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Subject Index.

Original Articles are entered in thick type; Translations, Reviews, and Notices of Magazines in thin type.

Index to Authors.

(Memoirs and Reviews Omitted.)

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Authors alone are responsible for the statements made and the opinions expressed in their papers.

BRIGADE TRAINING.

By Major A. F. Sargeaunt, R.E.

My excuse for again alluding to Brigade Training is that it is chiefly during training that R.E. are brought into contact with the other arms, and the latter form their opinions by what they see of the R.E. during this period and by the versatility of the R.E. to adapt themselves to the varying circumstances of training and manœuvres.

Some months before the 12th Company, R.E., was to be attached for a fortnight to the 16th Infantry Brigade for brigade training, the O.C. Company had lent the Brigadier and Brigade-Major a copy of General Heath's lecture delivered to the Aldershot Military Society last winter (*vide R.E. Journal*, August, 1911), and the Brigadier was as keen to make use of the R.E. as the R.E. were to be used. Consequently when the programme of work for the fortnight was drawn up, a copy was sent to the O.C. 12th Company and he was asked to make suggestions as to how the R.E. should be used on various occasions.

It was a great gain that much of the manœuvre area was open scrub land where the owners and tenants placed no restrictions on turning up the ground so long as trenches, etc., were afterwards filled in ; so that whereas as a rule the R.E. can do but little actual work when training with other arms, this year much of the work was of a practical nature.

Before the actual manœuvring, the preparation of the camping area gave some scope for R.E. work. A small stream 20′ wide ran along one side of the camp (pitched in a 30-acre field) and a dam was formed in this with the aid of a tarpaulin to make a bathing pool, a well was dug 18′ deep for drinking water, washing facilities arranged, cooking shelters erected, approaches made from the road into camp, communications improved, a market inaugurated, etc. Subsequently Colonel Rose, of The Black Watch, who is an ardent water diviner located water in a small area near the Officers' Mess, and he won a wager by water being found at a depth of 15′ by means of a Norton tube well.

It is now proposed to take some of the days and show what part the R.E. played, but the days selected were not necessarily consecutive.

1st Day.—Mountain warfare against savage tribes. The force had to march down a long narrow wooded gorge, and to enable men and animals to pass freely the track required considerable improvement; gaps had to be made in walls, a path cut through a belt of tall undergrowth, two causeways made across a river and a bridge built over a tributary stream.

2nd Day.—Attack against a flagged enemy. The ground was too open for the Sappers to be of any use during the attack, as when bullets are absent and the enemy a flagged one an attack knows no check of any duration; but, as soon as the position was captured the R.E. officers rode forward and made a reconnaissance of the position with a view to strengthening it against a counter-attack. Having viewed the ground himself and collected the reports and sketches from the subalterns, the O.C. Company submitted his report and proposals to the Brigadier.

3rd Day.—Strengthening a position for defence. Acting on the report of the previous day the Brigadier divided the position into four sections, and each battalion was allotted to a section and given four hours in which to dig trenches and generally strengthen the section allotted to it. A section of the field company was allotted to each section of the defence to assist and advise the infantry. The ground was hard and stony and in one place rock was found 18" below the surface; an urgent message was sent from O.C. Section for explosives but of course they did not exist. The Brigadier was strong on the point that everything attempted was to be completed at the end of the four hours, that is to say that the work was to be undertaken according to tools and material available, and all parapets, banks, etc., were to be bullet proof.

4th Day.—A retirement from the position strengthened on the previous day. The Brigadier, owing to the enemy being reinforced, decided to retire to a position selected in rear; this position consisted chiefly of a line of banks and walls. As soon as the order to commence the retirement was given, the Field Company was taken back to the second position and with pick and shovel strengthened it and improved the lateral communications. When the retiring troops had reached this second position the company was again assembled and was on its way to yet a third position when the "cease fire" sounded.

5th and 6th Days.—Outposts for 24 hours. One battalion was allotted to each section of the outpost line (comprising two sections), and ½ Field Company was allotted to each section to assist in strengthening the line and to advise as to method of defence, etc. It is questionable whether R.E. can be of any practical use in an outpost line by night, and having done their work in assisting and advising the Infantry their place would seem to be with the Reserve till required for other work, but the Brigadier was desirous of keeping some of the Sappers with the outposts by night so that they would be at hand if wanted; two sections of the company therefore remained out, and the other two sections joined the Reserve.

7th Day.—Attack and change of direction. As before there was not much scope for R.E. work during the attack, but the Sappers and tool carts followed the firing line as close as possible under cover, so that they might be at hand and ready for work after the final assault.

On two other days ½ company R.E. was attached to either side for tactical field days.

But a mere recital of facts is not of much use unless lessons are to be deduced from them, and during this training several lessons were learnt or former impressions emphasized, namely :—

If R.E. are to take their proper place with other arms and if they are to be used to the best advantage it is essential that the O.C. R.E. should by his actions show the G.O.C. that he is worthy of being taken into his confidence. In the present case the R.E. encamped alongside the Brigade Headquarters, and this is a decided advantage in cases where the R.E. are not represented on the staff of Headquarters. But it is not only in camp, but in the field too, that the O.C. R.E. must be constantly at the G.O.C.'s side so that he can at once send orders or information to the R.E. as the situation changes or develops. An O.C. of a Field Company has in addition to the mounted N.C.O.'s, who will probably be required with the mounted section, a mounted trumpeter who can well be used in carrying orders and messages.

Secondly, it is valuable experience for R.E. to train with other arms as by this means all learn each other's capabilities and limitations; and even in such matters as march discipline (for which on one occasion the 12th Company was specially commended by the Brigadier at the daily conference) the R.E. learn to take their place in a fighting column.

Again, it is very necessary for all ranks to be imbued with the spirit of initiative; N.C.O.'s and sappers must not wait for orders, or to be interrogated, but must themselves suggest where a trench should be sited or how a bank should be strengthened. This can only be done thoroughly if N.C.O.'s and men understand the scheme and what is taking place; and, if the O.C. R.E. is in touch with Headquarters he will be able to give early explanation of the G.O.C.'s intention, what it is proposed to do, and what are the dispositions of the other arms. This spirit of initiative is an important factor, and the other arms expect to find it in the R.E.

Lastly, seeing how much is expected of R.E. it is essential that the Royal Engineer should be a man whose technical qualifications are of the highest, and one who is also educationally fitted for the responsibilities which he must be prepared to take.

It was gratifying to find on the conclusion of the training that the efforts of the R.E. to make the training a success so far as they were concerned had met with the approval of the Brigadier who wrote conveying his appreciation of all the work the R.E. did, and hoping that the tactical aspirations of the R.E. as regards R.E. work had been more fully satisfied than in the previous year. This measure of success was only achieved because the Brigade Staff realized that the R.E. were there to be used, and gave them every opportunity of working in conjunction with the infantry and artillery.

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

(Continued).

In last month's *R.E. Journal* three papers, referring to the year 1809, were reproduced, and in the present issue a further instalment is given consisting of Capt. Squire's report on the first assault on Badajos in 1811, as well as some letters and memoranda from Sir R. Fletcher on engineering details of the siege.

The first memorandum by Sir R. Fletcher speaks only of "a particular service," but, as it was docketed with other papers referring to the Siege, it most probably refers to it.

(1). *Memorandum by Sir R. Fletcher.*

VILLA FORMOSA,
10th April, 1811.

Return of Ordnance contained in the accompanying list from Elvas, which it may be necessary to employ for a particular service, and which should therefore be examined under the direction of the Commanding Officer of Artillery with the Ammunition and Stores of every description belonging to it :—

GUNS.	
24 Prs. (Brass)	30
Mortars—(Brass).	
13 Inches	2
12 Inch	4
11 Inches	1
3 Inch	6
Howitzers.	
9 Inches	4
7 Inches	6
7 Inches	4

Ammunition.

To be in readiness—400 rounds for Gun and 200 for each Howitzer or Mortar with the proper proportion of grape and case shot for the two first descriptions of Ordnance.

(Sd.) RICHARD FLETCHER,
Lt.-Colonel, Commd. Rl. Engineers.

(2). *Letter from Lt.-Col. H. Hardinge to Capt. Squire, R.E.*

ABOUNA,
April 12th, 1811.

MY DEAR SIR,

The Marshal requests you to draw out an estimate of all that may be requisite to undertake the Siege of Badajos. It is very desirable to commence against the place with as little delay as possible—

Elvas cannot probably furnish much more than Guns, Powder and Shot of which Major Dickson can probably give you information—He begs you will consider and specify the means which you conceive the country on both banks of the Guadiana can supply in Gabions, Fascines, Timber for Platforms, etc., which the Marshal imagines can be prepared in the neighbourhood of the place, and that the Militia and Country people can make them, the Dimensions or models being given. Sandbags it will probably be difficult to obtain in sufficient quantities. Intrenching Tools will be a very principal want, but the Marshal begs your attention to the Working Tools made use of by the Country people, and whether with those from Elvas or now in your possession, it may not be possible to undertake the Siege of the Place applying to this object the means of every description which Elvas, the Army, and the Country can provide —Should the Country Tools be considered applicable, you will be so good as to state the nature and numbers required and the other articles likely to be procured in the country and which the Marshal will endeavour to obtain—

He desires me to remind you (although it will not have escaped your attention,) that the repaired breach may not be very perfect, and that you may judge it adviseable to conduct your approaches by those recently made and since filled up by the Enemy and which may render the inefficiency of the Tools less a matter of importance than it would otherwise be.

He also desires that you will take into consideration the circumstance of the Strength of the Enemy's garrison which he has reason to suppose does not exceed 1,500 men.

Believe me very truly,

Yours,

(Sd.) H. HARDINGE,

CAPT. SQUIRE, Royl. Engrs., etc. *Lt.-Col.*

(3). *From Lt.-Col. H. Hardinge to Capt. Squire, R.E.*

April 11th.

MY DEAR SIR,

The Marshal begs you to inform Major Dickson that he wishes him to remain with you for the present.

He has ordered 160 men of the Portalegre Militia to work at the trenches, these are the shy gentlemen who would not show their faces in the Defence of Campo Maior. Don't spare them in work for it is to be a punishment.

H. HARDINGE.

(4). *From Capt. Squire, R.E., to Lt.-Col. H. Hardinge.*

April 11th.

MY DEAR COLONEL,

I have just received your note of this day. I hope and trust the Marshal may be induced to alter his determination with respect to the Portalegre Militia. We shall need a working party of 200 men to be relieved every 4 hours and, as for our intended operation our *travailleurs* ought to be good men and true, I entreat the Marshal that our working parties may be taken from the troops which remain before Olivença. Besides we shall certainly want 20 intelligent masons and 20 good miners. Without such assistance I fear our operations will neither be of advantage to the service, nor do any credit to ourselves. Besides good superintending officers are indispensible. I know from experience how little I can depend upon the officers of Militia. Pray represent the subject to the Marshal for your note has thrown me into such a fit of despair that I see no relief for me unless certain efficient means are placed at my disposal.

I had fondly hoped that for our intended operations we should have had some of the best English soldiers in the Army. I shall do whatever I am ordered but in my present situation I think it right to speak the truth. Our Department has no means within itself and unless I am permitted to select such means as I think necessary to our success, I foresee great difficulties, great delay and consequently great discredit.

Believe me
Ever yours,
J. SQUIRE.

(6). *Memorandum from Capt. Squire, R.E.*

OLIVENÇA, *April 18th*, 1811.

SIR,

I request you will submit to his excellency Marshal Beresford the propriety of forming a Corps of Artificers (amounting to 100 men) from the British Regt. of Line, who should be attached to the Engineer Dept. during the attack on Badajoz.

Viz: Miners—50; Carpenters—20; Masons and Bricklayers—24; Smiths—6. Total—100.

Such men as have been employed in the lines in front of Lisbon will be best calculated for this service.

I should recommend that the men be regularly paid at the same rate as Military Artificers employed in England.

I have the honor to be
Your very obedient servant,
JOHN SQUIRE.

(7). *Memorandum of Instructions for the Siege issued by the Brigade Major, R.E.*

Orders and Instructions for the Guidance of the Engineers at the Siege of Badajos.

Arrangement and Distribution of Officers and Men.

Capt. Squire is to have the general superintendence of the attack under the orders of the Commanding Engineer.

The other Engineers and Assistant Engineers are brigaded as follows:—

1st Brigade.	2nd Brigade.
Capt. Patton.	Capt. Ross.
2nd Capt. Dickinson.	Lieut. Emmett.
Lieut. Thompson.	Lieut. Melville.
Lieut. Whitford, Asst. Engineer.	Lieut. Medlicott, Asst.

3rd Brigade.	4th Brigade.
Capt. By.	Capt. Macleod.
Lieut. Forster.	Lieut. Stanway.
Lieut. Davey, Assist.	Lieut. McPherson, Asst.

5th Brigade.	6th Brigade.
Capt. Boteler.	Capt. Mulcaster.
Lieut. Reid.	Capt. Mienite.
Ensign Leslie, Asst.	Lieut. Wright.
	Lieut. Goldfinch.

7th Brigade.
Capt. Wedekind.
Lieut. Hunt.
Lieut. ——, Asst.

To each Brigade of Officers is attached 1 N.C. Officer and 14 Privates Mechanics and 1 N.C. Officer and 5 Privates Miners—the former are to be considered as an integral part of the Brigade, and will invariably take the same tour of Duty as the Officers, but the Miners are to be considered as separate bodies attached to the Brigades and will occasionally be ordered to any duty when the rockiness of the Soil in any particular operation may render necessary their united exertions—

There are six Brigades of Carpenters of 8 each for the purpose of laying Platforms and constructing Magazines and their duty will be regulated as the work requires them and by an Order from the Commanding Engineer.—

To the Clerk of Stores at the Park are attached 2 N.C. Officers and 6 Privates R.M. Artificers, of whom 1 N.C. Officer and 3 Privates will be constantly on duty.

Method of carrying on the Duty.

The Duty of the trenches will be done by Brigades—

The Hours of relief being 4 p.m. Midnight and 8 a.m. The tour of Duty of the Brigade will be given out in daily orders.

On no account is the officer commanding a Brigade to withdraw from the Trenches till the officer relieving him expresses himself fully to understand the work in Progress, and he is to take particular care to explain to the relieving officer any Verbal directions received during the time of his being on duty.

Distribution of Workmen in the Trenches.

The Workmen are to be so arranged that 30 men shall occupy a line of 40 yards, *i.e.* the men shall be four feet apart, and in that proportion it is expected that in the first relief or 8 hours work a Trench shall be sunk at least $\overset{\text{ft. in.}}{3\text{-}6}$ deep by 4 feet in width.—

Parallels.

The first parallel when completed will be 12 feet wide at the bottom and $\overset{\text{ft. in.}}{3\text{-}6}$ below the level of the Natural ground—of which the full depth and 4 feet in width is to be excavated the first night.—

Tracing Fascines are to be laid to mark out the direction of the parallels, and the ground is to be opened two feet behind them and the earth to be thrown in their front in order to leave the space for the Banquette. The ascent to the Banquette will in the 1st instance be made as circumstances will admit of but is afterwards to be made with one step one foot in breadth.

The inclination of the Superior Slope of the Parapet when finished not to be greater than is absolutely necessary to give it a proper command of the ground in its front.—This is particularly to be attended to, that it may be completely shot proof.—

Approaches.

Approaches when completed are to be 10 feet wide at the Bottom, and $\overset{\text{ft. In.}}{3\text{-}6}$ deep below the Natural level of the Ground and each return is to be prolonged 15 feet towards the Rear.

Batteries.

In the construction of batteries when it is feasible, two Parties are to be employed, one in the Ditch to throw the earth inwards, the other in the inside to lower the Terreplein 2 feet and to throw the earth outwards.

All Batteries thrown up within 800 yards of the place are to have a thickness of Parapet at the top of 18 feet, and in no situation are to be made with a less thickness at the top than 15 feet. The Superior Slope will *rise outwards* and be made one twelfth the thickness—

The Parapets of all Batteries on the same level with the place to be made 7 ft. 6 in. high, those on a lower level 8 feet high, and in no situation are they to be made less than 7 feet—

It is intended that the interior of the Batteries should be supported with Gabions, and they have been made 3 ft. 6 inch in height, so that two Gabions by the addition of more or less earth to Cover them will in all situations form the height of the Parapet—all fascine work to have a slope of one foot in 3 feet, and Gabions of one sixth.—

Embrazures.

The Embrazures are to be laid out 22 feet from centre to centre when no obstacle to this being so shall present itself—Embrazures for guns to be made 2 feet wide at bottom on the inside: the slope to the cheeks to be one third unless they are to be retained by Gabions in which case it is to be only $\frac{1}{6}$.

Embrazures for Howitzers to be made 2 ft. 4 in. wide at bottom on the inside and the sill to be sloped upwards with the same inclination as the Parapet—For the height of the Genouilliere no rule can be given as the gun carriages are of various heights—

Platforms. The Platforms are to be made 12 feet wide at the Tail, 8 feet wide in front, and 12 feet long with four sleepers, and they are to be laid down with an inclination $\frac{3}{4}$ of an inch in a foot.

