THE ROYAL ENGINEERS JOURNAL.

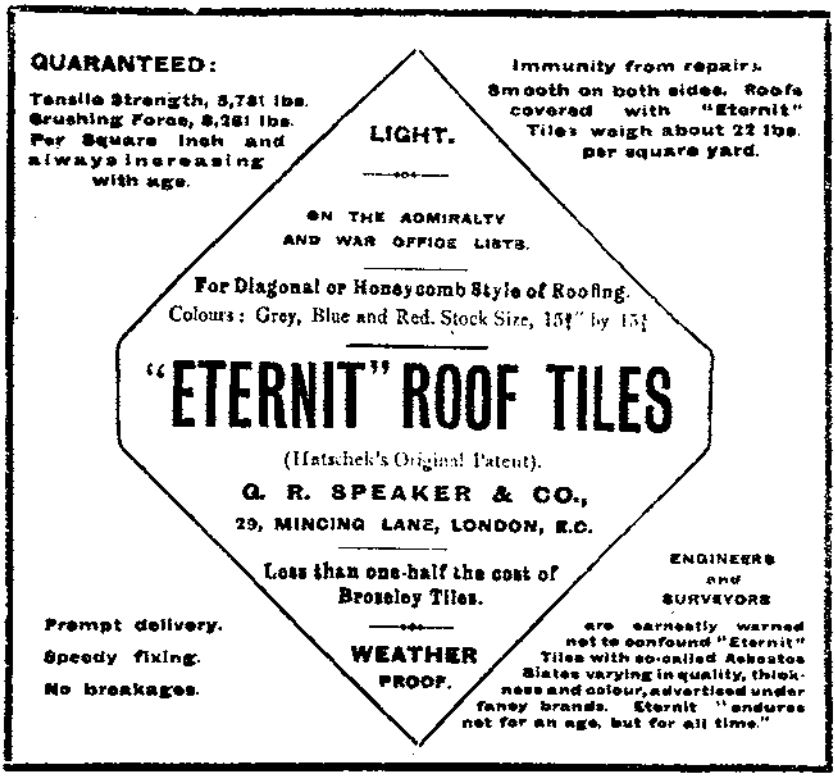
Vol. XV. No. 3. MARCH, 1912.

CONTENTS.

149

INSTITUTION OF RE OFFICE COPY

DO NOT REMOVE



G. E. CARRINGTON,

For many years Master Tailor, Royal Engineers,

TAILOR & MILITARY OUTFITTER,

53, HIGH STREET,
OLD BROMPTON, KENT,

And at CARLTON HOUSE, REGENT STREET, near Waterloo Place, S.W.

HOURS OF BUSINESS:—
Old Brompton, 8.30 to 7.30; Saturdays, 8.30 to 2.
Carlton House, 11 to 6; Saturdays, 11 to 1.

Telephone No.—East 53. Telegraphic Address:—"Constructive Ironworks, London."

MATTW. T. SHAW & CO., Ltd.,

MILLWALL, LONDON, E.

CONSTRUCTIONAL STEELWORK,
FRAMED BUILDINGS, BRIDGES, ROOFS, Etc.

Large Stocks of Joists, Channels, Angles, Tees, Flats, Plates, Chequers, Rounds, Squares, Rivets, Bolts, Galvanized Sheets, etc., etc.

VERY PROMPT DELIVERIES GUARANTEED.

BY ROYAL WARRANT.

THE

Goldsmiths & Silversmiths Company

Ltd.

With which is incorporated THE GOLDSMITHS' ALLIANCE, Ltd. (A. B. Savory & Sons). Established 1751.

Fine Gold and Enamel Scarf Pin.

£1 12 0

ANY BADGE ADAPTED TO ANY STYLE OF JEWELLERY.

Famous the World over for

DESIGN. QUALITY. VALUE.

REGIMENTAL JEWELLERY.

Fine Gold and Enamel Brooch.

£4 0 0

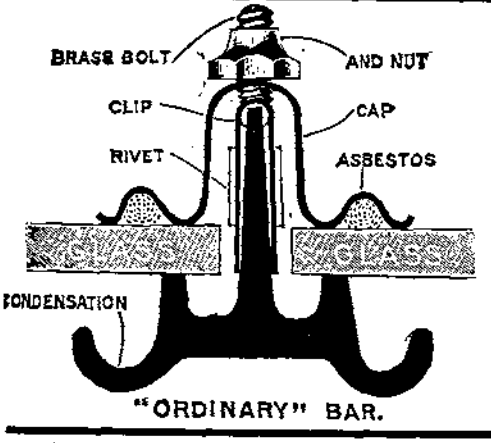
Fine Gold and Enamel Scarf Pin.

£2 10 0

CATALOGUE OF BADGE JEWELLERY SENT POST FREE.

THE PUBLIC SUPPLIED DIRECT AT MANUFACTURERS' CASH PRICES.

112, REGENT STREET, LONDON, W.



"ORDINARY" BAR.

THE "PERFECTION"

PATENT GLAZING.

No Putty. No Paint. Imperishable.

Steel Glazing Bars Galvanized or also entirely covered with lead to prevent corrosion.

GUARANTEED WATERTIGHT.

Apply:

HELLIWELL & Co., Ltd., Brighouse YORKS.

Extensively used by H.M. Government for Barracks, Drill Halls, Dock Sheds, Post Offices, Stores, Etc.

AKTIENGESELLSCHAFT HAHN, CASSEL, Germany.

SPECIALITY.

Instruments of every description for TESTING ARMS AND EXPLOSIVES.
Optical Instruments for Artillery.
"Hahn" Telemeters for use in the Army and Navy.

Agents:—PLUTTE SCHEELE & CO., Ltd., 18-19, Queenhithe, London, E.C.

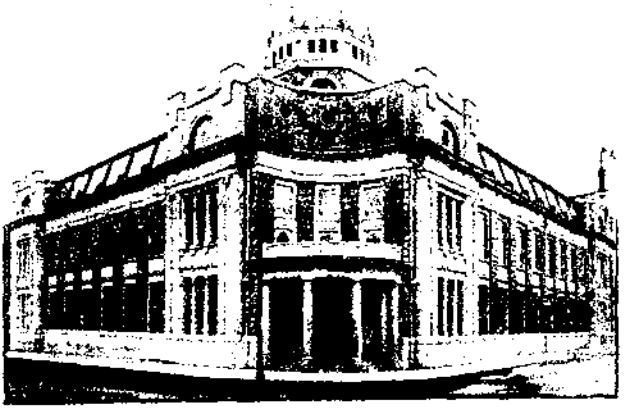
THE EXPANDED METAL CO., LTD.,

Patentees and Manufacturers of

EXPANDED METAL

FOR

REINFORCED CONCRETE & FIRE-RESISTING CONSTRUCTION.



TECHNICAL INSTITUTE, NEWPORT, MON.

Expanded Steel-Concrete Foundation Raft, Dome, etc. Expanded Metal Lathing and Plaster Ceilings, etc. Mr. Chas. F. Ward, City Architect.

Messrs. W. E. Blake, Ltd., London & Plymouth, Contractors.

REINFORCEMENTS FOR CONCRETE.

