance on the good faith of the inhabitants.

The heliographs actually supplied with lenses 15 c.m. in diameter, gave an intensity of light such that a detachment provided with three apparata could always maintain communication up to 150 k.m. in distance. The signalling apparatus was transported on the backs of horses and mules and presented no little difficulty, especially with the metallic oxygen receptacles, which were heavy. At all the stations a small detachment of from two to six men was stationed at each post, and signallers frequently had to remain alone for several months at altitudes, exposed to all the inclemency of the weather, deprived of succour, and in danger of attacks from the natives, having to trust to their own resources, with scarce provisions, little water, and without sanitary appliances. Many of the telegraphists were prostrated by nervous eye complaints, and the want of change made rest necessary which they could not obtain.

The station at Falkenhorst for 10 consecutive days remained completely blocked, and the men, suffering from heat and thirst, were finally reduced to using rum instead of water for cooking purposes, whilst one of the company held out by the apparatus so that the service might not be interrupted.

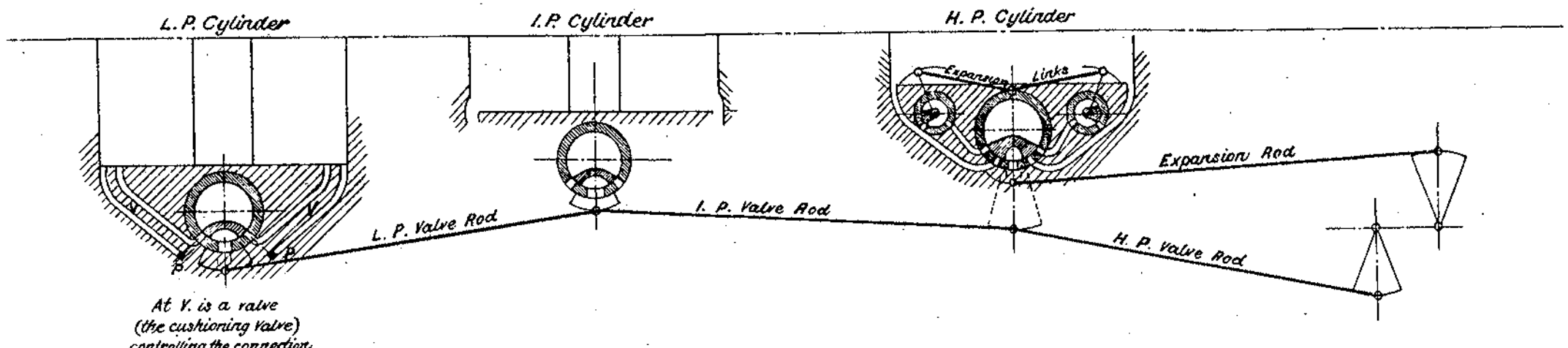
The network of signalling during the operations in South-West Africa was greatly extended. The lines Windhuk-Keetmanshoop-Ramansdrift covered a distance of 800 k.m. or about that of Berlin to Milan. The complete network in July, 1905, extended to 2,500 k.m.

E. T. THACKERAY.

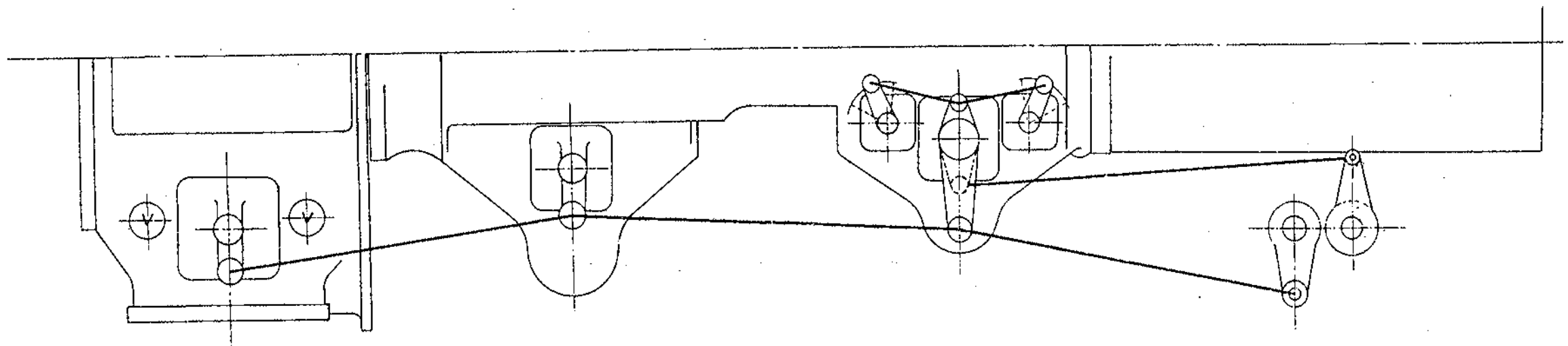
ECHOES FROM THE ENGINE ROOM.

WORTHINGTON TRIPLE EXPANSION PUMPING ENGINE.

SKETCH OF CORLISS VALVE GEAR.



At V. is a valve (the cushioning valve) controlling the connection between the 2 passages shown.



Cushioning Valve fixed at V. V.