Traverses. Splinter-proof Traverses are to be made in all the Batteries between every second Gun or Howitzer, their construction to be as follows:— 12 feet long, 6 feet high and 6 feet thick at top, placed at right angles to the Parapet and two feet distance from it at the Bottom:—

Magazines. The Magazines are to be made of the Splinter-proof construction, to be placed behind a good traverse or some secure cover—The Splinter-proof Timbers are cut of the following Dimensions:—12 feet long, and from 7 to 10 inches in diameter, and they are to be placed at an angle making the base half of the height—

The communications from the Magazines to the Batteries to be made 4 feet deep and 6 feet wide—

By order of the Commanding Engineer,

(Sd.) JOHN T. JONES,

Brigade Major.

To CAPT. SQUIRE, Rl. Engineers.

(5). *Memorandum from Sir Richard Fletcher.*

ELVAS,

7th May, 1811.

Memorandum.

Capt. Squire is charged with the direction of the attack against Fort St. Christoval—

As soon as Badajos shall be invested on the right bank of the River, he will choose a convenient Situation to form the Depôt of Stores—

He will select a favourable spot for the construction of a Battery of three Guns and two Howitzers to ruin the defences of St. Christoval and the parts of the Scarp Wall most exposed—This Battery should if possible be so placed as to enfilade the old wall of the East front of the body of the Place, without being itself exposed to the fire of two heavy Batteries commanding the Gorge of the Fort.—

If this situation should be favourable for the eight pieces of Artillery appropriated for the right bank of the River, and should not only enfilade the east front of the main work but command the North Wall near the angle, it would seem desirable to place the whole in one Battery—Should this not be the case another spot will be chosen to assist in these objects, and if practicable the second Battery should go forward at the same time with the first --

Such Parallels as appear necessary for a first covering party and proper trenches of communication will of course be added.

The Enemy having quitted St. Christoval, Capt. Squire will either by occupying the work itself, or by sinking cover for a body of men, Endeavour to prevent its being re-occupied but in doing this care must be taken to avoid an enfilade fire from the *Tête-de-pont*—

If a Battery for two or three Field-Pieces could be thrown up in some Covered Situation to enfilade the bridge it might of course tend materially to keep the Enemy within the body of the place—

(8). *Letter from Capt. Squire, R.E., to Sir R. Fletcher.*

RIGHT OF Y^E^ GUADIANA,
May 10th, 1811.

SIR,

I have the honour to report to you that at 7 a.m. the enemy made a sortie from Fort Christoval and from the line between that place and the bridge—They gained the parapet of our battery, but were immediately repulsed—our loss I believe has been rather severe—Lt. Reid was in the battery at the time he has received a slight contusion, but he is not incapacitated from doing his duty—It gives me y^e^ greatest pleasure to report to you the very handsome manner in which Col. Hammond and all the officers of the Covering party speak of the gallantry and zeal of that Officer. The battery has received no damage from the enemy's Infantry, but has been much injured by the heavy guns from the place—

I feel it my duty to call your attention to the present state of our operations—with our present means we cannot employ more than 300 men and as I shewed to you yesterday a battery directed against the bridge and the bridgehead appears to be absolutely indispensible—

The enemy seem now to have directed their whole attention to the attack of y^e^ right of the Guadiana, and if you do not carry on at present operations against y^e^ place on the left of the river would it not be adviseable to increase our means on this side of the water that we may proceed with vigour and effect—If Capt. Hawkin's brigade of Arty., a brigade of British Infy., and entrenching tools for 600 men were sent to the right of the Guadiana we might carry forward our operations with more confidence and a greater probability of success.

I have the honour to be,
Sir,
Your very obedient servt.,
(Sd.) J. SQUIRE.

Half a battn. of riflemen from Gen. Alten's brigade would also be of y^e^ greatest advantage. If we receive these reinforcements an additional brigade of Engrs. would be necessary.

Capt. Dickinson joined me last evening.

J.S.

(9). *Two letters from Sir R. Fletcher to Capt. Squire dated the 11th of May, 1811.*

CAMP BEFORE BADAJOS,
11th May, 1811.

MY DEAR SIR,

Finding our entrenching tools even more defective than I had believed, and those from England being actually at Elvas, we do not begin our further operations till to-morrow evening—I find from the Marshal that you are overpowered by fire, and I really think you would do well to block up your Embrazures entirely for the present, and even to have the guns withdrawn, that they may not be ruined by shells—I have ordered you English entrenching tools for 400 men immediately—I trust you will get them to-morrow morning, and 15,000 sandbags—

Ever very truly yours,
(Sd.) RD. FLETCHER.

CAPT. SQUIRE, Royal Engineers.

CAMP BEFORE BADAJOS,
11th May, 1811.

MY DEAR SIR,

I am truly sorry to hear that you have lost Capt. Dickinson and Lt. Melville—Pray have an inventory of their effects made, and the things themselves sent to Elvas, when you can.

We break ground this evening, and if your Battery can remain open in the morning, can you direct two or three of the guns to take in reverse and enfilade the guns in the Castle that can bear upon us—This might greatly assist us—If you cannot remain open, had you not better block up the Embrazures entirely, until your other Battery is ready? From the number of shells I see thrown I hope you are well traversed.

Believe me,
Yours most truly,
RD. FLETCHER.

(10). **Two letters from Sir R. Fletcher to Capt. Squire dated the 14th of May*, 1811.

CAMP,
14th May, 1811.

MY DEAR SIR,

I have this moment received a letter from the Marshal saying that continuing the entrenchments on this side is now out of the question, and that it is useless to work on one side or the other—that he was only waiting (at 3 p.m.) for D'Urban to determine if to withdraw the

* These two letters evidently refer to the first raising of the siege which preceded the Battle of Albuera, fought two days later.—ED., *R.E.J.*

troops to-night—As soon as the Guns and Stores are over I am to withdraw the Bridge at the mouth of the Caya—The Marshal says Soult was yesterday at *——— You had better send off to Elvas all you have. Your Batteries are now of little importance.

Yours ever truly,
RD. FLETCHER.

CAMP BEFORE BADAJOS,
14th May, 1811.

MY DEAR SIR,

If you have not already sent off all your stores, pray suspend that operation till you receive further directions, and do not destroy any timber, etc., that you did not think worth sending to Elvas—

Will you have the goodness to come over to me as soon as you can after the receipt of this letter. My Quarters are at an old chapel about 2,000 yards on the East of Badajos, and a little north of the Idowna Road—

Yours ever truly,
(Sd.) RD. FLETCHER.

CAPT. SQUIRE, Royal Engrs.

(11). *Report on Operations on the Right Bank of the Guadiana by Capt. Squire, R.E.*

CAMP BEFORE ST. CHRISTOVAL,
June 12th, 1811.

The attack on the right bank of the Guadiana consisted of four batteries with a parallel and trenches of communication. The batteries were numbered from the left and the Brigades of Engineers were distributed in the following manner :—

		24-Prs.	8-in. Howit.
No. 1	2nd Brigade	7	0
" 2	2nd Brigade	3	2

The object of No. 1 was to destroy the batteries and dismount the guns in the Castle and afterwards to enfilade the front of the Castle attacked.

The object of No. 2 was to breach Fort Christoval with the Guns and to enfilade the line of the Castle with the Howitzers. Should the Scarp wall of Christoval be sufficiently destroyed by the guns of No. 3—No. 2 would co-operate with No. 1 in enfilading the front of the Castle attacked.

	24-Prs.
No. 3—7th Brigade	4

The object of No. 3 was to ruin the parapets and dismount the Guns in Fort Christoval.

	16-Prs.	10-in. Mortars.
No. 4—5th Brigade ...	4	2

* Name illegible.—ED., *R.E.J.*

The object of No. 4 was to enfilade the Bridge and check sorties with the guns and with the two mortars to fire into Christoval and into the *tête-de-pont* if necessary.

The Parallel extended from No. 2 to the right of No. 4 and was about 900 yards in length.

The trenches were opened on the night of the 30th and 31st May.

Journal.

30th and 31st May.

Working Parties.

No. 1 and 2	400 men
No. 3	200 ,,
No. 4	200 ,,
Parallel	400 ,,
Total	1,200 ,,

Enough tracing fascines had been made at the Park to trace the whole line of the parallel.

The distribution of the Covering party delayed the commencing of our work; we did not break ground till 10 p.m. and the parties were withdrawn at daylight—½ past 3 a.m. Little progress made in Nos. 1, 2, and 3 on account of the rocky soil. No. 4 well advanced. The parallel opened and in the low ground cover obtained. On right of No. 2 soil rocky and not possible to remove without blasting.

31st May.

No. 1 and 2	100 men
No. 3	100 ,,
No. 4	100 ,,
Total	300 ,,

The platforms in No. 4 completed before sunset as well as three platforms in No. 3—obliged to blast the rock in No. 3 to make a level place for one of ye platforms.

31st May and 1st June.

No. 1	200 men
No. 2	200 ,,
No. 3	200 ,,
No. 4	200 ,,
Parallel...	400 ,,
Total	1,200 ,,

The men at work generally at ½ past 8 p.m. and the same party continues at daylight the work at No. 1 and 2. Much interrupted by shot and shells, extremely well directed.

The Guns and Mortars in No. 4 were mounted at midnight and 2 magazines finished.

June 1st.

No. 1	100	men
No. 2	100	„
No. 3	100	„
No. 4	100	„
Parallel	100	„
Total	500	„

The soil of No. 1—hard rock, obliged to blast for the platforms. The platforms in No. 2 laid this day—and 4th platform in No. 3—

June 1st and 2nd.

No. 1	200	men
No. 2	200	„
No. 3	200	„
No. 4	200	„
Parallel	200	„

The Parallel opened and generally completed to 8 feet in width. No. 1 and 2 much tormented by large shells well directed: the trenches to the right and left of No. 4 completed.

June 2nd.

No. 1 and 2	200	men
No. 3	100	„
No. 4	100	„

The men employed in filling sandbags at No. 1 and 2—at No. 3 and 4 in making trenches of communication and traverses.

June 2nd and 3rd.

No. 1	200	men
No. 2	200	„
No. 3	150	„
No. 4	150	„
Parallel	250	„

The platforms in No. 1 and 2 were laid yesterday: great difficulty in finishing the parapet of No. 1, it is made of sandbags filled in the rear with wool packs brought from Elvas.

June 3rd.

All the batteries ready to open at 7 a.m. The fire on this side of the Guadiana commences at ¼ before 10 a.m.

100 men employed in each of the batteries in making communications, traverses, etc.—

Before sunset one gun—one mortar and one Howitzer disabled by our own fire. A 10-inch shell fell and burst on the angle of the large magazine in No. 2, but without doing any injury.

3rd and 4th June.

No. 1	...	...	...	...	100 men
No. 2	...	...	...	...	100 „
No. 3	...	...	...	...	100 „
No. 4	...	...	...	...	100 „

The embrazures and traverses repaired during the night, and a good parapet for musquetry formed on right and left of No. 4 and on right of No. 2.

4th June.

50 men employed at each battery in repairs, etc.: before sunset both mortar beds useless and one gun in No. 1, by our own fire—

4th and 5th June.

50 men at each battery for repairs, etc. Lt. Forster approaches the Salient angle of the ditch of Fort Christoval, and reports the ditch to be no obstacle. This night we commenced two additional Embrasures on left of No. 1—

June 5th.

50 men at each battery—Lord Wellington desires one gun to be added to the right of No. 1—and another to the left of No. 2—one gun disabled this day in No. 1 by its own fire.

5th and 6th June.

250 men.

200 employed on No. 1 and 2, in adding 3 embrasures for one Gun and 2 Howitzers in No. 1, and for 1 gun on left of No. 2: all but one embrasure for the Howitzer was completed during the night, and the 3 Platforms finished; the 2 Howitzers are mounted; No. 3 is dismantled and the guns moved forward to No. 1.

6th June.

50 men at each of the batteries. The enemy fire little from the Castle—

6th and 7th June.

150 men employed on repairs.

The breach in Fort St. Christoval though certainly not good appearing practicable for at least 2 men at once, it was decided to assault the place; particularly as Col. Fletcher had written to Lord Wellington stating that the main attack was extremely annoyed by a light gun from Christoval. The duty of accompanying the assaulting party fell upon Lt. Forster as first Subaltern, although he indeed most handsomely volunteered his services. The assault took place at midnight, and the troops retired at one a.m. having failed in their object. Lt. Forster accompanied the advance; on his arrival at the breach he found that the rubbish had been cleared away, and that all access was impossible: ladders were applied to the wall but in vain, the enemy making a most obstinate resistance, they filled the ditch with shells, grenades, stones and rubbish. Forster received a slight contusion at the breach. As he retired a musquet ball passed through his body, and his wound was considered mortal. His excessive bravery on this occasion was the admiration of all who saw him. Our loss in the assault was 102 killed and wounded.

7th June.

100 men employed in repairs, etc. In No. 1 and 2; only 7 Guns and 2 Howitzers serviceable, the rest disabled. Lord Wellington recommends a second attempt as soon as the breach of S. Christoval is improved.

7th and 8th June.

Working party—120 men employed in repairs, etc. Grape fired occasionally from the guns and howitzers to clear the trench, and prevent the enemy working.

8th June.

100 men employed at the batteries. At 8 meet Lord Wellington and Col. Fletcher when it was decided to assault Christoval this night, but Col. Fletcher having stated that to take Christoval was not now of so much importance as he had altered the approach that was enfiladed. I recommended that the assault should be delayed for 24 hours when the breach would be more practicable. My proposal was agreed to. Poor Forster breathed his last at ½ past 11 a.m.; in him we lose a most promising officer, his zeal and undaunted courage will for ever be remembered.

8th and 9th June.

100 men employed at the batteries—Grape and round shot fired upon the breach.

9th June.

100 men employed at the batteries. The assault of Christoval was decided upon for this evening and as Lt. Emmett was not well—the duty of accompanying the storming party fell upon Lieut. Hunt—

9th and 10th June.

100 men at the batteries—The assaulting party advanced at 9 p.m.—The resistance was most obstinate—At 10 our troops were compelled to retire—Such was the conduct of our Officers and men that if success had been possible we should have succeeded—Lt. Hunt of the Royal Engineers was killed at the crest of the glacis—he is spoken of by all who knew him in the highest terms.

10th June.

At 7 a.m. Lord Wellington having decided to raise the siege we began to move our stores and entrenching tools to Elvas—100 men at the batteries.

10th and 11th June.

300 men—at the batteries.

Continue to empty sandbags and remove stores and timber during the night.

11th June.

Continue to remove stores and timber—200 men employed—

11th and 12th June.

200 men employed—

All the platforms, magazines, timber, etc., removed—and the batteries cleared before daylight—and the whole ready to be forwarded to Elvas—

(Sd.) JOHN SQUIRE,
Capt., Roy. Engrs.

(12). *Report on Execution of Assault.*

Execution.

June 9th and 10th, 1811.

Every arrangement being made and clearly understood by every officer and almost every man of the party—

Precisely at 9 the signal was made for the advance, and as the moon did not rise till ½ past 9, the different detachments arrived at the crest of the glacis without being perceived. As soon however as they descended into the ditch the enemy rolled down 5½-in. shells, grenades and fired musquetry from the parapets both at the Salient angle and the breach: the ladders however were planted in both places, but the enemy by means of large stones, and by poles threw down our men as they mounted to the assault. The gun in the flank of the left demi-bastion also fired upon the Salient angle. About ½ past 9 an Officer of y^e 51st arrived at No. 2 Battery stating that our loss was very great, that most of our Officers had been killed and that success was impossible. Capt. Maitland, Genl. Houstoun's A.D.C., immediately rode and informed the General of the fact; at ¾ past 9 he reached the battery and an order was dispatched for the retreat of the detachments. At 10 p.m. the whole had retired and all firing ceased. The Castle battery fired grape shot; we had also several shells from the town and the *tête-de-pont*. The enemy it seems had cleared away the rubbish at the foot of the breach—so that to apply ladders became necessary, but with such resistance success was impossible. Every exertion was made both by Officers and men that could be made by the bravest troops in the world.

Christoval can only be taken by advancing our batteries to the crest of the glacis.

(Sd.) J. SQUIRE,
Capt., R.E.

ECHOES FROM THE ENGINE ROOM.

(*Continued*).

By "INSPECTOR."

ECHO NO. 14.

HEAD AND LIFT.

When a pump is installed to shift water from one (lower) level to another (higher) level the difference in height between the two levels may be referred to as the "total static head," or briefly as the "static head." Ordinarily the pump will be sited somewhat above the lower level and appreciably below the higher level, under these conditions water will have to be lifted on the suction side of the pump and pushed on the delivery side. Apart from the "head" due to the actual difference of levels the flow of water will be opposed by the friction in the pipes and valves, in the pump, and in the meter, if any. Hence the "total head" to be pumped against will consist of the static head plus friction head, and as regards the latter it must not be forgotten that it occurs upon the suction side of the pump as well as upon the delivery side. Broadly speaking the friction varies in a complicated way, but with any given size of pipes and apparatus the resistance due to this cause varies directly as the square of the number of gallons passing, whether those gallons be lifted, pushed, or flow by gravity.

Although convenient to refer to the total head upon the suction side of the pump as the "lift," no intelligent reader will suppose that the water is actually lifted. The pump creates a vacuum, more or less imperfect, whereby the weight of the atmosphere acting upon the surface of the water in the (presupposed) well is enabled to push the water up the suction pipe to a height dependent upon (i.) principally the degree of vacuum produced and (ii.) the frictional resistance offered to the flow of the water.