EXPANDED STEEL SHEETS AND BARS FOR

Foundations, Walls, Floors, Roofs, Bridges, Reservoirs, Sewers, Conduits, Hoppers, Silos, etc.

LATHINGS FOR PLASTERWORK.

EXPANDED METAL LATHINGS FOR

Exterior Walls, Ceilings, Partitions, Steelwork-Encasings, etc.

EXPANDED METAL SHEETS

For use in

Fencing, Divisions, Guards, Ventilators, Lockers, Baskets, etc.

PLEASE WRITE FOR ILLUSTRATED HANDBOOK AND PRICE LIST.

THE EXPANDED METAL CO., LTD.

Head Office : YORK MANSION, YORK ST., WESTMINSTER, S.W.

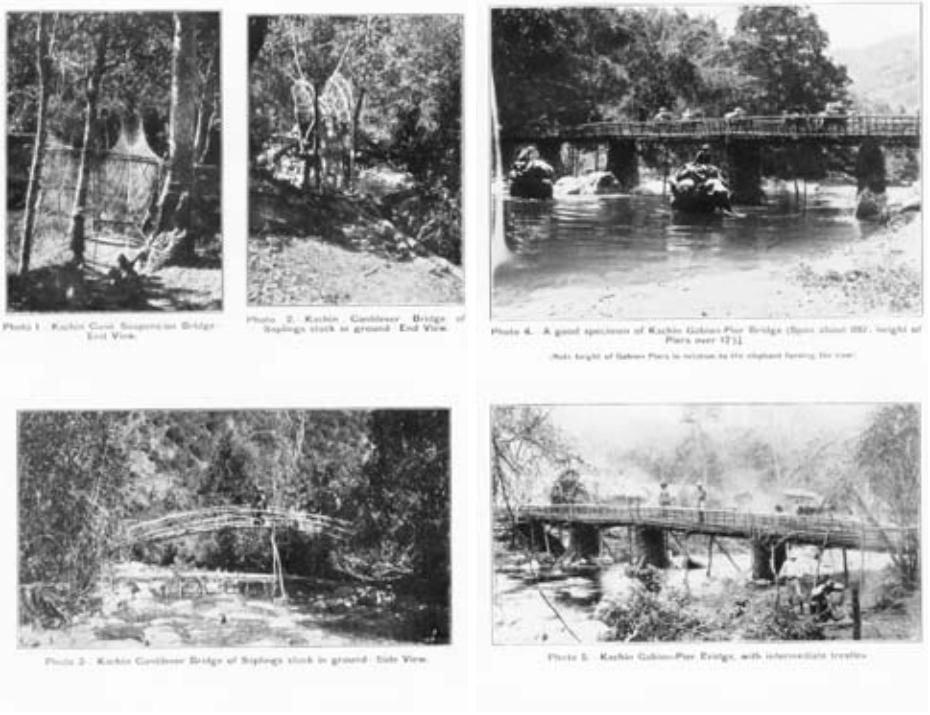
Telegrams :—"DISTEND, LONDON." Telephones :—Gerrard 819 ; Victoria 1514.

Works : Stranton Works, West Hartlepool.

Telephones 94 & 245. Telegrams : "Expansion, West Hartlepool."

CONTENTS.

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



Kachin Bridges

KACHIN BRIDGES.

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

In the extreme north of Burma, interposed as a buffer between the Burman of the Irrawaddy Valley and the Chinese of Yun-nan, lives a Mongolian race known as the Kachins. Their land being a blend of dense bamboo jungle, raging torrents, and precipitous mountain ranges, and being furthermore almost entirely unproductive of anything of the slightest use to the white man, it has so far been little visited by Europeans. Although largely represented on the map by an area void of anything but the conventional signs for mountains and rivers, it contains a number of villages tenanted by a hardy race of small stature, whose flat faces and oblique eyes lead ethnologists to conjecture that their possessors were originally immigrants from the steppes of Eastern Thibet.

Living amid such conditions of jungle, they have developed a remarkable skill in the use of the "dah" (a two-handed knife, combined tool and weapon), and in the application to useful purposes of the bamboos felled by its aid. Given dah and bamboo, the Kachin will make for himself a plaited belt or a house, a cooking-pot or a bridge. It is of these latter that this article proposes to treat, in the hope that a more general acquaintance with these jungle shifts may haply avert such sad episodes as quoted by Lord Roberts in *Forty-One Years in India*. Readers of that work will remember how, in the Lushai Expedition of 1871, the local coolies completed a very serviceable bamboo bridge across a certain river, while the R.E. officer told off for the job was still making calculations and searching for what he considered suitable material.

The various native bridges met with in the Kachin Hills may be classified under three main heads, though the design of any particular bridge is often a blend of two or more distinct types.

(1). The suspension bridge, made from canes or creepers.
(2). The cantilever, from saplings and bamboos.
(3). The trestle and pier, the former made from saplings and bamboos, and the latter from stone-filled gabions.

The two first are used mainly in the wet season, when every nullah is a roaring torrent. They cross the gap in one span well above high flood level, but are adapted only to carry single passengers. In the dry season, if there be no ford at hand, they are replaced by the third variety which will take all the local traffic including loaded pack mules.

(1). SUSPENSION BRIDGES.

For these it is usual to choose a point for crossing where two forked trees can be found to serve as piers at opposite sides of the stream (*vide Fig.* 1). If forked trees, however, are not to be found, two straight ones growing close together will be accepted as a substitute for either pier (*vide Photo* 1), or even posts planted in the ground will be used. Five cables of cane or creepers (which grow to a very considerable length in these jungles and run up to about $\frac{3}{4}$" in diameter) are usually employed to cross the gap. First a double cane, made of two twisted together, is stretched as tightly as possible between the bottoms of the forks of the two trees. This forms the roadway of the completed bridge. Next, two single canes are bound to each arm of each fork. These are also hauled as tight as possible, and are consequently more or less parallel to the roadway cable, the upper cane on each side being about shoulder high above it. These five cables are then linked together with thinner canes, till the whole forms one trough-like system inside which the passenger walks.

If either of the trees forming the piers is not stiff enough to resist the forward pull of the cables, it is stayed back with cane to another tree in rear. Should the forks of the trees (which are, of course, the shore ends of the bridge) be at an inconvenient height above the ground level, shore bays of logs are added to give access to the bridge (*vide Fig.* 1).

This type of bridge may be met with in spans of anything up to 60' or 80'.

(2). CANTILEVER BRIDGES.

To construct these, two rows of saplings of about 6" diameter have their butts well buried in opposite banks, and their tips (which previously pointed upwards at about 45°) hauled down till they meet and overlap in the middle, where they are then lashed together. This forms an arch of considerable strength. Some half dozen or so saplings thus fixed side by side go to form the roadway, while two or three more, set at a steeper curve, provide the hand rails, the whole being lashed into one system with small canes.

In the bridge shown in *Photo* 3, the centre is seen supported by two poles crossed like a pair of sheers. This extra prop is sometimes added, but as the first flood removes it (like the low-level trestle bridge seen beyond it) without making any apparent difference to the cantilevers, it can hardly be considered as essential.

(3). TRESTLE AND GABION PIER.