The maximum "lift" against which a pump will work depends somewhat upon the type and design of pump. A pump-end with large clearance spaces and with badly arranged valves will have a smaller maximum lift than, say, a well-designed piston pump with small clearances. The differences in this respect are however eliminated almost entirely if adequate arrangements are made for charging the suction pipe with water or for exhausting the air from it before the pump is put to work. These points are dealt with at greater length under the heading of "Suction Chamber" and in what follows here it is assumed that although the pump is not unduly handicapped by design or otherwise, no special air exhausting device is provided.

Were the pump capable of producing a perfect vacuum it would be permissible to make the lift nearly equal to the number of feet head of water equivalent to the absolute air pressure at the locality. The vacuum theoretically attainable depends upon the height of the place above sea level and upon the temperature of the water to be pumped. For practical purposes it is near enough to take the vacuum attainable at sea level as equivalent to 33′ "lift" with water not exceeding 60° Fah. For heights above sea level it is near enough to allow a deduction of one foot of "lift" per 1,000′ increase in elevation. An engineering pocket-book may be consulted as to the necessary correction for temperature of water. In practice this correction may be ignored as regards pumping stations unless the temperature of the water exceeds 60° Fah., but it can by no means be neglected if the water to be pumped in is what is commonly called "hot," *e.g.*, the condensed steam discharge from air pump of condensing plant, or water after treatment in a feed water heater. It is commonly stated that when the water is "hot" it must gravitate to the pumps, and although this can generally be arranged for there seems to be no just cause why such water should not be "lifted" if necessary, subject to a suitable limitation upon the lift attempted. In the case of a pumping station it is undoubtedly desirable that the water should gravitate to the pump upon the suction side, but actually it is generally necessary to lift the water more or less upon that side.

It frequently happens that the water in a well falls while pumping is in progress, so that there may be two water levels to be considered, viz. :—(i.) the normal level, (ii.) the working level.

The "actual" lift against the pump reckoned from normal level should not exceed 70 per cent. of the lift theoretically attainable, and the corresponding figure for the working level should not exceed 75 per cent. with an outside limit of 80 per cent. of the lift theoretically attainable from that level. For example, if the friction is calculated as 2′; then, at sea level, the suction valves in the pump barrel should be not more than $\frac{7 \times (33-2)}{10} = 21{\cdot}7'$, above the normal water level (cold water). And under those conditions it would be unwise to rely upon the pump, while working to lower the water level more than $\frac{75 \times (33-2)}{100} - 21{\cdot}7 = 1\tfrac{1}{2}'$, and the pumps would almost assuredly cease to draw water at all when the *total* lift amounted to $\frac{8 \times 33}{10} = 26{\cdot}4'$. Although when everything is in first-class order it may be possible to somewhat exceed the limits given above, *e.g.*, if a suction vessel with steam ejector is fitted on the suction pipe, under no circumstances whatever should the 80 per cent. limit be exceeded.

The above figures refer to pump ends of 6″ diameter and upwards and to centrifugal pumps of 6″ size and upwards; smaller pumps cannot be relied upon to work up to those limits. As much as 7′ should be deducted from the figures for reciprocating pump ends of 3″ diameter, and for centrifugal pumps the corresponding deductions would be about 5′ for 4″ size, and 10′ for smaller sizes.

Echo No. 15.

AIR VESSELS.

It is usual to provide all reciprocating pumps, except the smallest sizes, with an air vessel on the delivery side; failing this an air vessel is sometimes fitted on the delivery main itself, close to the pump outlet.

The object of such an air vessel is to reduce the fluctuations in the flow of water caused by the successive strokes of the pump and thereby eliminate water hammer in the rising main. It also acts as an elastic cushion and enables the pump valves to open and seat themselves with less shock.

A pump with which the variation in rates of flow is great should apparently have a bigger air vessel than would suit a pump for the same output but with a more even delivery. For example a single acting single ram pump should have a larger air vessel than a double acting duplex Worthington pump. That there is nevertheless some doubt in the matter appears evident from the practice of different makers. The variation in flow from a triplex power pump with single acting rams is small provided all three rams are working properly, nevertheless most modern pumps of this type have an air vessel and in some cases there is a separate air vessel for each ram. Again some of the earlier double acting duplex Worthington pumping engines had very large air vessels, but modern examples of these pumps have air vessels that are exceedingly small for the size of pump, the contention being that the variation of flow is so small a large vessel is unnecessary. Yet with another make of pump also double acting and duplex, but of the flywheel type, quite a large air vessel is provided. A final instance may be mentioned of a double, differential-ram flywheel pumping engine of about 25-H.P. working well and quietly at a ram speed of 127′ per minute, against a head of 1,500′ without any air vessels at all.

It is probably open to question whether the small air vessels on modern Worthington pumps are really big enough, and it is thought that the differential ram pump referred to could be run faster without knock were it equipped with air vessels. In support of this view it may be mentioned that an air charging apparatus for insuring that the air vessels may be kept filled or partly filled with air, forms an integral part of the Oddie-Barclay express pumps and of the larger sizes of hydraulic rams, and such apparatus is sometimes provided with large pumping machinery. In the case of a small Worthington pump not fitted with an air vessel it was found possible to increase its speed and output some 10 per cent. after an air vessel had been fitted. In one case a 15-H.P. modern Worthington pumping engine running at 55 cycles per minute (ram speed is 92′ per minute) delivers through a steel main into a steel reservoir against a head of 850′. Standing by the reservoir it sounds as if some one was hitting it hard with a good big hammer. The pipe in this case has flanged joints which have withstood this hammering satisfactorily for years, but it is suggested that the hammering would be much lessened or, indeed, eliminated were the air vessel on the pump larger.

The examples referred to indicate the uncertainty that exists as to the size of air vessel to be provided or indeed as to whether any such adjunct is necessary at all. It is however contended that not only should an air vessel be used but that it should be properly located and of a size suitable to the size and type of pump.

For a single acting, single ram, pump the volume of the air vessel may be equal to as much as 20 times the displacement of the ram per stroke. For single, or double, acting 3-throw pumps the air vessel has, in some designs, been given a volume as large as ten times the displacement of one stroke of one ram; this is perhaps needlessly large. For two barrel double acting pumps (more or less corresponding to an ordinary "duplex" pump) an air vessel equal in volume to 12 times the volume of one pump barrel is not unusual. No definite rules can be given, but a volume equal to six times the displacement of one stroke of one side or section of the pump seems an approximate *minimum* figure. With pumps of about 15-P.H.P. and upwards it would usually be worth while fitting the air vessel with gauge glass and cocks.

To be effective an air vessel must be suitably placed relative to the flow of water which it is intended to control. The more directly the water can flow straight into the air vessel the better chance has that vessel of satisfactorily performing its proper functions. If the pump is sited on a hillside or if the pump is placed below the general ground level in order to get within suction distance of the water it is probable that the delivery pipe rises, more or less, straight away from the pump. On the other hand the delivery pipe will, in many cases dip down after first leaving the pump. In the former case it may be best to purposely introduce some change of direction in the rising main, at, or close to, the pump, in order to locate the air vessel effectively, unless the vessel can be placed on the pump itself. In the latter case the air vessel should be placed on the pump side of the dip referred to. In two cases known to "Inspector" an air vessel has been fixed on the side of the dip remote from the pump, and although the air vessel in each case is large it seems to make but little difference whether it is full of air or has no air in it.

In conclusion it may be remarked that the matter is by no means a simple one, for, whereas in one case it may be found advantageous to work with the air vessel nearly full of water, in another it is preferable to use a large air cushion.

ECHO NO. 16.

VACUUM VESSEL.

An air vessel fixed on the suction side of a pump may be conveniently called a vacuum vessel although if the water gravitates to the pump the mean pressure in such a vessel will be more or less above atmospheric pressure.

Unless the suction pipe is quite short, a vacuum vessel on the suction side of a pump is no less desirable than is an air vessel on the delivery side, whether the water gravitates to the pump or has to be lifted. In the former case the pressure on the suction side may, due to the inertia effect of the water, reach an incredibly high figure if no vacuum vessel is provided, and in the latter case the presence of the vacuum vessel equalizes the flow of water in the suction pipe and gives the pump a better chance of drawing a full stroke of water.

It is relatively unimportant if there is a change of direction between the suction pipe and the pump but the vacuum vessel should be fixed so that the water can flow directly into it, and it should, preferably, be placed close to the pump.

As regards size, a vacuum vessel, which acts merely as a shock absorber in the manner indicated above, may be made not smaller than half the size of the corresponding air vessel. If, however, the vacuum vessel also acts as a "suction chamber" it will be desirable to make it at least equal in size to the air vessel.

Echo No. 17.

SUCTION CHAMBER.

If the water has to be lifted from below the level of the pump, the simplest possible arrangement is when the pump is fixed directly over or quite closely adjoining the well or sump from which the water is to be drawn. In such a case the pump when put to work will draw its water without any special arrangements for charging the suction pipe unless the "lift" approaches the permissible maximum. In any case however it is desirable to provide a by-pass from the rising main to the suction pipe, and if the "lift" is large such an arrangement, or some equivalent device, is necessary.

To insure smooth working it is desirable that the pump should draw a full charge of water every stroke, it is a particularly painful and thrilling spectacle when a "Straight Line" pump misses its water. Now "ordinary" water contains a certain amount of air in suspension and if the lift is great this air is liberated under the influence of the partial vacuum formed and is liable to cause a missed or partially missed stroke unless arrangements are made to get rid of it.

If the water supply is drawn simultaneously from several wells in the neighbourhood of the pump it is convenient to connect the several suction pipes to a cylindrical "suction chamber" fixed close to, and on the same level as, the pump or pumps. In this case the suction side of the pump is connected by quite a short pipe to the suction chamber and no separate vacuum vessel on the pump is necessary.

A suction chamber forms a convenient means of coupling up the various suction pipes, and its diameter may be more or less governed by the number of connections to be made at it. Except in so far as it serves as a junction point and as a vacuum vessel for the pump the suction chamber need not be considered in any other *rôle* if the "lift" is small, and indeed its place might be economically filled by a combination of a vertical piece of piping with "Y" and other junction pieces.

Again, if the lift is small a by-pass arrangement as already referred to will suffice for charging the suction pipes with water. Although the suction pipes are fitted with foot valves it is as well not to make the by-pass, or charging, pipe too small as the foot valves may not be quite tight.

On the other hand if the lift is large the "suction chamber" has an additional important function to perform in that it acts as a collecting point for the air that escapes from the water. Under such circumstances the suction chamber should be equipped with gauge glass and fittings and with some device for exhausting the air from it and from the suction pipes both before the pump starts and also while the pump is at work. If the plant is steam driven the most convenient device for this purpose is a steam ejector (similar to the apparatus used in conjunction with the vacuum brakes on railways). For electrically operated plant or oil engine installations it seems to "Inspector" that some form of vacuum pump should be provided, although with crank controlled or flywheel pumps the necessity for a full water stroke every time is less imperative. With a suction vessel fitted in this way it is possible to keep the level of the water in the vessel above the outlets to the pumps and thereby insure a full charge of water for every stroke. The arrangement works admirably in practice, but in order to enable it to satisfactorily meet this additional function and at the same time avoid having to frequently operate the ejector the suction vessel should be made fairly large *i.e.* its height may be equal to from three to four times its diameter. Examples from actual practice are of the following sizes:—(*a*) 10′ 6″ × 4′ diam.; (*b*) 10′ × 2′ 6″ diam.; (*c*) 6′ × 1′ 9″ diam.

It may be noted that the suction pipes from the wells should enter the suction chamber close to the bottom, either all on one level or, in order to avoid making the diameter of the chamber needlessly large, the inlets may be arranged on two planes. The outlets to pumps may be on the same level as, or below, the inlets. The inlets and outlets should be individually controlled by full way sluice valves at the suction chamber. The ejector should be fixed on or close to the suction chamber and its suction be connected, through a valve, to the top of the chamber. A properly designed ejector may be reckoned upon to give a vacuum within 6″ of the barometric column when supplied with steam at a suitable pressure (between 80 to 140 lb. per square inch). Special air ejectors are also made which will give a vacuum within 4″ of the mercury column if the steam pressure applied (between 50 and 100 lb. per square inch) is properly adjusted to the requirements of the case.

(*To be continued*).

THE VARIOUS SYSTEMS OF MULTIPLEX TELEGRAPHY.

By MAJOR W. A. J. O'MEARA, C.M.G., LATE R.E.

(1). INTRODUCTION.

THIS paper deals with the various systems of telegraphy which, when working on a single line, enable one to utilize the available channels of communication either wholly in one direction or partly in one and partly in the other direction. Systems which provide more than one channel either by means of the duplex balance only or by loop circuit working with one or more channels superposed, are intentionally excluded.

Multiple systems naturally divide into certain distinct classes according to the way in which the currents are utilized for transmission. These are indicated by the following divisions:—

Class I. Signalling currents which vary not only in strength, but also in direction.

Class II. Signalling currents of moderately high frequency working in conjunction with others of different frequencies, or with ordinary telegraph currents.

Class III. Signalling currents built up of a series of impulses sent at short and very frequent intervals.

Class IV. Signalling currents consisting of a number of impulses of varying duration sent at regularly recurring intervals.

In the limited time at my disposal, it is not possible to deal with every system, and I do not therefore propose to do more than briefly refer to the principles involved, as full details of every system can be found in technical literature. The advantages and disadvantages of each of the systems mentioned are however briefly stated in this paper.

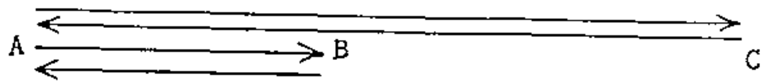
(2). MORSE QUADRUPLEX.

Class I. is well represented by what is known generally as the Morse Quadruplex with its many variations. To adopt Multiple terms, it is what one would designate a Morse Double Duplex.

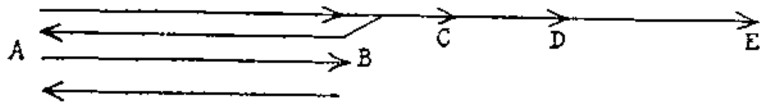
Although the main features of the system have not changed since it was first introduced into the telegraph service of Great Britain, much has done in recent years to increase the flexibility of the system in order that the channels available may be utilized to the greatest advantage.

The later-day developments of the quadruplex system are shown diagrammatically in the following cases where the lines indicate the working channels with the arrow-head indicating the direction of working.

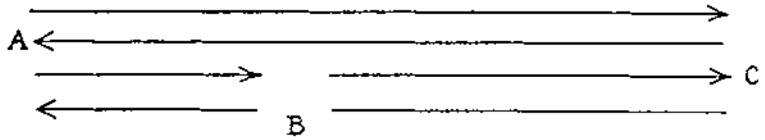
(1). Quadruplex with two channels extended.



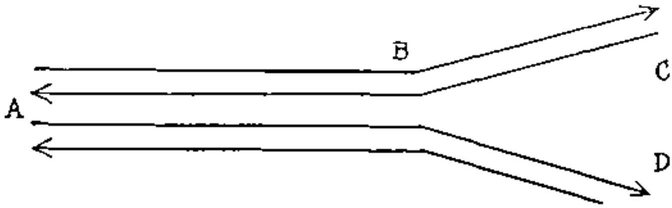
(2). Quadruplex with two channels extended as one channel to an omnibus circuit.



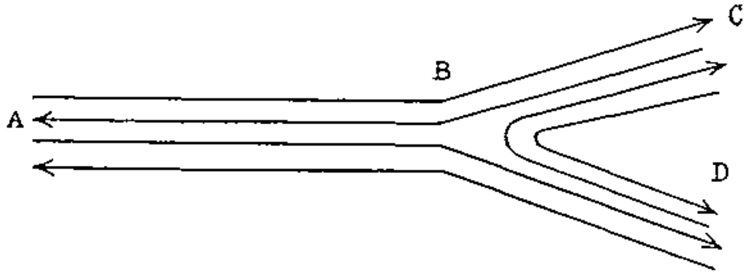
(3). Quadruplex with two channels extended to two others of a second quadruplex.



(4). Quadruplex with two channels extended to each of two different stations.



(5). Quadruplex with two channels extended to each of two other stations on a wire by which they are working quadruplex.



In the British Isles there are many of these extended circuits. In two instances a Quadruplex Repeater is used where an 80-mile section of submarine cable is joined to about 120 miles of aerial line. The repeater is distinctly complex, but it works well as specially qualified officials are in constant attendance. Although usually the four channels of quadruplex sets are worked by hand at a speed of about 25 words per minute, the polarized relay channel is often fitted with a Wheatstone automatic system working up to a speed of 150 words per minute or less according to the difficulty of the line. The amount of traffic that can be disposed of is therefore a very variable figure, and differs so greatly in different circumstances that actual figures obtained will be of no practical use without a considerable amount of detailed explanation. For this reason the speed rate of each channel in words per minute is perhaps the most useful guide for all practical purposes. It is obvious that on the polarised side, highly expert operators could work up to 40 words per minute or more: whereas on the non-polarized side where the signals are mutilated, it would not be advisable to exceed a speed of about 25 words per minute. The system has been found well suited for small offices, as its maintenance requires no mechanical skill and very little electrical knowledge beyond a few general rules for adjusting the different parts of the apparatus.

Its cost is also very low as compared with some other multiple systems, one complete terminal set costing about £35.

It may be of interest to state that at one time there was a strong division of opinion on the relative merits and advantages of the Decremental (see Appendix) as opposed to the Incremental system of working the "B" side of the quadruplex. The two systems were therefore given a prolonged trial under practical working conditions lasting a number of years. There is now no doubt that for practical purposes the Incremental method has some slight advantages and is now universally employed in Great Britain.

For many years a relaying sounder was employed in local circuit between the non-polarized relay and the reading sounder to overcome the breaks in the signals. As this arrangement involved the correct adjustment of two instruments, trouble was often experienced. Some six or seven years ago, the relaying sounders were replaced by condensers and resistance coils (see Appendix) resulting not only in economy in first cost of the plant obtained, but in a considerable simplification of the adjustments, thus rendering the system a more stable one. These changes have in consequence reduced the annual maintenance charges.

The system unfortunately still has its weaknesses, chiefly due to the fact that one cannot reverse the direction of current in a line without momentarily having no current on that line; that is to say, in reversing the current, the signalling key must either momentarily short-circuit the battery or disconnect it. This momentary interruption mutilates the signals which actuate the non-polarized relay, necessitating the use of special devices at the receiving end to mask the distortion. Unfortunately the extent of the distortion increases with the length or difficulty of the line, thus seriously limiting the practical application of the system. There are however very many lines of moderate length ranging up to 400 miles for a copper aerial line or 120 miles for an underground cable line where this system works quite satisfactorily.

(3). MERCADIER.

Class II. is well represented by the Mercadier system in which different rates of alternating currents are supplied at the transmitting end to actuate receivers which respond only to one particular frequency at the corresponding terminal station. The actual reception, if by Morse code, is obtained by the transmission of groups of long and short series of current alternations. If for Hughes working, then by the transmission of equal series of current alternations at varying intervals. The Morse or Hughes receiving instruments are in local circuit with the tuned receivers.

This system, although not adopted on British telegraph lines, has been subject to experimental investigation on two or three occasions. The results obtained have certainly demonstrated the practicability of the system from the point of view of the inventors, but the system unfortunately possesses the objectionable feature that serious disturbances are produced on neighbouring telephone circuits—described by some telephone users as resembling the singing of a number of birds.

The frequency used ranges from 480 alternations per second to 900. This obviously requires a line having a high transmission efficiency—equal to a Wheatstone speed of about 2,000 words per minute.

Owing to the close intermixing of telegraph and telephone lines in Great Britain, the system could not be generally adopted, although in certain cases where line conditions were favourable, it would prove very useful.

(4). PHONOPORE.

On a smaller scale the Phonopore is somewhat similar in principle to the system last described. It provides one channel for the ordinary Morse signals, and a second channel on which the Morse code is signalled by means of rapidly alternating currents cut up into short and long groups of current impulses.

The phonopore has been adopted to some extent by railway companies in England.

This system has also the drawback that it interferes with the satisfactory working of neighbouring telephone circuits although the disturbing effects produced are not so serious as those caused by the Mercadier. The disturbances created, however, are of a sufficient magnitude to prevent the system being adopted by the British Telegraph Administration owing to the difficulty in providing separate routes for telephone and telegraph circuits.

(5). PICARD.

The Picard is used in France to operate Hughes apparatus in the ordinary way on one channel, and to operate a second Hughes channel by rapidly alternating currents.

Neighbouring telephone circuits are disturbed by this system somewhat in the same manner as by the Phonopore, but the interference is much less than in the previous case owing to the fact that the Hughes instrument requires only one signal per letter, as compared with an average of four for the Morse.

The Hughes, however, is not used on short lines in Great Britain, and its use is confined to a few long underground cables on which it is worked duplex, or for International circuits which would not be suitable for carrying the second channel. For these reasons there is no field for this system in Great Britain.

(6). DELANEY.

Class III. is well illustrated by the Delaney system in which the separate channels are worked by the usual Morse keys each sending continuously at a rate of about 25 words per minute. A distributor at each end automatically connects the line to the several corresponding sending and receiving sets for brief but frequent intervals. This obviously means that the signals are mutilated before going out to line and necessitates the use of devices at the receiving end to rectify the distortion. This distortion increases with the length of line and results in rather delicate adjustment of the distributor speeds and the receiving apparatus. The system worked well for a number of years on several circuits in England, but eventually had to be abandoned because of the more or less imperfect character of the signals, a defect which increased as it became necessary to gradually increase the length of the underground sections in the lines leading into the important centres of communication.

The reeds controlling the apparatus proved a considerable source of trouble, and required to be carefully supported on rubber rings to avoid being disturbed by extraneous vibrations of any kind, as the smallest variations in the speed of the distributors at once caused trouble.

The actual line speed required was very high being something in the neighbourhood of 600 words per minute for an output speed of from 75 to 150 words per minute. On short lines where there was ample margin of speed, the system was extremely useful as the channels numbering in some cases up to six could be used at any moment in either direction as required, by merely turning a switch at each end of the channel affected.

The apparatus was designed to meet the most difficult traffic requirements, and thus in practice it was possible to utilize the channels at any instant either wholly in one direction, or any number of the channels in one direction and the remainder in the other.

(7). POLLOCK-DELANEY.

In order to improve the general working of the Delaney system, Mr. S. A. Pollock, of the British Post Office Engineering Department, developed a duplex arrangement of a quadruple set which, in addition to providing eight channels, enabled longer segments to be used resulting in the reduction of the line speed required from about 600 to 220 words per minute for an output speed of from 100 to 120 words per minute in each direction. The set worked very well indeed, and 400 to 480 messages in the hour were actually handled on a single aerial wire 180 miles long.

This apparatus was eventually abandoned on account of the difficulty in maintaining a sufficiently accurate balance (for the speed required) on aerial lines in the variable climate of England, and because the other lines working between the two towns where this apparatus was fixed were not suitable for the high duplex speed necessary owing to long sections of gutta-percha-covered wire forming parts of the lines; consequently an interruption on this line caused considerable disorganization of traffic by so largely reducing the number of channels between the two centres.

(8). MEYER.

I now come to the fourth class in which the line is joined at regular periods to the different channels in succession, thus allowing the signals to go out to line without being mutilated, and in consequence securing the best possible condition for signals being received in the most perfect form.

This method originated in the Meyer Multiplex, where an 8-key transmitting device was utilized to form a Morse letter in connection with a distributor which sent out the signals to line, once per revolution. At the receiving end each Morse letter was printed across a tape instead of along it as is now the general practice. The sending was performed by forming one letter per revolution of the distributor on each transmitting device or keyboard. The correct time for the formation of the letter being indicated to the operator by a cadence signal. This arrangement did not present any serious disadvantages, but the received record had to be transcribed from the slip instead of being written up from a sounder as in the Delaney.

The invention of the Baudot which did away with the tedious operation of writing up from slip very soon displaced this system.

(9). BAUDOT.

The Baudot is another representative of the fourth class.

Owing to the method of sending complete signals successively on the different channels between the different sets of corresponding apparatus the line speed required is not high, and a further advantage is obtained by using a shorter code than the Morse.

The line speed required for any particular type of Baudot is shown in the following tables in which the calculations have been made on the recognised basis of 30 segments per word for Baudot and 48 unit impulses per word for Wheatstone.

Types of Baudot with Output Speed, etc.

Type.	Output Speed w.p.m.	Equivalent Morse Speed.	Output in Messages per hour of Average British Message of about 20 words.	
Double	60	49	100 to 200	
Double Duplex ...	$\left\{\begin{matrix}60\\60\end{matrix}\right\} = 120$	$\left\{\begin{matrix}45\\45\end{matrix}\right\} = 90$	200 „ 240	
Triple	90	67·5	150 „ 180	
Triple Duplex ...	$\left\{\begin{matrix}90\\90\end{matrix}\right\} = 180$	$\left\{\begin{matrix}64·7\\64·7\end{matrix}\right\} = 129$	300 „ 360	50 to 60 per Channel.
Quadruple ...	120	90	200 „ 240	
Quadruple Duplex	$\left\{\begin{matrix}120\\120\end{matrix}\right\} = 240$	$\left\{\begin{matrix}82·5\\82·5\end{matrix}\right\} = 175$	400 „ 480	
Sextuple	180	120	300 „ 360	
Sextuple Duplex...	$\left\{\begin{matrix}180\\180\end{matrix}\right\} = 360$	$\left\{\begin{matrix}120\\120\end{matrix}\right\} = 240$	600 „ 720	

The vast difference in line speed required for a Sextuple Baudot and Sextuple Delaney is most marked, the Baudot requiring only one-fifth of that required for the Delaney. Further, the Baudot gives typed characters at the received end as compared with more or less accurate Morse signals on the Delaney.

Another great advantage of the Baudot system is as in the Morse Quadruplex the practicability of obtaining separate channels on one wire working quite independently to different stations. The Baudot has been adopted in England comparatively recently for inland working, and sufficient apparatus is not yet available to carry out any comprehensive scheme involving the most advantageous use of line plant. The French Administration has courteously placed much information at my disposal, and it is therefore possible for me to give the following circuit arrangements which will, it is hoped, give some idea of the elasticity and value of the Baudot system.

The London-Paris-Zurich-Marseilles circuit consists of a single wire London to Paris, a single wire Paris to Zurich and another single wire Paris to Marseilles. On this circuit London works two channels to Marseilles, and two channels to Zurich while Paris also works two channels to Zurich. The circuit works exceedingly satisfactorily, and there have been fewer stoppages between London and Zurich since this arrangement was installed than when a simplex Hughes was being worked between London and Zurich.

The Paris-Algiers communication works over one wire Paris to Marseilles, and three submarine cables each about 800 kilometres long between Marseilles and Algiers. Four channels are worked between Paris and Algiers (three in one direction and one in the other, as required) while Marseilles works two channels with Algiers, one in each direction.

It is surprising that such a promising invention has taken so long a time in finding appreciation outside the country of the inventor. Although it is some 30 years old, it is only during the last few years that it has commenced to attract serious attention. Its use is now, however, spreading rapidly in Europe and Asia; the Russian Administration it is understood, has already installed during the last five years about 75 sets and the Telegraph Administration in British India has installed 30 sets during the same period.

The British Telegraph Administration has to deal with a somewhat difficult requirement. Owing to the very cheap newspaper tariff rate, very special conditions have to be met in dealing with this class of work, and the Baudot so far has not been found suitable for the purpose.

The Wheatstone which was first in the field holds its own for this class of work, but the use of the Baudot is likely to be extended in the British Isles for handling ordinary messages.

Twelve quadruple sets have already been installed, and provision has been made for installing the equivalent of at least ten more sets during the next twelve months.

The Baudot has been developed in France as a simplex system only and this, it is understood, fully meets the telegraph requirements of that country.

An officer of my staff, Mr. A. C. Booth, has made a very careful study of this system and has successfully duplexed the Baudot.

In October, 1910, the Engineering Department of the British Post Office installed a quadruple duplex giving eight channels (four in each direction) on an underground line between London and Birmingham, also a double duplex between London and Berlin over a submarine cable of about 500 kilometres in August, 1910. The results obtained on these circuits have been eminently satisfactory, so much so indeed that the German Administration have been encouraged to fit a double duplex on an underground line having two repeaters between Berlin and Cologne.

The British Telegraph Administration is about to take another step forward, for it is proposed shortly to instal a sextuple duplex between London and Birmingham. If this experiment should prove successful, and there is every reason to expect that it will, then the Baudot system will prove itself to be the most expeditious machine printing telegraph system yet invented for dealing with large volumes of traffic.

The Siemens Photographic Printer has proved, under experimental working conditions, to give the highest rate of transmission of all the printing telegraph systems investigated in England. It is not, however, a multiple system, and therefore the treatment of its features does not come within the scope of this paper.

(10). Murray Multiplex.

I come now to what may be termed an offspring of the Baudot, namely, the system devised by Mr. Donald Murray. Mr. Murray has adopted the Baudot code but has designed his printing mechanism on entirely different lines. Instead of printing on tape from a revolving type-wheel, a small typewriter is used, and the messages are printed in page form entirely automatically. Special signals are used at the transmitting end to control all the movements necessary to move the form for each fresh line, and also to put a fresh form in position.

The complete installation is a distinct advance on the Baudot system, as each channel works at the rate of 40 words per minute as compared with 30 words per minute on the original Baudot. A great saving in labour is expected from the adoption of page printing as the received message only requires to be checked as the forms are withdrawn from the typewriting machine. It remains to be seen whether on aerial lines subject to occasional interruptions any real advantage will accrue from the method of reception in page printed form, or whether actually this will prove to be a positive disadvantage. The experiments now being made in England are not sufficiently advanced for any conclusions to be drawn on this point. The experimental installation is a double duplex giving four channels working at a total speed of 160 words per minute (80 in each direction). Unfortunately, figures are not yet available as to the amount of traffic that can be dealt with in the hour. It is however believed that very good results will be obtained in the trial equipment, and Mr. Murray hopes to be in a position to work triple duplex, quadruple duplex, or sextuple duplex with his system.

(11). MUNIER.

The Hughes instrument has from time to time been arranged for multiple working with a view to increase the output speed of the line. One of the methods to effect this purpose is that known as the Munier arrangement whereby the output of the line was increased by about three times by equipping it with four complete sets of Hughes apparatus at each end of the line, a fifth set being used as a distributor. This arrangement does not allow the maximum speed of each Hughes set to be developed, since only one signal can be sent per revolution. The reduction is equivalent to about 30 per cent. of the mean speed. Naturally the letters composing words do not follow the sequence of letters as arranged on the type wheel for printing, and therefore the average output speed is about one-fourth of the actual printing speed. The simplicity of the transmission is in its favour, being theoretically four times more favourable than the Morse. These two features therefore are opposing factors, the result being that the Hughes output under average working conditions is about the same as Morse. That is to say, a Hughes working at 120 revolutions per minute, although its printing speed is 112 words per minute, gives an output speed of 28 words per minute and requires a line speed of 28 words per minute Wheatstone but it has a great advantage over the Wheatstone as regards the transmission of figures. This amounts to about 65 per cent. The natural delicacy of the apparatus itself, if added to the additional difficulties of any multiple system, render the whole a rather unreliable combination, and this is no doubt the reason why so very little has been done with the Hughes instrument as a multiple system.

(12). ROWLAND.

This system which provides four channels in each direction by means of the duplex balance, was given a somewhat extended trial in the United States of America, but is now no longer in practical use. It is capable of working at a speed of 40 words per minute on each channel, giving an output speed of 160 words per minute each way. The apparatus is rather elaborate, as the page printing method of reception is provided for and controlled entirely from the sending end on each channel.

The disadvantage of the system is the comparatively large number of signals per letter, 12·5 units as compared with eight for the Wheatstone and six for the Baudot.

The fairly high rate of working at 160 words per minute is equivalent to a speed on Wheatsone of 250 words per minute. For such a speed at duplex, the balance must be very accurate and is necessarily delicate; also the disturbance produced on neighbouring conductors is fairly considerable. The electrical and mechanical parts are somewhat numerous and require some skilled attention to maintain in good working order.

The saving of labour by the use of page printing is an advantage in certain conditions; but taken as a whole, the disadvantages of the system outweigh the advantages as compared with other systems that are available. The operators signal direct on to the line, and in consequence false signals are recorded on the forms at the receiving station. It is difficult to make corrections on the forms which have to be sent out to the public in a manner sufficiently satisfactory not to disturb the confidence of telegraph users. When the system was in use in America, the practice was adopted of rejecting the forms on which false signals appeared, and in consequence the messages had to be completely resignalled, and the system thus proved costly and unsatisfactory.

Conclusion.

In considering the question of the utility of the Multiplex systems, it is necessary to compare them with the automatic high speed systems because the problem of telegraphic transmission must be viewed from several standpoints, the more important of these being:—

(*a*). Saving in wire mileage.
(*b*). Saving in labour costs.
(*c*). Saving in maintenance costs.
(*d*). General convenience of system with special reference to the handling of messages and the correction of errors.

Multiplex systems are not only in competition with each other, but they are as a class in competition with the high-speed automatic systems.

The character of telegraphic traffic falls into two definite classes so far as Great Britain is concerned, one, consisting of comparatively short messages dealing either with commercial or domestic affairs, and the other consisting of newspaper messages which are often exceedingly lengthy. The former embraces the greater bulk of the work which has to be handled and requires to be dealt with very expeditiously as small units. The latter also requires expeditious treatment, but can stand the initial delay of the few minutes required for preparing the perforated tape, so long as its reception at the newspaper office is in time for printing. With the increase in the number of newspaper editions that are now published, the latitude in this direction has been considerably diminished.

It will be readily understood that the question of rapid transmission of messages and delivery at their destination becomes a highly important factor in the situation, owing to the short distances between large centres and the highly developed railway facilities now provided between such centres.