Ordinary trestle bridges, the trestles being made from saplings and the roadway from split bamboo covered with a little earth, are used across the smaller streams. By a judicious use of forked poles

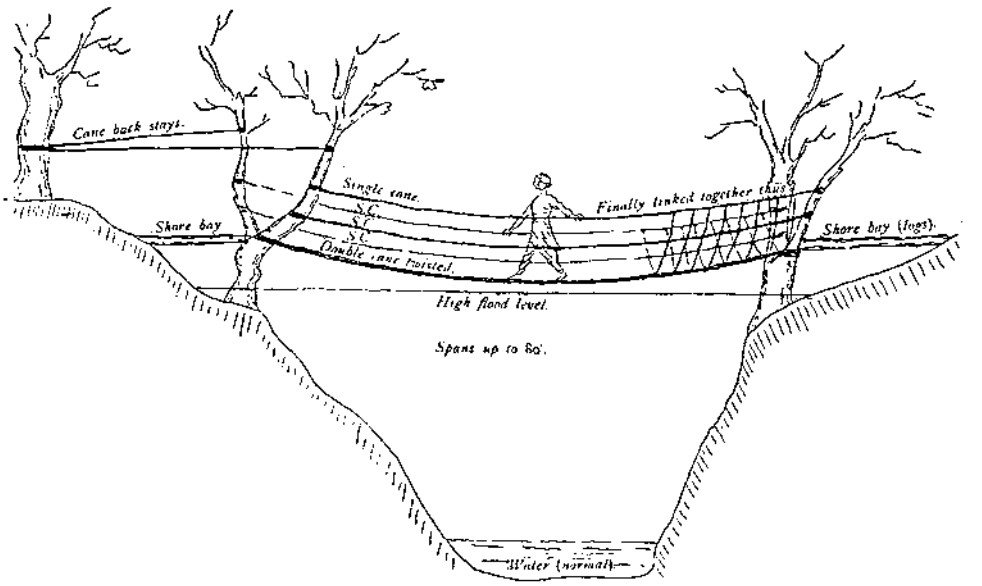


FIG. 1.—*Kachin Cane Suspension Bridge.*

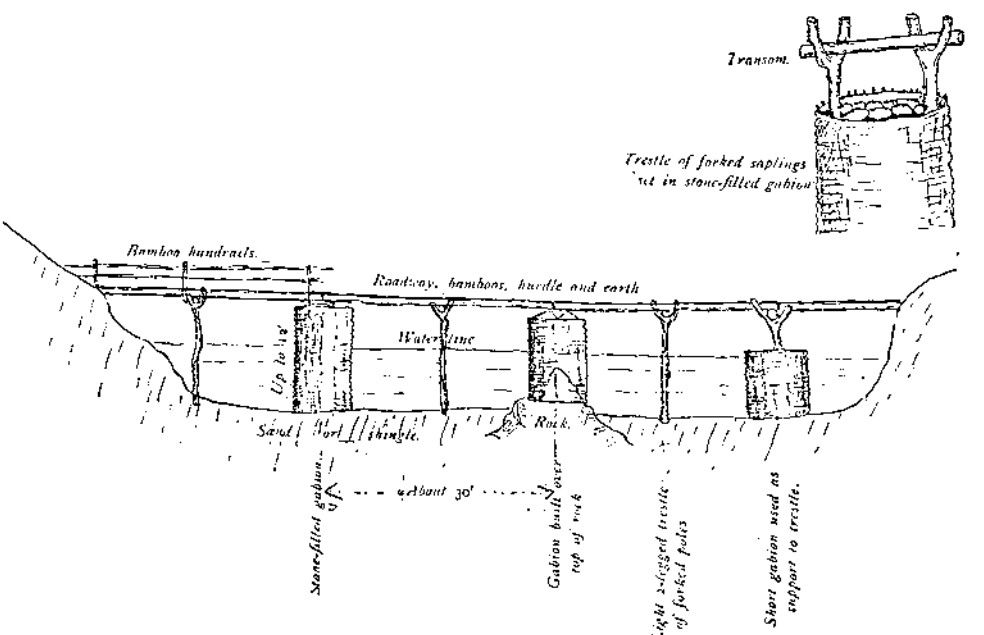


FIG. 2.—*Kachin Gabion-Pier Bridge with intermediate trestles.*

for the trestle legs, the Kachin avoids having to use lashings (always unsatisfactory and perishable) for connecting transom and standards. Ledger and diagonals are usually dispensed with, but inclined struts are sometimes used from roadway level to the bottom.

When, however, the depth of water is considerable (over 4′ or 5′) these trestles have a tendency to lift and float away. Also, they are unsuitable for rapid currents. To provide weight against the former contingency, and stiffness against the latter, gabion piers are used, sometimes alternating with, sometimes in complete replacement of, the trestles. These are large bamboo gabions, often 10′ to 12′ in height, and 4′ to 8′ across, completely filled with stones as large as can be conveniently lifted. On the top of these rest the road-bearers, which are saplings or large bamboos, and above these comes a continuous bamboo hurdle, made *in situ*, covered with a few inches of earth. If a large rock should occur in the stream, it is made use of as a combined anchor and foundation for one of the gabions, which is built to enclose it. Sometimes a low gabion is used to give support to a trestle for about half its height, and sometimes a plain trestle is placed between every two gabion piers. This is perhaps the most usual type, and is shown in *Photo* 4 and *Fig.* 2.

This form of bridge is marvellously quickly constructed and uncommonly useful and enduring. It will stand any sort of flood until the water actually begins to wash over the roadway, when the latter is destroyed by the earth washing out, and the road-bearers then floating away. But even then the gabion piers often remain, and the bridge is quickly repaired when the water falls. On the recent Hpimaw Expedition a series of such bridges occurred on the L. of C. of the column, and with very slight repairs served to carry all its pack transport for some five months.

A PONTOON BRIDGE FOR STEAM TRANSPORT.

(Concluded).

By Capt. W. L. de M. Carey, R.E.

In the February number of the *Journal* four types of bridge were considered under a load of a $7\frac{1}{2}$-ton steam tractor. Design IV. was shown to be unsuitable, whilst Design II. necessitates extra stores and more labour during construction, giving in return no adequate advantage. These two types will not be further considered.

The load, the effect of which has been investigated, is the simplest for calculation, but will not be the usual one in practice. An engine will nearly always be drawing one or more trucks, loaded or empty, and may be following close behind a similar train, ordinary transport, or troops.

Design I.—Using the same notation as before, first consider the case of a tractor drawing one loaded truck, the axles of which are $8'\ 9''$ apart and each bear a load of $3\frac{1}{2}$ tons. The distance from the driving axle of the tractor to the front axle of the truck is taken as $10'$.

Fig. 7 shows this load for Design I. when the driving axle is over a pontoon.

If the baulks were stiff their positions under the load would be as shown in *Fig.* 7*a*, but the baulks *ce* and *eg* being unsupported at the centre will bend, and the ends of the baulks *df* will be deflected upwards with respect to *e* by the forces B*d*, B*f*, until the saddles of the pontoons *d* and *f* touch the baulks *ce* and *eg* and take a portion of their loads.