It seems to me from a general view of the situation that it is preferable for the short messages to be handled as complete units rather than that a number of such small messages should be put together in bulk at the transmitting end and signalled as one continuous stream of signals which have to be again cut up, and checked. If repetitions or verifications are necessary considerable delay to the units concerned arise owing to the references required and the search that has to be made to trace them and signal them forward. With a multiplex the message is dealt with immediately it is received and corrections, etc., are asked for and given at once without any delay. Further, the Multiple systems have the great merit of enabling the fullest use to be made of the line time in dealing with not only long but with short messages also. The general public have in consequence the advantage of a quicker service than is possible with ordinary high speed transmission systems requiring the preliminary preparation of a perforated tape.

Opinions are still divided on the subject of reception by tape as compared with reception in page form. If the matter is considered from the point of view of a quick and cheap service which avoids all the waste of time involved by using elaborate means for disguising errors or corrections and in other ways to improve appearances, in the form and not the substance of the message, then the tape form of reception is superior to the page form.

It seems probable that future developments in printing telegraphs must follow the lead of the Baudot principle on account of the great advantage in respect of the saving of line time, and from the point of view of simplicity in mechanical details.

APPENDIX.

(1).

The Decrement Method of Morse Quadruplex.

By C. C. Vyle.

In the Decremental quadruplex the tongue of the non-polarized relay is normally held by a spiral spring against the spacing contact and when the current is decreased sufficiently, the tongue moves over to the other contact known as the "marking" contact, to actuate the sounder.

The Decremental system does not avoid the difficulty that arises when the current in the line is reversed, but the arrangement changes the effect from a tendency to split the signals which exists in the Incremental system, to a tendency to prolong the signals excessively in the Decremental system.

The advantages claimed for the Decremental system are:—

(1). Simplification of adjustment as it is easier to correct prolonged signals than to avoid split signals.

(2). Slightly less apparatus required.

All facilities such as extensions and repeating arrangements offered by the Incremental system are also provided in the Decremental arrangement.

As the description of the Decremental method does not appear to have been published, a diagram of the connections is shown on page 366.

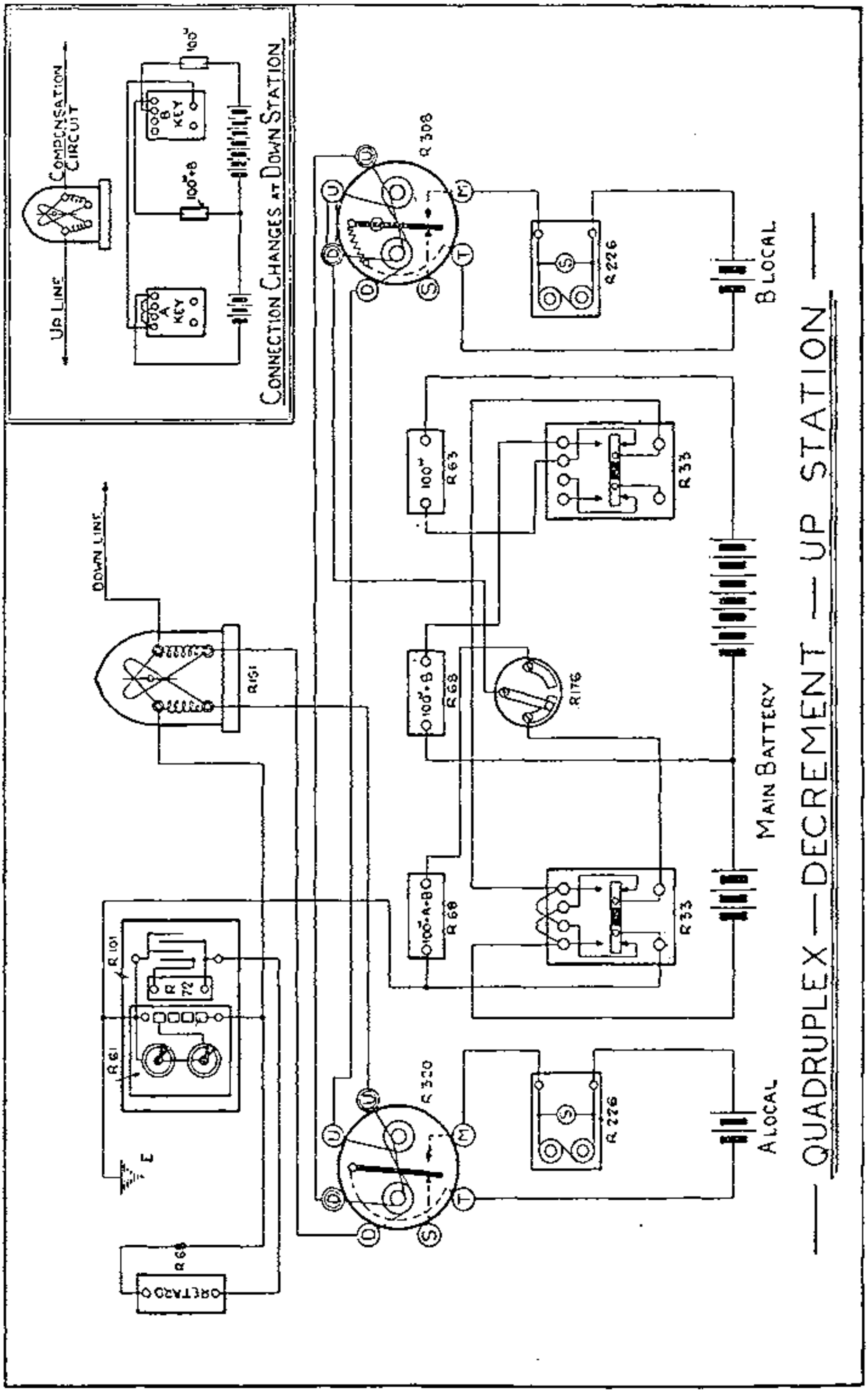
(2).

Quadruplex (Increment System).

Local Circuit of "B" Side.

By C. E. Hay.

It is very necessary to obtain the most suitable values of resistances and capacity to bridge over the unavoidable mutilation of the signals that actuate the B relay and these values for the local circuit of the B side can fortunately be readily obtained mathematically.


QUADRUPLEX — DECREMENT — UP STATION
CONNECTION CHANGES AT DOWN STATION
UP LINE
COMPENSATION CIRCUIT
A KEY
B KEY
100^ω+B
100^ω
DOWN LINE
R 161
R 101
R 72
R 61
E
R 68
RETARD
R 320
R 308
R 226
A LOCAL
B LOCAL
R 33
R 63
100^ω+B
100^ω+A+B
R 176
MAIN BATTERY
U
D
S
T
M

The local circuit is shown diagrammatically in *Fig.* 1. The sounder is joined up in series with a resistance varying from 100 to 700 ohms and a battery of 40 volts, the sounder and the variable resistance being shunted by a condenser of 8 mf.

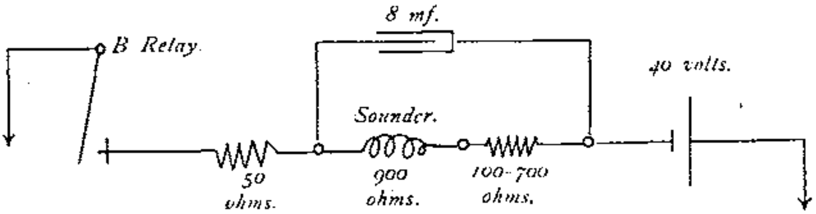


FIG. 1.

The small resistance of 50 ohms is provided in order to prevent the relay contacts from welding during the charging of the condenser. It is not required if the battery possesses internal resistance.

The function of the condenser, as is obvious from the diagram, is to supply current to the sounder during the short interval of time that the tongue of the B relay is away from the marking contact when the A key reverses the direction of current in the line, and the capacity of the condenser is of such a value as to furnish a quantity of electricity which will provide a current of the necessary magnitude to flow through the sounder and maintain the magnetic flux for the desired time.

Two current values have to be considered, (*a*) that from the condenser discharging through the sounder and resistance in series with it, and (*b*) the current due to the self-induction of the sounder itself which passes through the resistance and capacity. They are obtained as follows.

From the equation for current:—

$$\frac{d^2i}{dt^2}+\frac{Rdi}{Ldt}+\frac{1}{LK}i=\frac{1}{L}f'(t)$$

when $f'(t)=0$, the solution when RK is greater than 4L is well known to be:—

$$i=\epsilon^{-R/2L.t}(A\sin\theta+B\cos\theta)$$

or $$i=A\epsilon^{-R/2L.t}\sin\left\{\frac{(4LK-R^2K^2)^{\frac{1}{2}}}{2LK}t+\phi\right\}$$

A and ϕ being arbitrary constants of integration

where A stands for $(A^2-B^2)^{\frac{1}{2}}$

and ϕ ,, ,, $\tan^{-1}B/A$.

At the time $t=0$, the following values obtain, $i=0$, $\phi=0$ and

$$A=\frac{2Q}{(4LK-R^2K^2)^{\frac{1}{2}}}$$

Consequently the current from the condenser is

$$i_k=\frac{2Q}{(4LK-R^2K^2)^{\frac{1}{2}}}\epsilon^{-\frac{R}{2L}t}\sin\frac{(4LK-R^2K^2)^{\frac{1}{2}}}{2LK}t$$

By substituting in the above equation the following values which relate to apparatus actually in use,

$$Q=KV=8\times10^{-6}\times40 \text{ coulombs}$$

$$L=20 \text{ henries}$$

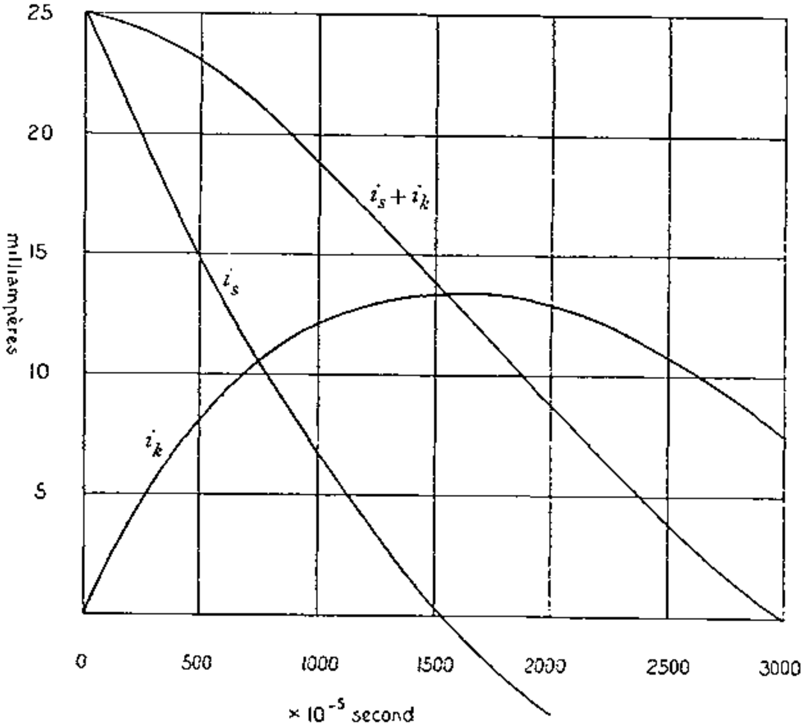
$$K=8\times10^{-6} \text{ farads}$$

$$R=1600 \text{ ohms.}$$

The result is obtained :—

$$i_k=29\epsilon^{-40t}\sin 68.1\,t \text{ milliamperes.}$$

The current due to the inductance of the sounder may be obtained thus.



From the similar equation for quantity of electricity

$$q = A_1 e^{-\frac{R}{2L}t} \sin\left\{\frac{(4LK - R^2K^2)^{\frac{1}{2}}}{2LK} + \phi'\right\}$$

it is seen that $q = 0$, and $\phi = 0$, at the time $t = 0$.

By differentiation of the above equation and by substitution, the current due to the inductance of the sounder is obtained, namely,

$$i = -I\sqrt{4LK/(4LK - R^2K^2)}\, e^{-\frac{R}{2L}t} \sin\left\{\frac{(4LK - R^2K^2)^{\frac{1}{2}}}{2LK}t - \phi\right\}$$

and when the constants of the apparatus already given are substituted

$$i_s = -29 e^{-40t} \sin(68.1t - 59.583^\circ) \text{ milliamperes.}$$

The total amount of current in the sounder is $i_k + i_s$, and these calculated values are shown on the attached table, and graphically on the curves.

QUADRUPLEX (INCREMENT SYSTEM).

Current in Sounder when "B" Relay Contact Broken.

Time second.	Current due to Inductance of Sounder $= i_s$ mas.	Current due to Condenser $= i_k$ mas.	Total Current in Sounder $= i_s + i_k$ mas.
0	25	0	25
5×10^{-5}	24·92	0·101	25·021
10×10^{-5}	24·82	0.2018	25·0218
100×10^{-5}	23·02	1·896	24·916
200×10^{-5}	21·03	3·632	24·662
400×10^{-5}	17·16	6·645	23·805
600×10^{-5}	13·46	9·06	22·52
800×10^{-5}	10·00	10·9	20·9
1000×10^{-5}	6·835	12·22	19·055
2000×10^{-5}	−4·139	12·75	8·611
3000×10^{-5}	−7·335	7·75	0·415
4000×10^{-5}	−5·808	2·362	−3·446
5000×10^{-5}	−2·746	−1·038	−3·784

Colonel A W Baird CSI FRS
Late Royal Engineers

MEMOIRS.

COLONEL ANDREW WILSON BAIRD, C.S.I., ROYAL ENGINEERS.

By COLONEL R. H. VETCH, C.B.

COLONEL A. W. BAIRD was descended from a younger son of the family of Baird of Auchmedden. His great grandfather, Charles Baird, settled in Aberdeen as a manufacturer, became a man of some importance and influence in that city, and was one of the first in Scotland in the 18th century to erect machinery, imported at great cost from England, in his mills. At a later date, when early in the 19th century Napoleon Bonaparte threatened to cross the Channel and invade England and a large British Volunteer Army was formed to oppose him, Charles Baird showed his patriotism by raising a company of Volunteers in Aberdeen. He married Jean, daughter of John Matheson, of Bennetsfield, Ross-shire, who claimed to be chief of the Clan Matheson, and by her had a family of five sons and two daughters. He died in 1836. One of his daughters married Capt. Mason of Leith, and their daughter Agnes Scarth Mason was the first wife of Sir Fitzroy Kelly, the last Chief Baron of the Exchequer of England.

Charles Baird's youngest son Thomas, born in 1794, grandfather of the subject of this Memoir, married a Miss Hay, sister of Major Patrick Hay, who fought as an ensign in the 42nd Highlanders at Waterloo and died some years afterwards in Madras. By her he had a small family; he was suddenly seized with cholera at Fortrose, Ross-shire, in September, 1834, and died after an illness of six hours at the age of 40, leaving a son Thomas, born in 1820, and not yet 14 years old, to meet great financial losses. Thomas Baird, of Woodlands, Cults, Aberdeen, went into business when he was 16 years old and eventually became very prosperous. Marrying Catherine Imray he had a family of nine childern—five sons and four daughters—several of whom died in infancy.

The eldest son of this family was ANDREW WILSON BAIRD, born at Aberdeen on the 26th April, 1842. Educated at the Grammar School and at Marischal College, Aberdeen University, where, having been for some years a pupil of Dr. Rennet, the well-known mathematical tutor in Aberdeen, he showed distinct mathematical talent and carried away several prizes. A nomination was procured for him to a cadetship at the "Military Seminary," as it was officially called, of the Hon. East India Company at Addiscombe and he joined the College in June, 1860. In January of the following year he was transferred to the Royal Military Academy at Woolwich, on the amalgamation of the Indian Army with the Royal Army and the consequent closing of Addiscombe College. He received a commission as lieutenant in the Royal Engineers on the 18th December, 1861, and joined at Chatham in the following February for the usual course of professional instruction.

Sailing for India on the 1st March, 1864, Baird was at first employed as Special Assistant Engineer of the Bombay Harbour Defences. He had charge of the construction of the batteries at Middle Ground and Oyster Rock until the end of 1865, and was then appointed Special Assistant Engineer of the Government reclamations of the harbour foreshore. It was a time of great commercial excitement and speculation in Bombay. Shares in the various improvements of the harbour and city were in demand, particularly the Back Bay reclamations which were at their height. He had great temptations thrown in his way to speculate but although young he had a cool head and his character was strong enough to enable him to avoid these pitfalls.

In 1868 Baird was ordered on active service and appointed Assistant Field Engineer in the Abyssinian Expedition under Major-General Sir Robert Napier, afterwards Field Marshal Lord Napier of Magdala. Arriving at Zula, Annesley Bay, the port of disembarkation in Abyssinia, on the 28th February, he was at once attached to the railway department and appointed traffic manager of the railway then being constructed from the base at Zula to the camp formed at Kumeyli at the foot of the hills 10 miles away. The actual work was executed by men of the 23rd Punjab Pioneers and 2nd Bombay Grenadiers, but the officers who superintended the construction, maintenance and working of the line were Capt. Darrah, and Lieuts. Willans, Pennefather, and Baird, all of the Royal Engineers. The devotion to duty shown by these officers on the railway, early and late, day by day, for upwards of five months under most trying circumstances of climate was acknowledged by the Commander-in-Chief in his despatch, and Baird as traffic manager was especially mentioned for his conduct of the troops and baggage to the base at the termination of the successful campaign (*London Gazette*, 30th June, 1868). Baird received the war medal for his services. On his return to Bombay he was retained until the end of November in the Military Department to wind up the accounts of the Engineer Park.