To find the true positions of the pontoons let x be the pressure that the pontoon *d* exerts on the baulks *ce*; y that of *f* on *eg*; B' the buoyancy of a pontoon due to immersion I.

Then, considering the baulks *ac* and *bd*

$$3 \cdot B'a + 2 \cdot B'b + B'c = \tfrac{3}{2} \cdot 7840 + (\tfrac{2}{3}\,7840 - \tfrac{1}{2}x) + 1500\,(3 + 2 + 1 + \tfrac{1}{2})$$

$$\triangle\, bd = Ic - \tfrac{1}{2}\,(Ib + Id)$$

$$\triangle\, dc = Ib - \tfrac{1}{2}\,(Ia + Ic)$$

Considering the baulks *df*

$$\triangle\, df = Ie - \tfrac{1}{2}\,(Id + If)$$

$$2(B'f - y) + B'e = 11200 + 1500 + (\tfrac{1}{3} \cdot 7840 - \tfrac{1}{2}x + \tfrac{1}{2} \cdot 1500) + (\tfrac{1}{2} \cdot 5600 - \tfrac{1}{2} \cdot y + \tfrac{1}{2} \cdot 1500)$$

Since ce and eg touch d and f respectively

$$\triangle ec = \mathrm{I}d - \tfrac{1}{2}(\mathrm{I}c + \mathrm{I}e)$$

$$\triangle eg = \mathrm{I}f - \tfrac{1}{2}(\mathrm{I}e + \mathrm{I}g)$$

Since the total load must equal the sum of the forces "B'"

$$\mathrm{B}'a + \mathrm{B}'b + \mathrm{B}'c + \mathrm{B}'d + \mathrm{B}'e + \mathrm{B}'f = 5\tfrac{1}{2} \times 1500 + 2 \times 7840 + 11200 + \tfrac{1}{2}(5600 - y) + y$$

The load on g is approximately $\frac{1}{2}(1500 + 5600 - y) + 1500$; $\mathrm{I}g$ can be computed from this.

From these equations the values obtained for I when there are 20 baulks are approximately a $5\frac{1}{2}''$, b $11\frac{1}{2}''$, c $16\frac{1}{2}''$, d $18\frac{1}{2}''$, e $17\frac{1}{2}''$, f $13''$, g $6\frac{1}{2}''$, and the portion of each of the forces B'f and B'd acting on the baulks df is 5,100 lbs.

When dealing with the load of a tractor only, it was shown that I for the corresponding pontoon was $10\frac{3}{4}''$, and B' 5,750 lbs., *i.e. by adding a loaded truck behind the tractor the maximum stress in the baulks under the load has been reduced.* It may therefore be expected that by adding more trucks this stress will be further decreased, especially if the tractor is close to other trucks preceding it.

For the sake of calculation, the portion of bridge under load considered must be small. *Fig.* 8 shows such a portion bearing an engine with two trucks on each side. From the results of the investigation of this case, the effect of a continuous load of steam transport may be deduced.

Assuming the baulks to be stiff the values of I for the centre pontoons would be e $16''$, f $17\frac{1}{2}''$, g $17\frac{1}{3}''$, h $17''$, i $16''$.

The distance between f and the centre of eg and between h and the centre of ig would be $1''$ and $\frac{1}{3}''$ respectively but, as before, the deflection of the baulks will cause f and h to touch eg and ig.

Calculating in the same manner as in the previous case, it can be shown that the values of I for the several pontoons are

a $7\frac{1}{2}''$	d $15\frac{1}{3}''$	g $16\frac{2}{3}''$	k $14\frac{3}{4}''$	n $13''$
b $12\frac{1}{2}''$	e $15\frac{2}{3}''$	h $15\frac{1}{2}''$	l $14\frac{3}{4}''$	p $7\frac{1}{2}''$
c $15''$	f $16\frac{1}{2}''$	i $14\frac{3}{4}''$	m $14\frac{3}{4}''$	

and the stresses in the baulks under the centre of the load, will never be greater than when the heaviest axle is in the centre of a span.

There will however be a stress in the baulks at the ends of the load, caused by the forces B'a B'p, which are only *directly* opposed by the weight of the superstructure above them. These forces will vary as the weight on the last axle of the load, being in the present case

3,700 lbs. approximately, and therefore causing a bending moment in the baulks in question of $(3700-1500)\times 7'\ 6''$, *i.e.* just within the limit of safety of 5 baulks.

These last stresses can be avoided by having a continuous load across the bridge or by having loads gradually diminishing towards each end, *e.g.* by having ordinary transport or troops on the bridge close in front and behind the steam transport.

The heaviest axle (11,200 lbs.) can be carried by 8 baulks but as 3 have to be grouped under each wheel track, 9 or 10 are necessary in order to support the chesses at other points.

It therefore appears that this type of bridge can be constructed with 9 baulks, if traffic is to be regulated, but otherwise needs 20 baulks to be strong enough for all contingencies.

Design III.—In this type of a bridge with a load of a tractor and one truck the values of B in the four cases can be calculated in the same manner as for a load of a tractor only.

In Case 1, the maximum value of I exceeds $18\frac{1}{2}''$ (*i.e.* freeboard of $7\frac{1}{2}''$) and tie-baulks at $3\frac{1}{2}''$ clearance must be used to obviate this. This is shown in the following table :—

	Case 1.				Case 2.		Case 3.		Case 4.	
Position of Driving Axle.	Over *e* (*Fig.* 9).				Between *e* and *f*.		Over *d*.		Between *d* and *e*.	
	With Tie-Baulks.		Without Tie-Baulks.							
Pontoon.	B.	I.	B.	I.	B.	I.	B.	I.	B.	I.
a	140	$3\frac{1}{4}''$	376	$3\frac{2}{3}''$	−879	$1\frac{1}{3}''$	3623	10″	1362	$5\frac{2}{3}''$
b	3583	10″	3014	9″	2589	8″	5677	$14\frac{1}{3}''$	4570	12″
c	7026	17″	5651	$14\frac{1}{3}''$	6257	$15\frac{1}{3}''$	7731	$18\frac{1}{2}''$	7778	$18\frac{1}{3}''$
d	7405	18″	7896	$18\frac{2}{3}''$	7111	$17\frac{1}{3}''$	7047	17″	7686	$18\frac{1}{3}''$
e	7783	$18\frac{1}{2}''$	10142	$23\frac{1}{3}''$	7764	$18\frac{1}{2}''$	6363	$15\frac{2}{3}''$	7594	18″
f	4661	$12\frac{1}{3}''$	5162	$13\frac{1}{3}''$	5709	$14\frac{1}{2}''$	2633	$8\frac{1}{3}''$	3625	$10\frac{1}{3}''$
g	1540	6″	186	$3\frac{1}{3}''$	3454	10″	−1097	1″	−344	$2\frac{1}{3}''$
	T = 2756 lbs.									

The maximum bending moment is 7,000 lbs. $\times$ 3′ 9″ at *e* in Case 2 which is slightly less than the maximum when the load was a tractor only, and as before, 10 baulks are necessary as road-bearers, and 4 as tie-baulks. The effect of deflection is negligible, it being less than $\frac{3}{4}''$ in any baulk.

Fig. 10 shows a load for this design of bridge corresponding to that in *Fig.* 8.

The following table gives the values of I and as before in Case 1 tie-baulks are necessary but with 2" clearance only.

	Case 1.		Case 2.	Case 3.	Case 4.
Position of Driving Axle.	Over *i*.		Between *i* and *k*.	Over *k* (*Fig.* 10).	Between *k* and *i*.
Pontoon.	With Tie-Baulks.	Without Tie-Baulks.			
a	$2\frac{1}{2}$"	$2\frac{1}{2}$"	3"	$\frac{1}{4}$"	—
c	$5\frac{1}{2}$"	$5\frac{3}{4}$"	$3\frac{1}{2}$"	$16\frac{1}{4}$"	$10\frac{3}{4}$"
e	18"	$18\frac{1}{4}$"	$15\frac{1}{4}$"	$14\frac{1}{4}$"	$15\frac{3}{4}$"
g	$14\frac{2}{3}$"	13"	$16\frac{1}{2}$"	18"	$17\frac{1}{2}$"
i	$18\frac{1}{2}$"	$21\frac{3}{4}$"	18"	$15\frac{1}{4}$"	$16\frac{3}{4}$"
l	$14\frac{2}{3}$"	13"	$13\frac{1}{2}$"	14"	$15\frac{1}{4}$"
n	$14\frac{1}{3}$"	$14\frac{3}{4}$"	$17\frac{1}{2}$"	18"	16"
r	$16\frac{1}{4}$"	$16\frac{1}{4}$"	$15\frac{1}{4}$"	$5\frac{3}{4}$"	$10\frac{1}{2}$"
t	$\frac{1}{4}$"	$\frac{1}{4}$"	$3\frac{1}{2}$"	$2\frac{1}{2}$"	—
	T = 1,850lbs.				

The maximum stress in the baulks in any of these cases is that caused by the driving axle in the centre of a span. The effect of deflection on the positions of pontoons is negligible, the greatest being $\frac{3}{4}$" in *gi* in Case 3, and $\frac{1}{2}$" in *ce* in Case 1. Design III. can therefore be constructed for continuous or gradually diminishing loads with 9 baulks as road-bearers and 4 as tie-baulks (lashed at their centres).

COMPARISONS OF DESIGNS.

Providing that the practical details of securing the tie-baulks do not prove a difficulty in Design III., both types of bridge will be of use, being suited to different circumstances which may be summed up as follows :—

1. If time and material are no object.
2. If water is rough and freeboard is all important.

} Design I. with 20 baulks.

3. If material is scarce.

} Design I. with 9 or 10 baulks and traffic regulated.

4. If time is all important.
5. If the bridge has to be made from rafts.

} Design III., 2nd pontoons and tie-baulks being added whilst the troops are crossing.

6. If transport cannot be regulated and material is limited.

} Design III., with clearance of tie-baulks regulated for single heavy loads.

Design I. causes more deflection in the baulks than Design III. which is a disadvantage from the point of view of wear and tear, and liable in time to make the baulks fail under the horizontal shearing stress.

Details of Construction.

Tie-Baulks.—It has been assumed in investigating Design III. that extra baulks which have been called "tie-baulks" were so arranged that the amount the pontoons under their centres could sink below the adjacent pontoons was limited to some fixed distance.

There are three ways of carrying out this arrangement.

Firstly; by placing the baulks as ribands and securing them to the saddles below them, at their tips by light lashings, and at their centres by lashings strong enough to take a strain of 5,500 lbs. (eight complete turns of an $1\frac{1}{2}''$ lashing are necessary) and made loose enough just to give the amount of play determined on.

Secondly; by placing the baulks beyond the roadway, and after blocking them up the necessary amount from the gunwales of the pontoon they are to support, lashing them by turns passing under the pontoon. This will take 15 fathoms for each lashing (*i.e.* two $1\frac{1}{2}''$ lashings per pontoon in the bridge) but will save $\frac{1}{3}$ of the tie-baulks, as has already been shown.

Thirdly; by placing the baulks on the projecting ends of the saddles and lashing them either as in the first case or, after blocking them up the necessary amount from the saddles at their centres, lashing them tightly there and leaving the ends unlashed.

Each method has its advantages but the first seems the most practical, its chief disadvantage being the necessity for notching the chesses to allow the lashings to be made.

Adjustment of clearance can be made in all cases by making the centre lashings to suit the greatest clearance ever to be required and inserting chocks to reduce it to that required at the time.

It may with reason be argued that the extra factor of safety for live load need not be as great for tie-baulks, as for road-bearers, because the strains on the former are more gradually and only indirectly applied. On this assumption, a bridge of Design III. with 10 baulks and 4 tie-baulks (*i.e.* for continuous loads) would carry any traffic except a steam tractor alone without alteration of the clearance of the tie-baulks.

Racking and Ribands.—The calculations for Design II. and for tie-baulks give some idea of the strains that may be brought on ribands, and to avoid this only pliable material should be used for the purpose, or else racking should be loose. Furthermore the stress in a riband increases, in some cases, the stress in the baulk it is racked to, by tending to even up the levels of the pontoons.

Chessing.—Double chessing is not a necessity as regards strength when baulks are grouped under the wheel tracks, and it would be more economical as regards wear to single chess only and add wheel tracks, made either of chesses, or better, of any suitable material that could be obtained on the spot and discarded when worn out.

Conversion of Medium Bridge to Heavy Bridge of Design III.—The second pontoons can be floated into place without their saddles by loading them up with men, and the saddles with their cleats under the correct baulks may be slid into position from the side of the pontoon.

If the road-bearers and chesses have to be added to, the necessary numbers for each bay can be placed on the gunwales of the pontoons, and every alternate 15′ length of the bridge can be simultaneously unchessed, have baulks inserted, and be double chessed.

Traffic would be interrupted for less than 10 minutes, and if the full number of road-bearers were available for use when the bridge was being built, there need be no interruption at all.

Forming from Rafts.—15′ rafts can be constructed with the full number of baulks and chesses for the finished bridge, and with three pontoons, the fourth, necessary for the space between two rafts when in bridge, being towed.

Forming Up.—When forming up there is a trouble in placing baulks that does not occur in the present type of bridge. The cleats on the saddles of three pontoons covered by any set of baulks must be accurately in line or the baulks will not fit. In rough water or where there is a strong current it is very hard to hold the pontoons in position even for the short time necessary to place the baulks, and if the centres of the outer baulks are not placed in the correct cleats, the centres of one of the inner baulks may come over a space between cleats too narrow to give it a bearing.

This can be avoided in Design III. by having the saddles of the pontoon under the centre of a set of baulks loose, and securing it after the baulks are placed.

Cuts may be formed in either type of bridge with 10 road-bearers by making a slight modification in design, but with more than 10 road-bearers there is not room for the extra baulks necessary.

The cut-raft in both types of bridge should be a 5-boat section constructed on the lines of Design III.

In Design I., the baulks, the centres of which rest on the last pontoon in bridge, must be replaced by ribands. In Design III., five ribands in addition to other road-bearers would have to be placed in this position.

The cut-baulks are placed on the cut-raft.