Appointed Assistant Superintendent in the Great Trigonometrical Survey of India in December, 1868, Baird was employed successively on the triangulation of the districts of Kathiawar and of Guzerat. He suffered much from the extreme heat of that arid country and in the spring of 1870 he was compelled to take leave of absence to England. His zeal and accuracy in scientific work had become well known to Colonel (afterwards General) J. T. Walker, the Surveyor-General of India, and while both Baird and Walker were on furlough in England in 1871–2 Baird was selected by the Secretary of State for India, on Colonel Walker's recommendation, for special duty in connection with scientific research as to tidal observations. In the first instance tidal observations were only undertaken by the Survey of India with the object of determining the mean sea level as a datum for the Trigonometrical Survey. The first observations were of a very imperfect character, and it was not until 1855 that a self-registering tide gauge was used and even then the observations were restricted to a month in duration.

In a preface to his valuable *Manual of Tidal Observations* Baird himself gave an account of the origin of the Tidal Survey which may be summarized as follows. Subsequently to 1855 it was desired to investigate the relations between the levels of land and sea on the coasts of the Gulf of Cutch, which were believed by geologists to be gradually changing. This necessitated a more exact determination of the mean sea level than had hitherto sufficed for the operations of the Survey. While Colonel Walker was at home he found that a committee of the British Association presided over by Sir William Thomson, afterwards Lord Kelvin, was engaged in initiating a system of tidal investigations which it was anticipated would secure results of the highest value. He decided to have observations made at stations in the Gulf of Cutch, in accordance with the system proposed by this committee, by self-registering gauges set up for at least a year to determine the existing relations of land and sea, and again for another year when a sufficient interval had elapsed for a sensible change to have taken place. Baird was deputed to study the details of tidal registrations and the reduction of observations by harmonic analysis in accordance with the method suggested by Sir William Thomson and his committee. He made arrangements to secure self-registering barometers and anemometers to indicate the atmospheric conditions prevailing at each tidal station as it was most necessary to record them concurrently with the changes of sea level. He tested at Chatham a new self-registering tide gauge constructed by Adie and, in December, 1872, went to India and made a reconnaissance of the Gulf of Cutch.

Visiting first Juria Bandar, close to the head of the Gulf, he there fitted up a country boat for navigating the creeks and channels of the Gulf, and secured the services of an experienced pilot to accompany him in his explorations. After a month's cruising about and long searching along the muddy shores of the Gulf three places well adapted for tidal observations were found and were, indeed, the only places that would have answered the requirements. His instructions to establish a station "at a point as far into the Runn of Cutch as possible to which the tide has free access" meant that the point selected must always have at least 4 or 5′ of water over it at lowest tides, and also that the sea should approach it directly and not by tortuous channels. Such a position was found at Hanstal Point at the head of the Gulf, 18 miles from Juria; a second point he chose was Nawanar midway up the Gulf on the Cutch coast, 15 miles from Mudra; and a third at the mouth of the Gulf was Okha Point on the Kathiawar coast, opposite the island of Beyt. The observatories and their accessories having been established required periodical inspection and Baird and his assistant visited them turn about. Native subordinates were placed in charge of the instruments and provided with huts and water tanks and a guard at each station; a line of post runners was arranged to the nearest postal communication and daily reports were sent to Baird by the men in charge of the observatories.

The inspections entailed a great deal of hard marching and necessitated exposure, privation, and some risk. Even as early as in the month of May before the setting in of the monsoon, the Runn of Cutch was covered with water, from 6″ to 1′ in depth, which had to be waded through for many miles to reach the station at Hanstal. Camels of the country, accustomed to wading and very sure footed, were used. Of one of his journeys to Hanstal Baird wrote: "Our only landmarks in the whole of the last 14 miles were two small mounds of earth thrown up—when there were postal chowkies there—at 4 or 5 miles apart, and the observatory itself; we felt a curious sensation as if we were being carried out to sea, which was occasioned by seeing small branches of scrub floating on the surface of the water and being driven by the wind inland; and once, with the exception of one of the mounds above mentioned in the distance, there were no fixed objects visible to destroy this optical delusion."

It may here be mentioned that the three stations in the Gulf of Cutch, having been reopened after a long interval, the previous mean levels have been ascertained to be virtually unchanged.

Baird was promoted to be captain on the 4th April, 1874. Two years later he received the commendation of the Governor-General in Council for his successful labours and in July, 1877, instructions were promulgated for the establishment of systematic tidal observations at all the principal Indian ports and at certain other ports on the coast lines where results might be obtained which would be of general scientific interest, apart from their practical usefulness in affording data for the calculations of the rise and fall of the tides and for the construction of tide tables for the purpose of navigation. By direction of the Government of India the general superintendence—under the Surveyor-General of India—of tidal observatories was entrusted to Baird, who by that time had attained the grade of Deputy Superintendent in the Great Trigonometrical Survey Department.

In the meantime Capt. Baird had been sent home in 1876 with his observations in the Gulf of Cutch, and had worked out the results with the assistance of Mr. Roberts, of the *Nautical Almanac* Office. In the autumn of the year he read a paper on "Tidal Operations in the Gulf of Cutch" before the British Association at Glasgow. On his return to India in 1877 he organized in accordance with the instructions of the Government of India an entirely new department of the Survey, spread along the coast lines from Aden to Rangoon with its centre at Bombay. "Perhaps," says Sir George Darwin, who first met Baird in 1882 at Lord Kelvin's house and was for the next three years in constant communication with him, "the most convincing proof of the care and foresight with which the tidal department was founded is afforded by the fact that there is nothing to record as to its subsequent career, but it is obvious that the work demanded, and still demands, constant attention to scientific details" (Obituary Notice, *Proceedings of the Royal Society*).

Four years later in the summer of 1881, Capt. Baird was sent to Venice by the Government of India as one of the Commissioners to the Third International Congress of Geography. The other Commissioners were General Sir H. E. L. Thuillier, C.S.I., and Lieut.-Colonel C. T. Haig, R.E. The preparations for the proper display of the Indian collection were made by Lieut.-Colonel Haig and Capt. Baird. Among the exhibits of the Indian Survey was the new self-registering tide gauge which formed a special object of interest.

In his report to the Government Sir Henry Thuillier says: "It was at work daily showing the tidal courses in the adjoining canal and, as so well explained by Baird, was one of the most successful sights in the entire exhibition, and eagerly enquired after and studied by the Venetians as well as other foreigners . . . Major Baird [he was promoted major on the 18th December, 1881] was peculiarly happy with his new tidal gauge, which I may say formed one of the very chief attractions of the meeting. To this officer is due equal credit with Colonel Haig for unremitting attention, and the most successful efforts in causing everything to go off well, whilst his social relations with the numerous foreigners with whom we were so constantly in contact, and his general happy disposal of every transaction with the General Committee of the Congress, calls for my unqualified praise and entitles him to much credit." Baird was awarded the Gold Medal of the 1st class for his work in connection with tidal operations and he received the thanks of the Government of India and the Secretary of State for his services at Venice.*

* *See* Report of the Terzo Congresso Geografico Internazionale tenuto a Venezia, 1881, pp. 237–8; also *Proceedings of the Royal Geographical Society*, December, 1881; and Blue Book, Government of India, Revenue and Agricultural Department, "Exhibition," 1882.

From Venice Baird went to England on furlough and in May of the same year he became an Associate Member of the Institution of Civil Engineers. In December, 1882, he was elected a Fellow of the Royal Geographical Society. Returning to India in March, 1883, Major Baird resumed charge of the Tidal and Levelling Department of the Survey, his area of operations including India, Burma, Ceylon and the Andaman Islands.

On the 27th and 28th August of the same year the great volcanic eruption in the island of Krakatoa in the Straits of Sunda caused a wave which was distinctly traceable in the majority of the tidal diagrams and a paper on the subject by Major Baird was published in 1884 by the Royal Society (see *Proceedings*, No. 229, 1884). Writing to Professor (afterwards Sir) G. H. Darwin from Poona on the 27th September, 1883, Baird said :

"The wave caused by the volcanic eruption at Java is distinctly traceable on all the tidal diagrams hitherto received and I am informed of great tidal disturbance at Aden on August 27th ; but the daily reports are always meagre in information. Karachi and Bombay also show the disturbance, and as far as I have examined, the wave reached halfway up to Calcutta on the Hugli. . . .

"Negapatam was most disturbed and at Port Blair there was very great disturbance. I have reports from Port Blair of tremendous noises as if a ship were firing guns as signals of distress, and they sent out a steamer to look about. Similar reports come from the Nicobars. . . ."

In May, 1885, Major Baird was elected a Fellow of the Royal Society for his work on the tidal operations in India and Burma.

From July, 1885, to August, 1889, Major Baird acted on different occasions for some months at a time as Master of the Mint at Calcutta and also of that at Bombay during the absence on furlough of the holders of those offices. On other occasions he officiated for the Assistant and Deputy Surveyors-General of India. He was promoted to be brevet lieutenant-colonel on the 18th December, 1888, and on the 12th August, 1889, was appointed Mint Master at Calcutta, a post he held until his compulsory retirement from the Service, which took place in accordance with the regulations at the age of 55 years on the 26th April, 1897. In the meantime he had been promoted regimental lieutenant-colonel on the 9th April, 1891 ; brevet colonel on the 29th September, 1893 ; and substantive colonel on the 9th April, 1896.

During the eight years that Colonel Baird was at the head of the Calcutta Mint he carried out almost a complete reorganization of the manufacturing department, which resulted in both increased efficiency and economy. In 1895—1896 the Government of India directed him to enquire into the state of the coinage of India, which was becoming so seriously worn that it was necessary to withdraw some of the older issues from circulation. In his report* Colonel Baird dealt elaborately and scientifically with the average annual wear of the rupee and of the smaller coins, as well as with the mean annual accretion of dirt on the old coins, which was almost proportional to the age of the coin. He also at some length discussed plans for the withdrawal of the old coins from circulation. The Government adopted most of his suggestions and it was in consequence of his work that the coinage was established on a satisfactory footing.

Although it was proposed by the Government of India to grant an extension of service as Master of the Calcutta Mint to Colonel Baird he felt obliged to decline the offer. After many years' service in India, the climate was beginning to tell upon his health and he was anxious to settle down at home with his family. In acknowledging the receipt of his final report on the Calcutta Mint, dated 11th March, 1897, the Secretary to the Government of India wrote on the 29th April following that the Governor-General in Council desired him to convey to Colonel Baird the special thanks of the Government of India for his valuable services both as Mint Master at Calcutta and also throughout his employment in India. Colonel Baird was created a Companion of the Order of the Star of India in June, 1897.

The Plumian Professor of Astromony and Experimental Philosophy at Cambridge at the close of his obituary notice of Colonel Baird in the *Proceedings of the Royal Society*, 1908, has written of Baird and his work in India in the following terms: "It is on such men as Baird and on such unwearying services as those sketched above that the administration of the Indian Empire depends. . . . In science he has left a permanent mark as the successful organizer of the first extensive operations in tidal observations by the new methods. The treatment of tidal observations is now made by harmonic analysis in every part of the world, and this extensive international development is largely due to the ability with which he carried out this pioneer work in India."

Leaving India for good in 1897 Colonel Baird returned home and bought a small property, Palmer's Cross, near Elgin. His health gradually became very delicate and he frequently passed the winter abroad in warmer climates. His death was sudden, the result of heart failure, and took place on the 2nd April, 1908, while he was on a visit to London with his wife and daughters, at 23, Bentinck Street, W. His remains were buried at Highgate Cemetery on the 6th April.

Colonel Baird married at Aberdeen on the 14th March, 1872, Margaret Elizabeth, only daughter of Charles Davidson, of Forrester Hill, Aberdeen, by his wife, Jane Ross, and sister of Major G. Davidson,

* No. 278, dated 17th March, 1896—"From Colonel A. W. Baird, R.E., F.R.S., etc., Master of the Mint, Calcutta, to the Secretary to the Government of India, Finance and Commerce Department."

R.E. (Retired List). She survives him with a family of two sons and five daughters. The elder son, Percy Thomas Charles Baird, born in 1872, is a captain in the Queen's Own Cameron Highlanders; the other son, Harry Beauchamp Douglas Baird, born in 1877, is a captain in the 12th Cavalry, Indian Army, and Brigade Major to the Inspector-General of Cavalry in India. The second daughter married, in 1906, Captain Hugh de B. Miller, D.S.O., Royal Field Artillery; and the third daughter married, in 1908, Captain H. S. H. Richmond, Royal Marine Light Infantry.

Colonel Baird was the author of the following works:—"A Manual of Tidal Observations and their Reduction by the Method of Harmonic Analysis," 1886*; articles in the *Bombay Gazetteer* on the Gulf of Cutch, Little Runn and Gulf of Cambay; Notes on the Harmonic Analysis of Tidal Observations, published by order of the Secretary of State, 1872; Paper read before the British Association in 1876 on the Tidal Observations of the Gulf of Cutch†; Auxiliary Tables (two pamphlets) to Facilitate the Calculations of Harmonic Analysis of Tidal Observations, 1879 and 1882; Account of the Tidal Disturbance caused by the Volcanic Eruption at Krakatoa (Java), August, 1883, *Royal Society Proceedings*, 1884; Joint Report with Professor G. H. Darwin of the Results of the Harmonic Analysis of Tidal Observations, *Royal Society Proceedings*, March, 1885; Account of the Spirit Levelling Operations of the Great Trigonometrical Survey of India, British Association, 1885‡; Tide Tables for Indian Ports (annual) jointly with Mr. Roberts, of the *Nautical Almanac* Office.

"Baird," says one who knew him, "was of an upright and lovable character, and of a very generous and genial disposition."

Another writes: "Baird was always a steady and careful worker and however employed—whether on the reclamations in Bombay, on the Trigonometrical Survey of India, or finally as Master of the Mint in Calcutta—his whole heart was in his work. The care and forethought he exercised in the preparations for his tidal observations, by which every difficulty that might arise was forestalled, enabled him to obtain results of great scientific importance. . . . He was a good genial companion and a true and sincere friend. His sympathetic and kindly nature disposed him to view with leniency the faults of those with whom he came in contact and his dealings with all were scrupulously just."

Another friend writes: "Baird I knew for over 20 years and in him

* Published by Taylor & Francis at the expense of the British Association. It contains a valuable account of practical experiences together with full instructions for the application of the harmonic method of reduction.

† This paper was reprinted in the *Royal Engineers Journal* for October, 1876.

‡ Also printed in Supplementary Papers of the Royal Geographical Society.

I lost one of my dearest friends. I first met him in Calcutta and I remember I was speedily attracted by his personality and presence. As I got to know him better and to perceive the many fine traits in his character, feelings of respect and affection were engendered in me and these last grew deeper as years passed by. He was a truly loyal friend with a very sympathetic heart which made him always very sensitive and quickly responsive to all that affected or concerned his friends. His sense of duty and of honour was very high, and considering his achievements he impressed me as being so modest."

One who worked with Baird as a colleague in the last official post he held in India, the Calcutta Mint, and who knew him for many years in family life and as a member of the same club has written an appreciation of his friend, from which the following extracts are taken :—

"His nature was evidently and truly charitable. When conversing with him about acquaintances or men of the day it was remarkable how much praise he had in store for an enormous percentage of them. He seemed singularly free of jealousy regarding promotions, rewards and decorations. On the rare occasions when someone was mentioned whom he could not conscientiously praise he would endeavour to change the topic; or if compelled to admit that some individual had mismanaged a certain piece of work, he would strive to show that in some other direction the same person had done really well.

* * * * *

"In club life the general verdict of the members of all ages was that he was 'a good fellow.'

"He was always very much in earnest over his Mint work and constantly strove to make improvements, most of which, from their nature could not redound to his credit outside the walls of the Establishment. . . .

"The writer often had occasion to admire the orderly and methodical habits of his late friend. His notes on the work he was engaged in were so handy and well arranged that he could refer to them with the least possible delay. He never had to make the common remark—'I have a note on the subject somewhere, but do not know where to lay my hand on it just now.' On an occasion when Baird contemplated an excursion to a distant part of the Himalayas with a rather large party, the writer found that he had, by consulting time tables, guide books, and so forth, drawn up an admirable programme showing dates, special articles to be taken, etc., etc., with a most useful estimate of the probable cost of the whole trip. How much petty trouble must have been saved in this way!

"Baird always shone when asked by friends for advice and help. On such occasions he seemed possessed of a feverish anxiety to do everything he possibly could, and never to let the thought of trouble obtrude. . . .

"His disposition was eminently fair as what follows may illustrate. He and a certain colleague had a difference of opinion about their official relation to one another, and Baird determined to refer the point to superior authority. When he had composed his letter he sent it to the colleague for perusal and remarks, adding that if the colleague particularly wished it he would drop the matter. The colleague thought the case had been fairly stated. The reply from superior authority was to the effect that there seemed to be no occasion for making a change in the established relation. Baird at once loyally accepted the ruling, and during a long subsequent collaboration never showed any desire to get it altered. Indeed, pushing the matter to its logical conclusion, he sought to bring his colleague more prominently forward. This he did by more frequent consultation, by suggesting joint reports when views had to be given by both on the same subject, and in other ways. Here there had been an appeal to the umpire and the decision had been given against Baird. He accepted it thoroughly in the spirit of a true sportsman."

The above Memoir is founded partly on information supplied by Mrs. Baird; partly on Colonel Baird's own publications; an article on him in *Men and Women of the Time*, 1891; a Memoir by Professor Sir G. H. Darwin in the *Proceedings of the Royal Society* and a Notice in the *Proceedings of the Institution of Civil Engineers*, Vol. 172, Part II.; the Obituary Notice in *The Times*, 10th April, 1908; *Journal of the Asiatic Society of Bengal*, Vol. 47, 1878, Part II.

The portrait is from a photograph taken in India when Colonel Baird was Master of the Calcutta Mint.

Colonel J L Irvine CB RE

COLONEL J. L. IRVINE, C.B.

THE name of James Laird Irvine will call to the memory of many, one who was esteemed by all for his lovable qualities, and especially for the ready sympathy which he invariably showed to all who came to him for advice or assistance.

He was born on September 5th, 1858, at Bruckley, near Liverpool, educated in Switzerland, and obtained his commission from the Royal Military Academy in June, 1877. After the usual stay at the School of Military Engineering he was sent in January, 1880, to Aldershot, where he was destined to spend so much of his service. He joined the "A" (Pontoon) Troop, and served with it in the Egyptian Campaign of 1882, including the Battle of Tel-el-Kebir. Some interesting extracts from his diary, describing the work done by the troop during the operations are given in Volume II. of the *History of the Corps*.

At the end of 1883 he was transferred to the 6th Company, which he accompanied to Bermuda, where he remained till 1888, being Acting Adjutant from 1884 to 1888. On his return home he spent three years on the Ordnance Survey at Clifton, and then returned to Aldershot to take up the duties of Adjutant, R.E. Troops. In April, 1895, he succeeded to the command of "B" Troop, Bridging Battalion, and to the command of "A" Troop in September of the same year. He retained the command of "A" Troop till 1902, and with it went through the South African War, where he served with much distinction, further details of which are given below. He was C.R.E. in Egypt from August, 1903, till March, 1904, when he again returned to Aldershot to take up the appointment of Officer Commanding Troops and Companies R.E. In October, 1908, he became A.A.-General, R.E., at the War Office, from the onerous duties of which he was transferred to Chatham in 1910, as Commandant of the School of Military Engineering. Owing to failing health he was never able to undertake fully the work of that appointment, in March, 1911 he found retirement inevitable, and only survived for five months afterwards.

Of his work in South Africa, for which he was several times mentioned in despatches, the following recollections of officers who served there with him, show that few have done better work in the Corps on active service than he did during that campaign.

Captain J. W. Skipwith, R.E., writes :—

"Irvine's big reputation in Natal was obtained in two ways. Firstly, by his tact and perfect manners he always got the Staff to do things *his* way, and secondly, in the estimates of the time for bridging operations he was most extraordinarily (almost uncannily) accurate. The result was that the Staff felt, and knew by experience, that, if Irvine said he would make a bridge in a certain time, they knew they could absolutely rely on him, and that he would never play them false by wrong or misjudged estimates of time. And the absolute reliance, which the Staff thus learnt to place in him, earned not only him, but also "A" Troop, a reputation second to none in Buller's Natal Army."

Major-General H. M. Lawson, who was in the same batch with Irvine, adds the following note:—

"I can corroborate what is so well written above. When I joined the Headquarter Staff of the Natal Army directly after the relief of Ladysmith, nothing of what I heard from my comrades on the Staff struck me so much as the unstinted praise bestowed on Irvine and the Pontoons This feeling too went far beyond the mere Staff. The army that relieved Ladysmith was essentially one of brave deeds and brave men, but no body of men in it bore a higher or better recognized reputation for courage and devotion than did the Pontoon Troop and its commander.

"Irvine's name was on so many people's lips in those days, and it would be difficult to exaggerate the high reputation that he enjoyed. This was due, much to what the previous notes have described, and much also to an unfailing modesty, cheerfulness, and readiness. Irvine could never make a difficulty, no day and night was too long for him and his men, and fresh obstacles only spurred him to greater efforts. Of him the old saying is especially true 'He never said he wouldn't, or he couldn't, or he didn't know how.'"

Irvine, in the minds of all those who served with him, will always remain connected with Aldershot. His early days were spent there, it was the place where he acquired the love for riding and hunting which he ever retained, where the successes of his mare "Molly Bawn" are still remembered, where the N.C.O.'s and men and their families still speak affectionately of the kindly interest ever taken by him and Mrs. Irvine in their welfare. Those who saw him bravely battling for his life towards its end, know that his happiest recollections were of those days when he lived at Wood End, Farnborough, or at the house near the R.E. Mess, Aldershot, where he was in intimate touch with the Corps, into whose advancement he threw himself heart and soul.

Probably Irvine would have appreciated more than any other words, those in which a non-commissioned officer, who served under him for many years, spoke of him. "He was a first-class regimental officer and a thorough gentleman."

Irvine was married during the time he was in Bermuda to Miss Dora Louisa Gallwey, daughter of Lieut.-General Sir Thomas L. J. Gallwey, K.C.M.G., R.E., then Governor of the Island. His son has joined the Argyll and Sutherland Highlanders, in which his uncle Major Thomas Irvine served. "Laird" and "Tom" Irvine now rest side by side in the cemetery near Fort Pitt, Chatham.

NOTICES OF MAGAZINES.

Giornale del Genio Civile.

August, 1911.

High Tension Transmission in America.—*Generators.*—These are generally alternators of 13,000 or 20,000 volts. Three-phase current is generally used (periodicity 25), the voltage varying with the distance, the usual tensions being:—110, 240, 1,100, 2,200, 3,300, 6,600, 11,000, 13,000. In illumination circuits round the works, the periodicity of 60 is also used.

Power Stations.—In the larger works, the generators are in a building by themselves the apparatus for measuring and distributing the energy being in a separate building connected to the first by means of a gallery which contains the cables carrying the electricity, in suitable concrete pipes. The electrician in the generator room has only to put the generators in circuit and take them out again. There is in the bigger works a small central observation post in which the electrician in charge of the switchboard sits, and from which he can watch the hands in charge of the various machines and panels of the switchboard.

Bus Bars.—The bus bars for the main switchboard are almost always supplied in double, but seldom are they in separate closed circuits; they are not divided into sections. There is not a circuit breaker between each machine and its feeder.

Switchboards.—Generally polished slate is used for the switchboard; it is mounted on angle or tube iron frames fixed directly into the ground. The apparatus concerning the exciters, auxiliary motors and accumulator batteries are on a separate switchboard.

Circuit Breakers.—Generally oil switches of 2,000 to 3,000 amps. at 2,500 to 15,000 volts are employed. They have proved very satisfactory, and require no special looking after. Switches of 60,000 volts have also been used for three years without any need to replace the oil. Tests have also been recently made with switches of 400 amps. at 110,000 volts. In smaller power stations air switches have been tried, they cost less but require a free space of 3 metres in height. Oil switches in which the breaking of the circuit takes place in a horizontal direction are preferred, as this enables the spark to be more easily put out.

Fuses.—These are only employed when air switches are in use.

Tension of Power Circuits.—The insulating materials used allow a tension of 110,000 volts. Efforts are being made to get insulators to stand a pressure of 200,000 volts, with more hope of success than existed a few years ago when they were looking for insulators to withstand 100,000 volts. There is actually at work at present a line 200 kilometres long on which a tension of 135,000 volts is used.

Supports of Aerial Lines.—In districts where wood can be obtained posts 9 or 10 metres long are used; diameters at base and head are from 25 to 30 and 18 to 23 c.m. One-fifth to one-seventh of the post is buried in the ground. These posts are first of all put into cylindrical vessels, at a temperature of 100° to 120° Centigrade, then are placed in a second cylinder where there is a vacuum, to get all traces of moisture out of them, finally they are placed in a third cylinder where a very good disinfectant is put into them at the required pressure. The average life of these posts is 20 years for cedar wood, 15 for chestnut, and only 10 for fir or pine. If the part of the post in contact with the ground rots, it is sometimes surrounded with iron bars and the whole is covered in concrete. It is however always better to replace the post. The best procedure of all is to encase the base of the pole in concrete which comes at least 20 c.m. above the surface of the soil. Reinforced concrete posts are used where extra strength is desirable.

The general practice to-day is to employ iron girder work posts, with rectangular or square bases; U or T iron is generally employed. The height is about 14 metres, side of square at base 1·83 metres, depth buried in soil 1·52 metres, encased in concrete, average span 75 metres; for greater spans of 125 metres, posts of 19 metres are used.

The conductors are 12 m.m. in diameter and consist of seven steel wires. They are carried at the corners of an equilateral triangle of 2·13 metres side. The above figures refer to the lines of the "Ontario Power Company."

Protection.—Networks to protect telegraph or telephone wires from contact with high tension wires in case of breakage of the latter are rare, probably because they are not legally enforced.

Transformers.—Three-phase static transformers are used, it having been found more economical to use them than to use single-phase ones. In the case of small transformers, they are cooled by air and water circulation; in the case of larger transformers, forced ventilation is used. Star or triangle windings are used; it has been found that the star windings work better if the neutral point is connected to earth.

A. H. SCOTT.

RIVISTA DI ARTIGLIERIA E GENIO.

July—August, 1911.

ON THE IMPORTANCE OF AUXILIARY TECHNICAL METHODS IN ADVANCED RECONNAISSANCES.—In an article that lately appeared in the *Vierteljahrshefte für Truppenfürung und Heereskunde*, 1911, the principal ideas on the subject mentioned above are explained by Major Thomsen of the German General Staff.

In advanced reconnaissances the cavalry in discovering the locality and movements of the enemy are always likely to come into contact with mixed detachments of the three arms which have been pushed forward on the enemy's front and flanks. To overcome such resistance it should be provided with power of fire that it does not possess in its present equipment; and even if it were provided with a rifle of equal power with the infantry, it would always find itself in a condition of inferiority, owing to the small numbers that would be found in the firing line, and also to the fact that the horses are an impediment to profiting by the advantages which might eventually be obtained.

Although the fire of the cavalry should be rapid and have the character of surprise, the idea now seems to be favoured of assigning horse artillery to the masses of cavalry in advanced reconnaissances, and also detachments of infantry and mitrailleuses which would give the necessary fire power, and which should possess such mobility as would not interfere with free movements, this can be obtained by automobiles and bicycles. Isolated detachments of cavalry should be employed between the patrols and squadrons; but between these and the commander of the cavalry on advanced reconnaissances the necessity will be felt of technical means of communication. The telegraph and the telephone are the technical means now in use, but the automobile and the motor cycle, movable stations for wireless telegraphy, and apparatus for visual signalling, are also now of the greatest importance. The automobile as a means for transporting fire power, as represented by rifles and mitrailleuses, is found to be ill adapted to this work; the heavy wagons for carrying 40 men with their arms and equipment, besides the mitrailleuses, are always tied to the roads, and have to be abandoned by the cavalry, thus losing that cohesion between the two elements which is so essential to success.

If however the cavalry regulates its movements to those of the column of automobiles, its action becomes restricted, especially in regions with a network of muddy roads, the freedom of its movements being hindered, which freedom constitutes the principal basis of its employment.

Again the idea of assigning to the cavalry on advanced reconnaissances armoured wagons with cannon, which, left on the roads, may be captured by the enemy's exploring parties, is shown to be impracticable, owing to their weight and inability to turn on ordinary roads. Means of this kind for transporting rifles and mitrailleuses on automobiles should not be assigned permanently to bodies of cavalry when employed on such service. There are also grave objections to the use of ordinary automobiles for exploring roads, etc.; such carriages pushed forwards in advance beyond our extreme lines would certainly be lost, either by capture by the enemy in the vicinity, or by the drivers being struck by projectiles; so that it may be impossible under the enemy's fire either to advance or to recede. It is therefore necessary to abandon the illusion that automobiles can be of great service for reconnoitring the roads, and to avoid the assignment of such vehicles to the cavalry commands. There is, however, a large scope for the employment of automobiles on advanced reconnaissances as a means of transport for the reinforcements for the masses of cavalry in poor and exhausted countries. The reinforcement at great distances from the depôts is a matter of great difficulty and inconvenience with long and slow columns of wagons drawn by horses, which seriously impede the movements of the cavalry.

The employment of autocars of medium weight that would carry a useful load of 2 to 3 tons, and with a speed of about 15 k.m. would seem destined to effect a complete change in a remodelled service. The automobile is also an effective means of communication between the command of the cavalry and that of the army; an encounter with the enemy being exceptional in this case. In an enemy's country the hostility of the inhabitants may cause difficulty, but on the other hand the possibility of communication in a short time, between two commands at a distance, is of the greatest importance.

The substitution of the motor cycle for the automobile is not advisable; the working of the motor is not always reliable, and the motor cycle is too much affected by the state of the weather and of the roads, and calls for an extraordinary tension of the faculties of the motor cyclist, the only advantage offered is that it is able to pass long columns easily on the march. The bicycle however is well adapted for the transport of rifles, and for following the cavalry on advanced reconnaissances. The simplicity and the lightness of this machine gives to the cyclist detachments a mobility which enables them to keep in close touch with the cavalry wherever they go.

The telegraph and the telephone are the means of communication most in use, and the cavalry in advance should be well provided with the necessary material. Now, it may be observed that in war time the long lines of wire which constitute the communications are exposed to damages which may compromise the security of the latter; the employment of permanent lines such as those used in peace manœuvres, is only permissible in a friendly country. In an enemy's country the permanent lines would be destroyed and any repairs that could be executed would always be liable to interruption by the hostile population.

The apparatus for visual signalling does not present such inconveniences as those caused by the use of flying lines of telegraph wire, but it is necessary to establish a series of intermediate stations for the transmission of telegrams to great distances, and their use is much influenced by atmospheric conditions. Notwithstanding the above, this system is much favoured on account of its simplicity and facility of transport which permits of its use between the various lines of the exploring cavalry. The movable radio-telegraph system does not answer entirely to the above idea; the mobility which is required has not yet been obtained together with sufficient power, and the employment of stations transported by wagons and automobiles limits the communication between the commands of the cavalry and the supreme command.

In conclusion, in considering the three rôles of cavalry on advanced reconnaissances, fire power, mobility, and adaptability for transmitting information, we find that the first may be obtained by arming them with the best firearms existing, and by assigning to them detachments of trained mitrailleusists, and cyclist detachments, in addition to the horse artillery; the second may be increased by the exclusion of cars or wagons that tend to restrict them to the roads, so becoming an impediment, and by assigning automobiles only for the transport of reinforcements; and the third may be favoured by the use of wireless telegraphy, and visual signalling which would render them independent of telegraph lines.

The successes obtained by dirigibles have given rise to the idea that the perfecting of this technical branch would not only be a complement to the explorations of the cavalry but would tend to a diminution of that arm. But this idea is not correct, because the great mass of cavalry in advanced reconnaissances does not only fulfil the duty of distant exploration, it serves also as a powerful means of protection to the army; the fact that the cavalry has to perform its duty during and after battles is of such importance as to exclude the idea of reduction of any kind.

But again let us consider how in carrying out distant explorations the cavalry is indispensable, whatever progress may be made in aerial navigation. Only by the aid of cavalry will it be possible to keep in touch with the enemy at night and in mist, and in all other cases when the action of the dirigibles or aeroplanes will be impeded by natural causes which will always exist.

Notwithstanding the difficulties of keeping account of all the factors which influence the action of the dirigible (force and direction of the wind, ascending and descending currents, variation of temperature, mist, rain, snow, etc.) it has to be considered that a dirigible of the latest model can under particularly favourable circumstances, make a flight of 250—300 k.m. in about 10 hours at a height of 1,200—1,500 m.

From observations made of the atmospheric conditions of Central Europe it would seem that similar conditions prevail only in a limited number of days of the year, so that the activity of the dirigible, especially in the spring or autumn, may be completely paralyzed for whole weeks.

Another difficulty in the employment of dirigibles for exploring purposes, is the necessity of having to keep up the hangars. The stations on the borders of the frontier would only serve for the first few days of a campaign, and the problem of adapted roofs, easily removable and transportable, is still far from being satisfactorily solved.

The principal advantages of the aeroplane consist in its simplicity and the small number of persons required for its preparation and manœuvring, and the possibility of preparing a great number in a relatively short time is of great value. The rapid flights which have recently been performed have also to be considered, sometimes more than 100 k.m. in the hour, and this last is of especial value in a military point of view.

The first natural consequences that aerial exploration will cause in a campaign will be the discovery and location of the enemy's troops, of their cover, and concealed trenches, etc.

Finally it may be observed that in increasing and bringing to perfection the means of exploration and communication it is impossible for the commander to avoid all uncertainty, and strong as the temptation may be to await new information, and to retard the sending of orders or despatches until a fortunate flight may clear up any doubt as to the enemy's position, such temptation would only suggest weakness. To command is so to speak to foresee, and when information is wanting, according to Clausewitz recourse should be had to the law of probability. In any case the commander ought to act, and not to leave the initiative to the enemy,—in action comes success, in inactivity defeat.

E. T. THACKERAY.

CORRESPONDENCE.

TACTICAL RECONNAISSANCE.