To form cut; after pushing back the cut-baulks, the 5 riband-roadbearers are slid back under the superstructure of the raft in bridge. The tie-baulks over the end pontoons of the cut-raft can be

slid back clear of the rafts in bridge at leisure, when the time to form cut approaches, provided that steam transport is not crossing at that moment.

Shore Ends.—When trestles have to be used at the shore end of a bridge, in order to get an even bearing for the baulks resting on both trestles and pontoons, special arrangements are necessary.

The system of breaking joint with baulks (Design I.) is obviously not suited to more than the slightest change of slope, and the variation between the levels of the bridge loaded and unloaded will be more than enough to upset the bearing of the baulks that rest on a trestle.

Take a case where one trestle is necessary between the shore transom and the first pontoon. If the transom of this trestle is adjusted to the level of the unloaded bridge, as the first axle of a load passes it, the first pontoon will sink and leave the baulks on its shore side acting as cantilevers.

To avoid this, a second trestle can be placed a foot from the first (*Fig.* 11) to receive the ends of the baulks *b′d* its transom being adjusted 1½″ to 2″ above the general level of the bridge when under its heaviest load. The transom of the original trestle to be placed at a level half-way between the loaded level and the unloaded level of the bridge. The baulks *ac* must always be the full number in a bay, *i.e.* between *b* and *c* in Design I. there will be half again as many baulks as in any other bay.

In the case of Design I. with 20 baulks and a tractor coming off the bridge alone, the 20 baulks are strong enough to carry the driving axle in the centre of their span. In the case of a bridge of 10 baulks (Design I.) the tractor will be followed by trucks and the pontoon *c* will be at such a level that the baulks *ac* are just bearing on the trestle. As the driving axle comes to *c* and starts up the incline *cb*, the pontoon *c* will tend to sink, but will be prevented from doing so by the baulks *b′d* taking the extra load.

For Design III. the best arrangement would appear to be to have the baulks from *b′* to *d*, *d* to *f*, etc., when the shore end would act as in Design I. If the baulks are placed from *c* to *e*, *e* to *g*, the tie-baulks from *c* would rest on *b′*.

In this type of bridge, if a tractor is to cross alone the clearance of the tie-baulks throughout the bridge needs adjustment and the transoms *b′* and *b* can be adjusted at the same time.

Tidal ramps may be constructed with trestles 7′ 6″ apart, but not with baulks breaking joint owing to the changes of slope necessary. The deflection of the baulks under load will take up any small errors in adjustment of the transoms.

An experimental heavy bridge with pontoons at 7′ 6″ centres was constructed at Wouldham last autumn, of which a portion was loaded till there was a freeboard of 12″. The bridge was swung

successfully both with and against the current, which was flowing at $2\frac{3}{4}$ miles per hour, showing that the obstruction to the waterway by the intermediate pontoons is not so great as to cause too heavy a strain on the anchors. No test for the strength of baulks could be made as the heaviest vehicles available were pontoon wagons, but valuable information might be obtained from such tests by noting the deflection of a set of baulks for various positions of the load. If the concentrated dead load which could cause such a deflection is less than the safe *live* load for the same length of span, the baulks are not being strained beyond their safe limit.

Cuts were made in the manner previously mentioned but without tie-baulks, and in consequence there was a tendency for the end pontoons of the cut-raft to sink more than other pontoons when the load came over them. The time taken to form cut was only half a minute longer than in the case of "medium" bridge.

THE LATEST DEVELOPMENTS IN MUSKETRY.

A Lecture delivered at the S.M.E., Chatham, by BRIGADIER-GENERAL W. N. CONGREVE, V.C., C.B., M.V.O.

I FIND myself put down to address you on the subject of "The Latest Developments in Musketry," and when I first heard my subject I said to myself,—But there are none!

Consideration, however, and looking back over the last two years, convinced me that things have moved to some extent during my time at Hythe, and that it is only their gradual growth following naturally from the system started by my predecessors—Generals Monro and Egerton—that prevented me from seeing them at the first glance; at the same time there is nothing which can be called new.

"Developments" is the exact word wanted, and I propose to bring some of these to your notice. To do this, I must more or less go through the whole subject of musketry.

The first consideration is, do we now, in these days of flat trajectory, long-range rifles, collective fire, and an often invisible enemy, require a high standard of individual skill? Many people have said we do not, and the Japanese, I believe, set little store by it—so little indeed that our 2nd Class shot is about equal to their marksman. There are two arguments which I think quite convincing in its favour,—

(1). That confidence is bred by it, and terror by its absence.
(2). That it is essential for instructors, a man being believed in in the ratio of his own skill.

Your work as sappers will often put you in small isolated detachments, and for you, skill with the rifle is, I consider, an enormous asset worth any effort to attain.

Being then agreed as to the necessity for a high standard for the individual,—how is it to be obtained? Ranges are often difficult to get to or non-existing, and ammunition is little and very expensive. Barrack square work—miniature ranges and 30-yard ranges, supply the deficiency. In all these, we have advanced to some extent, and we have proved that men thoroughly trained by such methods have really very little more to learn as far as individual proficiency goes. Even the miniature range alone goes far to make an accurate bull's-eye shot which, mind you, up to 1902 was nearly *all* we aimed at. The Secretary of Lord Roberts' Society of Miniature Rifle Clubs told me only the other day that lots of their clubs can produce men to

compete on equal terms at bull's-eye shooting on the open range, and at distances up to 800 yards, with any team in the kingdom.

It would take too much of the time at my disposal to go into all the details of the improvements made in these above-mentioned methods of training, but I would mention new landscape targets, accurate ammunition and rifles for miniature ranges, improved apparatus for working targets, perfection of the Solano target, and improved construction of the 30-yard ranges.

The great point about all these things and any other odds and ends of contrivances, is that they tend to keep the men's interest, and prevent them from being bored—a very important matter if good results are to be expected.

I am not concerned in the firm, but Messrs. Graham & Latham of Charing Cross are about the best people for all range appliances, and I advise anyone fitting up a miniature range to send for their catalogue. At the same time, we claim to provide all they do with the standard patterns, shortly, I hope, to be in Part II., *Musketry Regulations*, and invented by Capt. Hobbs, R.E. These cost enormously less, but certainly are very rough and less attractive. I so often see miniature ranges in a most neglected and unattractive state for which there can be no excuse, for a little initiative and a little money (very little) will put them all right. Hythe is always ready to give the benefit of its advice, if people will only ask, and they certainly will save money by doing so.

I find some units do an enormous amount of voluntary night practice on miniature ranges, and the non-commissioned officers and men quite keen about it. But for this you must make the range attractive with smooth working and, most essential, good lighting.

Before I leave the question of the individual, I would say a word on eyesight.

I am often told that our standard of vision admits men to the Service who are physically unable to aim, but the Americans have proved that soldiers artifically blinded by glasses to a standard considerably below our rejection limit can still shoot almost as well as with their normal vision, and not only shoot but pick up targets on the field. When therefore you get a recruit who pleads bad sight for his bad shooting do not attach too much importance to it for in most cases patience in the instructor and will power in the man will overcome the difficulty.

Now we will pass on to the next consideration in training, which is the teaching for collective fire rendered necessary by the inability to see service targets, or the strike of single bullets beyond close range. Men who have not considered the question are apt to say that the only proper system of training is at the bull's-eye, and that the individual is useful up to 1,100 yards or even more. Well, for such people a very simple cure is to show them a practical demonstration

such as shooting at head and shoulder targets at successive ranges from 400 yards to 800 yards. I have never known it fail.

Collective fire is, as you all know, the power to co-ordinate the fire of individuals at the will of one; to get the maximum result from it requires a highly trained commander, with a knowledge of what we call the error of the day—of ground, and of tactical considerations which influence fire—and of methods necessary to place the shots of his men where he wishes.

From the men we must expect ability to hold steady, aim, and let off correctly, and appreciate from their commander's description the place he wishes them to hit. It really, as far as their part goes, may be summed up in the word "discipline."

The Spectator lately said, talking of the Italian-Turkish War,—"Fire control is the first proof of military discipline." My experience is that in this particular point we have very much to learn. Men can now shoot well as individuals; their ability to kill dummies and knock down plates is generally of a very high order; but there it ends—whereas it should be the beginning.

It is no use if kept for range practices; we must insist on careful aiming and careful positions, and careful fire orders at all times, and especially at manœuvres; it is when men are tired that discipline shows, and what we have got to get from the men is such a discipline as shall make correct sight setting, aiming, and firing, a habit under all circumstances, and from fire unit commanders, a perfect control of fire, and an ability to see what is wrong and have it put right.

Now, how are we going to get these things? We are again brought up by want of ammunition and of ground, and again we must have recourse to substitutes, such as barrack square training, miniature ranges, and 30-yard ranges. On these, with the help of landscape targets, magic lantern targets, Solano, and Sykes targets, a very great deal can be done.

There is no need for me to go into details of any of these except the Sykes target and the lantern target, which may not be familiar to you. The former has only lately been brought to my notice by Colonel Mark Sykes, M.P. It consists of a miniature theatre stage, with wings and drop curtain; the stage is covered with sand, which can be modelled to make a landscape, on which are placed models of houses, churches, bridges, trees, etc., made to scale according to whether in foreground or background. The ground is coloured with a sprinkling of dyed sawdust of colours required by the picture. A landscape target is in fact actually made. Fire can be opened on it, all bullets being caught by the sand, and miniature targets scaled to distance can be placed anywhere on the picture. The use of the drop curtain is for competitions; each commander in turn is given a landscape and can place his force where he pleases on it; the curtain is then raised and the opponent has to find and engage the enemy

within a given limit of time. One of these targets has been erected at Hythe and we shall be very glad to give any information as to measurements and costs.

The lantern idea is the product of Capt. de Putron's visits to Territorial Force, and seems to promise well, particularly for work at night, and putting in practice the competitions in collective firing which have been found to be popular.*

By such means as these we can go a long way towards making up for lack of ground and ammunition, and I am confident can produce well-trained leaders and firers without going to a full-sized range at all, but you must so arrange that musketry is made a part of all your work and not kept apart as such.

Before I leave this part of my subject I would mention the points that we are weakest in and must amend if we are going to do any good in war. They are, in the men, bad aiming at service targets, bad positions when at field firing and manœuvre, bad recognition of targets through idleness or want of training; in the fire unit commanders, inability to give good orders, and slackness in checking faults. If we do not see to these in peace, assuredly we shall get failure in war.

Before I go to the last part of my subject, which is how we are to make the best use of the perfectly trained instrument when we have got it, I would say a word on machine guns, for they can hardly be left out in any considerations of musketry.

We have, I am thankful to say, thanks very largely to my chief instructor—Colonel Campbell—caught up our leeway and are abreast of foreign nations in this particular. Now we have got to get ahead of them in the same way as I believe we are ahead of them in rifle fire.

It can be done, but only by a determination to have the best possible training and by clear thinking as to how guns will be used in war; but what most concerns you is how they are to be opposed when met. So far, we think the chief considerations are to avoid giving a good target—to avoid places which will afford observation of fire to the gunners, for it is everything to a machine gun to get the correct range owing to the close grouping of its fire compared with that of riflemen—and if you are caught in close order, scatter, take cover, and concentrate fire on each gun in turn to destroy it. I have no time to go into the subject properly, for it is a large one, and a very important one, but I could not avoid mention of it in any question dealing with firearms, for I am certain it is going to develop

* The lecturer then showed a few slides to illustrate the possibilities and pointed out that any clearly defined lantern slides of landscapes will answer the purpose. Those giving clear detail of objects within 1,000 yards are desirable. The lantern should give very clear definition and have a focal length exceeding 15 yards, which is the minimum distance for miniature range shooting.

enormously, till some day we shall see each company in possession of machine guns.

Having now considered the methods by which we can get fire applied exactly where we want, let us consider a few points of its tactical handling.

I do not propose to go into matters which are already detailed in *Infantry Training* and *Field Service Regulations;* the former are new, and a huge advance, from our point of view anyway, on anything we have had before.

There are, however, a few points which are worth bringing to your notice before I finish.

First, as regards the regulations themselves, we must use common sense in interpreting and applying them, but there are certain things which admit of no variation, and these we have got to get our men to use as a habit, so that when bullets are thick and all control has become impossible, they will still do the right thing, as it were, automatically.

In this particular matter of which I am talking to-day, sight-setting, aiming carefully, and firing correctly, using cover properly, and always advancing when opportunity offers, are the things which have to become second nature, and they are all grouped together under the words Fire Discipline. We can only get it by stiffening up discipline until men find that it does not pay to do wrong—nothing else will make the habit we want.

Next I would mention reconnaissance, because it is most neglected. It applies to everyone, from the Commander-in-Chief to the private soldier; every commitment of troops must be preceded by reconnaissance, and before every advance the same. Battalion commanders, company commanders, section commanders, for all alike it is essential, for so only can proper use be made of ground and of fire. How often at manœuvres do we see men crowded together in a firing line and unable to see any target, or supports lying exposed to the enemy's fire and unable to reply to it owing to their front being masked by other troops. There is no penalty for such things at manœuvres, but a very terrible one will be exacted when it comes to war. It is always due to the want of reconnaissance and thought before moving. Remember, however, that to do it properly takes time, and so give the necessary time for it, and do not hustle your subordinates unduly but insist on a reasoned course of action in every case.

There are five points to be considered before fire can be opened:—

(1). Volume, which is of course dependent on the number of firers, and the rate at which they fire.

(2). Whether fire is to be concentrated or distributed, the maxim being to concentrate for decision, to distribute to neutralize.

(3). The range and elevation required, which latter does not always agree with the range; wind, altitude, temperature, may all affect it.

(4). Allowance required for the error of the day, and the point of aim, which latter alone should be mentioned, irrespective of the target itself.

(5). The description of the point of aim, so that all can recognize it.

Since the whistle has been stopped as a signal for ceasing fire, the problem of how fire is to be stopped is rendered more difficult; I suggest for trial, to name the number of rounds invariably, and to train someone in each section to look out for the commander's signals.

In an advance under fire, whether it be artillery or rifle, we have to present the most difficult target to the enemy, and this is believed to be the simultaneous advance of a number of small bodies from constantly varying parts of the attacking line; in other words, an "ordered disorder"—a thing very hard to arrive at, and requiring much practice.