SIR,

At a tactical reconnaissance tour carried out recently in the Lake District by two batches of young officers, the enclosed report was handed in by 2nd Lieuts. W. W. Peache and K. D. Yearsley.

As the report so thoroughly fulfils the requirements for which it is intended, the Commandant, S.M.E., thinks that its publication would be of general interest to the Corps and he trusts therefore that you may be able to find space for it the *R.E. Journal.*

Yours faithfully,

H. W. WEEKES,

S.M.E., Chatham. *Brigade-Major.*

SCHEME.

Report on the road between Portinscale and Buttermere with a view to the retirement of the artillery from the right of the position by this route.

What can you do to improve it with your section of the 55th (Field) Company?

REPORT.

Ref.—Sketch Map Attached.

(1). The road from Portinscale to Stair (A5) being steep in places (1 in 8), we considered the advisability of going round by Braithwaite: but we considered that this road would be required for troops retiring by the Whinlatter Pass; so we have not reported on it. Also the Braithwaite-Stair road would be more exposed to hostile artillery from the east of Keswick.

(2). From Portinscale to Stair the road is well covered from view by woods. The metalling is good, and there are stone walls which could be broken up, in case of a bad fault in the road. Slopes of 1 in 12. (See sketch).

(3). Just after Stair there is a bad hill (1 in 8 for 150 yards), width only 8'. At the top the road is flat for 300 yards and about 20' wide.

The upper part of the hill and the flat at the top are exposed to the enemy's artillery positions above Keswick.

This is the only portion of the road which is exposed.

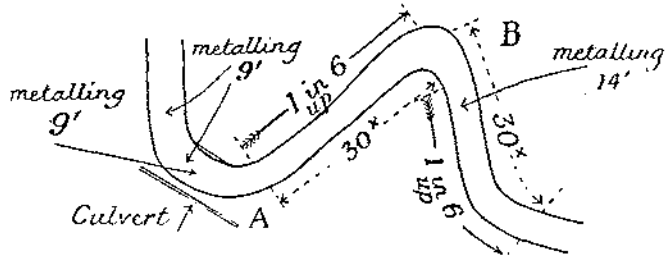
(4). Some mounted infantry near Cat Bells (C6) would be all that would be required to protect the retirement. Their horses could be placed near Little Town (B6); and they could follow the artillery over the pass.

(5). The next difficult place on the road is the hill after Newlands Hotel (B5). About 300 yards of 1 in 10. If extra horses were required they could be sent back by the track in Newlands Valley (B4).

There is a sharp corner with deep slope (1 in 13) at Baird Hall (A—B4). This could probably be rushed as the road is 16' wide.

The metalling from Newlands Hotel (B5) to Devil's Elbow (A3) is moderately good, and stone walls are at hand for repair.

DEVIL'S ELBOW (A3).



(6). The above is a hand sketch showing the road at the "Devil's Elbow."

The metalling on culvert is only 9′ wide; but it could be widened to 16′ at A, and a ramp made so as to enable horses to rush the corner.

At B is a gate where broken-down vehicles could be run in.

If extra horses are required they can be sent back across the fields to south-east of road.

(7). After "Devil's Elbow" the road is fairly level for a mile: metalling moderate.

The road is unfenced, and a stream runs beside it at which horses could be watered without buckets.

The stream bed is full of stones which could be used for metalling.

The last hill up (B2) is 1 in $4\frac{1}{2}$ for 200 yards. There is a level space at top 50 yards × 50 yards where some guns could be run off the road, and their teams sent back by north side of road to help other guns.

(8). If necessary some guns could be sent down to Buttermere with four horses to keep road clear; the lead horses being retained to bring up the rest of the guns.

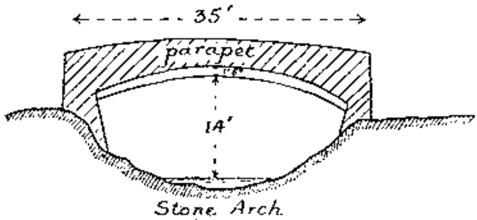
The road from the top to Buttermere is steep (constant gradients of 1 in $6\frac{1}{2}$). There are deep drains across it at intervals which could either be filled in or passed slowly.

There are a lot of side tracks, etc., all along the road, where broken-down vehicles could be run off the road. (See sketch map).

(9). Appended is a sketch of Stair Bridge (A5).

STAIR BRIDGE (A5).

(For other Bridges, see Sketch).



Width between parapets 12'.

Stair Bridge is marked as unsafe for heavy vehicles and locomotives, but should be perfectly safe for field guns and howitzers, though not for heavy artillery. The latter could not be taken up this pass in any case. Suggested that hedge opposite N.W. end should be cut away for 20 yards, to avoid sharp corner, and facilitate unhooking horses for watering in firm field beyond. Join road again 100 yards along hedge, through the gate.

K. D. YEARSLEY, *2nd Lieut., R.E.*
W. W. PEACHE, *2nd Lieut., R.E.*

DRIFT OF A BULLET.

DEAR SIR,

I have only just seen Major Carey's letter or would have replied to it before. His statement of the two points raised by him is so esoterical as to make it difficult to be sure of what he means.

(*a*). Whether the viscosity of the air is the only factor that can *affect* the *rolling motion of the bullet*. As I do not admit that the bullet rolls I do not see how viscosity, or anything else, could affect a movement which, for me, does not exist. I am satisfied that viscosity could not *cause* the rolling; and I know of nothing else which could.

(*b*). *Why* upward pressure *should be applied* to the nose of the bullet or gyroscope, when every known fact tends to show that the resultant force produces a downward movement of the nose. I do not know *why* the bullet should have its nose pressed upwards when the nose is above the line of the trajectory; but it is a fact. I equally do not know *why* a stone should fall to the earth, but I know it always does. There is nothing inconsistent in the nose of the bullet being pressed upwards whilst the nose is actually moving downwards. Pressing the nose of a rotating bullet upwards will cause *not a vertical* but a *horizontal* movement of the nose.

I am sorry to contradict Major Carey but I think the "rolling theory" of drift, being inconsistent with known laws of Nature, can hardly have any pretensions to being called scientific.

Yours faithfully,

6th November, 1911. R. DE VILLAMIL.

NOTES ON SKI.

SIR,

Now that the ski-ing season is again within measurable distance, the following minor emendations and comments on Capt. Bremner's article on this subject in the *R.E. Journal* for June, 1911, may perhaps be useful.

1. LOCALITIES.—(*a*). *Feldberg* (Black Forest).—Is apt to be very crowded, especially by Germans. Not unlike Norway.

(*b*). *Switzerland.*—The heights—by which most places are judged—are not quite accurately given. Full details are to be found in Baedeker, or Wroughton's *Winter Sports Annual*; some of the more important are:—Davos, 5,100′; Arosa, 5,800′; St. Moritz, 6,000′; Engelberg, 3,300′; Grindelwald, 3,400′; Mürren, 5,400′; Adelboden, 4,500′; Kandersteg, 3,900′; Gstaad, 3,500′; Saanenmöser, 4,200′; Montana, 4,900′; Villars, 4,100′.

The Siegfried Atlas maps, $\frac{1}{50000}$, are admirable, and every ski-runner should use them.

(*c*). *Tyrol.*—St. Anton and St. Christoph are practically synonymous from the ski-ing point of view. In general the country hereabouts is steeper than in Switzerland. Heights in Tyrol are lower than in the Alps; hotels and inns 2,500′ to 4,000′, huts perhaps 6,000′. See Baedeker's *Eastern Alps* or Wroughton's book above mentioned.

2. Equipment.—(*a*). *Telemark Ski.*—Length, for runners of moderate skill, should be to the *tips* of the fingers when the hand is held up above the head to its full extent. The tendency is to have ski too short. Upper surface of ski is better oiled than varnished; snow sticks less to it.

(*b*). *Sticks.*—The tendency among the best runners is to use one light bamboo stick the height of the elbow. The stick should only be used uphill or on the level, like a walking-stick; no decent runner ever uses his stick *at all* downhill (a narrow icy path, where there is no possibility of braking with the ski, is an exception).

(*c*). *Sealskin.*—The detachable kind, preferably with patent clips instead of strap and buckle, is practically universal, and is worth a dozen of any rope arrangement.

(*d*). *Wax* applied hot usually overdoes the effect required.

(*e*). *Repairing Outfit.*—A "tin toe" is just better than nothing. The best provision against a broken point is a pair of small metal clamps (sold in the shops) to screw on.

The so-called "handy tool" is usually dispensed with.

Screws, nails, sheet brass, etc., are most unpleasant to work with on a mountain-side, and are only necessary on a long and serious tour.

(*f*). *Gloves.*—For all ordinary work Jaeger's woollen ski-ing gloves are first-rate. Three pairs should be taken.

(*g*). *Clothing.*—Trousers, tied in round the top of the boot with a bit of old puttee 4′ long, are more comfortable than knickerbockers. The coat and trousers should above all be *thin*, summer-weight stuff. A Viennese oil-silk wind-jacket is a very sound thing to carry in the rucksack.

(*h*). *Goggles* are absolutely essential, even though they may never be used.

(*k*). *Crampons* are advisable.

3. Books, etc.—Mr. Caulfeild's *How to Ski* is far and away the best in any language for a beginner. Mr. Richardson's *The Ski-Runner* is the next best. The military uses of ski have been dealt with in the *United Service Magazine* and in the *Journal of the U.S.I. of India*. The various clubs all publish interesting literature.

4. Clubs.—(*a*). *Ski Club of Great Britain.*—At present the premier British club. Covers all branches of ski-running. Requires a moderate standard of skill in its candidates. Subscription £1 1s. 0d. *per annum.* Secretary's address, Caxton House, Westminster.

(*b*). *Alpine Ski Club.*—Ski-running in its application to winter mountaineering, of which some experience is required. Subscription 10s. 6d. *per annum.* Secretary's address, 12, Liverpool and London Chambers, Liverpool.

(*c*). *Scottish Ski Club.*—Address Dr. Wigner, Dundee University. I do not know what the subscription is, but the club is the fountain head of ski-running in Scotland, and is a flourishing and enthusiastic institution.

Yours faithfully,

C. Hordern.

BOOKS RECEIVED.

1863. CHANCELLORSVILLE AND GETTYSBURG. By Colonel P. H. Dalbiac. The "Special Campaign Series," No. 13. Price 5s. net. Messrs. Geo. Allen & Co., Ltd., 44 & 45, Rathbone Place, London.

THE CAMPAIGN IN VIRGINIA AND MARYLAND, June 26th to September 20th, 1862. Cedar Run, Manassas and Sharpsburg. By 2nd Lieut. E. W. Sheppard. The "Special Campaign Series," No. 14. Price 5s. net. Messrs. Geo. Allen & Co., Ltd., 44 & 45, Rathbone Place, London.

MY EXPERIENCES OF NAN SHAN AND PORT ARTHUR WITH THE EAST SIBERIAN RIFLES. By Lieut.-General N. A. Tretyakov. English translation. Price 12s. 6d. Hugh Rees, 119, Pall Mall, S.W.

THE IRRIGATION OF MESOPOTAMIA. With Portfolio of Plans. By Sir W. Willcocks, K.C.M.G., F.R.G.S. Price 20s. net. Messrs. E. & F. Spon, 57, Haymarket, S.W.

REINFORCED CONCRETE CONSTRUCTION. Elementary Course, with Examples worked out in Detail for all Types of Beams, Floors and Columns. By M. T. Cantell. Price 4s. 6d. E. & F. N. Spon, Ltd., 57, Haymarket, S.W.

HANDBOOK OF THE SOUTHERN NIGERIA SURVEY AND TEXTBOOK OF TOPOGRAPHICAL SURVEYING IN TROPICAL AFRICA. By Major F. G. Guggisberg, C.M.G., R.E. Price 3s. 6d. W. & A. K. Johnston, Edinburgh.

A MILITARY WORD AND PHRASE BOOK. German, with English translation. By Professor F. Sefton Delmer, Lehrer an der Kriegsakademie und an der Militär-technischen Akademie, Berlin. Price 3 marks 60 pfen. A. Bath, Mohrenstrasse 19, Berlin.

MANUAL FOR CADETS OF THE O.T.C. JUNIOR DIVISION. Compiled by Capt. G. T. Hankin, O.C. King's Coll. School Contingent, Wimbledon. Price 1s. Harrison & Sons, St. Martin's Lane, W.C.

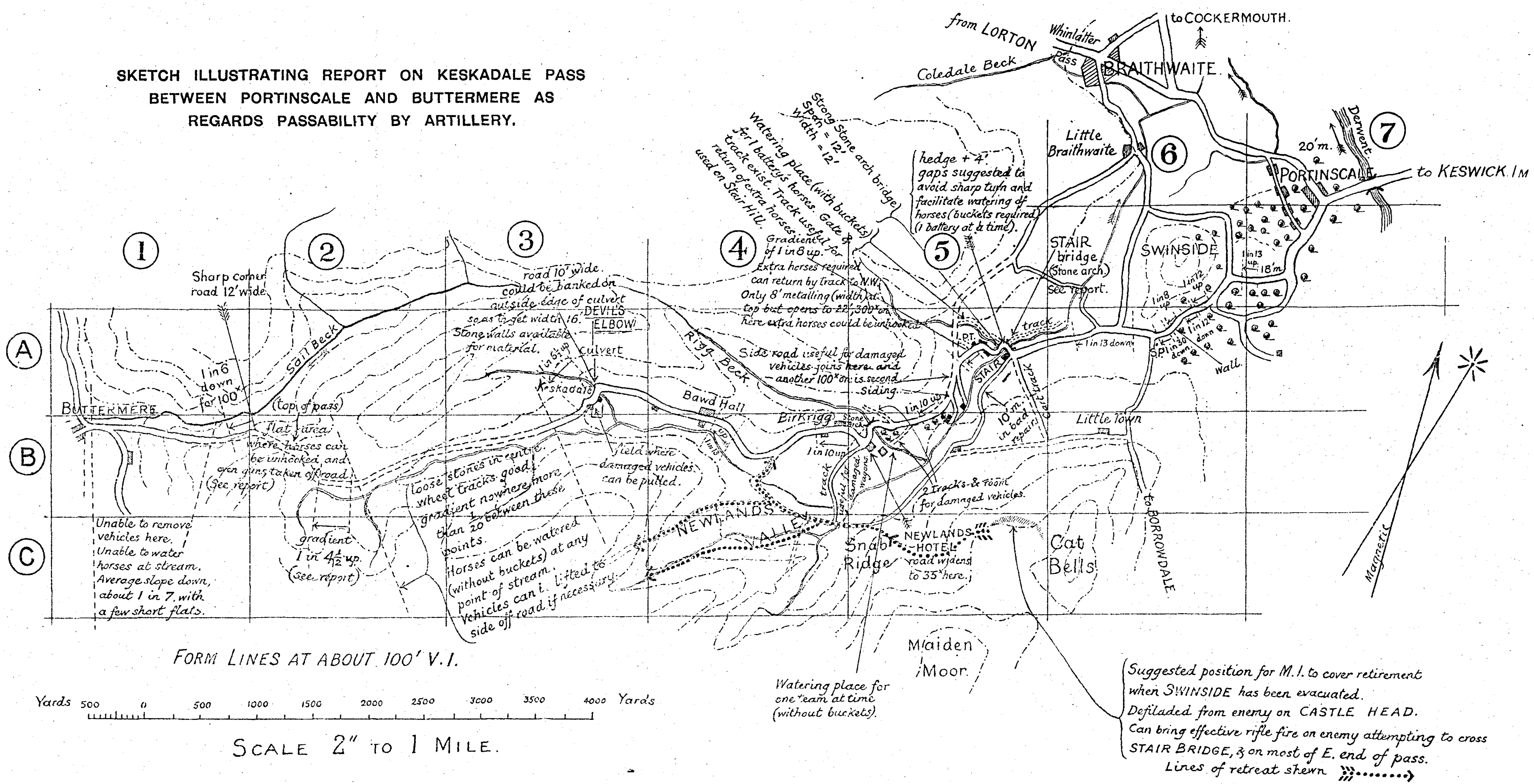
DERRIÈRE LA FAÇADE ALLEMANDE. Par P.D. du journal "La Dépêche." 1 fr. 50 c. R. Chapelot & Cie., 30, Rue Dauphine, Paris.

MILITARY HISTORY FOR EXAMINATION QUESTIONS ON THE RUSSO-JAPANESE WAR, 1904, from 23rd August to end of October. With Map. By Lieut.-Colonel H. M. E. Brunker. Price 1s. Forster, Groom & Co., 15, Charing Cross, S.W.

SKETCH MAP TO ILLUSTRATE THE RUSSO-JAPANESE WAR, 1904–5. With Notes and References. 2s. 6d. Forster, Groom & Co., Ltd., 15, Charing Cross, S.W.

HISTOIRE ÉLÉMENTAIRE DE L'ARCHITECTURE MILITAIRE DEPUIS L'ANTIQUITÉ JUSQU'AU XVI. SIÈCLE. Par Albert Mersier, Membre de la Société Française d'Archéologie. Ernest Leroux, 28, Rue Bonaparte, VI[e], Paris.

SKETCH ILLUSTRATING REPORT ON KESKADALE PASS BETWEEN PORTINSCALE AND BUTTERMERE AS REGARDS PASSABILITY BY ARTILLERY.



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