Our object must be to keep our men in hand as long as possible, for once they are extended, the power of manœuvre is gone.

The best cover is bullets, therefore every advance must be covered by fire; the advance of a company by another company; of a section by another section; of two men by another two; the principle runs right through, and when we at manœuvres see bodies of troops advancing and no fire, we may be sure it is unreal and could not be done in war. The *raffales* of artillery should be the signal for infantry to rush forward and gain ground.

The question of the advance is difficult; it must of course depend on the volume of the enemy's fire, but the guiding principle should be to push forward the greatest number that the covering fire will permit of. Still more difficult again is the question of length of advances—they must be regulated by the fire positions, and not be a question of so many yards. Advance from fire position to fire position and get to each new one as quickly as possible; avoid crowding and dead ground from which you cannot fire. Rise quickly and lie down quickly. The Japanese found their greatest losses were when halting and starting again; as the result of their experience they try to keep their men on their legs as long as possible. Avoid aiming marks for the enemy and hedges or ditches oblique to the enemy's fire. Look out for opportunities to help neighbouring troops forward, but in such cases leave some men to keep down the fire of those in front whose fire you have mastered. If at any time there is a lull and you have opportunity, use it to reconnoitre lines of advance in every direction, for you can never tell in what direction the next advance may take you.

Then come the final stages when control ceases to be possible and men have to work forward themselves until they reach a position from which, with a line of maximum density, they can beat down the enemy's fire and obtain such superiority of fire as will permit the assault to be delivered; the only alternative is to entrench and wait for nightfall to carry out the assault.

Throughout an attack there will of necessity be much confusion and mixture of units, therefore every opportunity must be taken to re-form and reorganize; constant practice will be required in accustoming men to act under the nearest section commander, no matter to whose section they may belong.

A final consideration is whether it is possible to deliver fire in movement in order to get over the last few hundred yards in delivering the assault; it has been done, and is practised by some armies still. Our own regulations are silent on the question, but it is one worth consideration, for to leave the enemy unmolested seems to give him an opportunity to again get his head up and fire at us without any danger to himself.

I referred a moment ago to work by night. It seems likely that perfection of arms and modern fieldworks may make attacks by day too costly to be undertaken. Moreover, modern systems of communication and the extended front of battles have made it possible to repair the losses and disasters of day by working at night, bringing up fresh troops, or retiring to a new and previously prepared position.

These considerations seem to demand more action by night so as to prevent the rest of darkness causing a loss of all that has been gained by day, and we must therefore consider how we are going to act. Our regulations go fully into the question. Working on miniature ranges lighted by acetylene gas or some other powerful illuminant, has been found by the Austrians to be a great help in training to pick up targets, and hit them when working with search lights.

Search lights are all very well for the defence, but inpracticable for the attack, which will, I hope, be our *rôle*, so we must consider the matter from that point of view.

We think that men can be trained to an automatic alignment, so that on throwing the rifle up at the flashes of the enemy's rifles they will, though they can see neither rifles nor sights, put a fair proportion of bullets near the enemy, but to get this automatic alignment requires very constant practice. We have tried it, and got some encouraging results, but not enough yet to speak authoritatively, for we have yet to compare those results with others obtained from untrained men.

Remember that whenever fire is employed at night, men must be left to themselves—to choose their own targets, rate of fire, and sighting, for control will be impossible. Therefore high fire discipline and the judgment learned from experience is essential. Austria has

begun to recognize this, and has undertaken regular field firing by night. I am bound to say it reads a little theatrical, but they claim to have learned a good deal. The chief point brought out is, I think, the tendency to shoot high, so that in any exercise of the sort it is necessary to put sights several hundred yards below the normal, and this applies equally to shooting by search light.

I have lately been staying with General Gorringe, a very distinguished member of your Corps, and told him I was coming here to-day. He said "Tell them always to remember that they are soldiers first and engineers after." Well, gentlemen, if you accept that saying then you must accept my idea of the primary importance of skill with the rifle *Infantry Training* says "The rifle is by far the most deadly of the weapons with which soldiers are armed. In recent wars it has been responsible for 85 per cent. of the total loss in battle." Another authority has said that 75 per cent. of the fire in battle is misdirected, and there is the old saying it takes a ton of lead to kill a man, which show how far armies in the past have been from anything like high training. It lies with us to attain a better standard than anyone else has. We can easily do it, for we have more ammunition than any other army and we keep our men seven years against others two. But it is in the hands of us officers; if we are content with a low standard we shall certainly have it and we shall still expend an enormous weight of metal in killing one man. Our numerical inferiority seems to make it essential for us to grasp every means which may in any way counterbalance it, and if you think the matter over you will I feel sure agree with me that perfection of fire action promises the best hope for us.

NOTE ON THE GRAPHIC CHART.

SHOWING THE SCANTLING AND NUMBER OF ROAD-BEARERS OF VARIOUS TIMBERS TO CARRY TYPICAL KINDS OF MILITARY TRAFFIC UPON BAYS OF DIFFERENT SPANS.

By LIEUT. S. M. COLLINS, R.E. (T.), M.A., BARRISTER-AT-LAW.

THE Graphic Chart which is issued with this number (see *Plate*) is an attempt to obviate the necessity of calculation in respect of the road-bearer members in field bridges and similar structures of timber. It is complementary of some graphs contributed to the R.E. *Professional Papers* by Capt. C. E. P. Sankey, R.E., some of which it incorporates. It is now possible, given the traffic, the span of bay, the quality of timber, and the scantling, to determine instantly the number of baulks necessary to carry the load safely. This would be, perhaps, the most usual question asked of the chart when a work is being designed, but any one of the factors can, of course, be found if the others are known. Thus an estimate of the capabilities of already-existing structures can be made, or verified, from the diagrams. The method of use is explained in the text on the chart itself. All the scales, with the exception of that of the span of bay, are, it will be seen, logarithmic. The position of certain of the commoner kinds of timber is, for readier reference, indicated specifically on the scale of Modulus of Rupture at the approximate values usually assigned to them; but subdivisions of the line at regular intervals are also shown, to admit of the interpolation of the breaking strength of any sort of timber or other material within the limits of M_r adopted. Similarly the M_f for loads other than the troops and vehicles specified, stationary as well as moving, can be estimated on the vertical scale. The types of military traffic selected for illustration are:—(i.). Troops in all march formations. (ii.). The heaviest carriages that accompany, severally, such units as are most commonly found acting alone, (the names of these are appended to those of the corresponding vehicles). (iii.). The heaviest guns used in the field and some representative heavy transport conveyances.

The chart as a whole will be found more forbidding in aspect than intricate in practice. It is contended that in a few seconds, accurate information can be obtained which would otherwise demand lengthy and irksome computation; consequently, several alternative combina-

tions of span, scantling and number of road-bearers can be readily compared. And by the inclusion of traffic chart and spar charts in one diagram to the same scale, the liability to error in transferring readings from one chart to another or of adjusting them to differing scales is avoided.

Opportunity is gladly taken of acknowledging Capt. Sankey's generous permission to make use of his work, without which the spar charts would have been but partially complete; but it is right to add that he is not responsible for the accuracy of the matter, nor for the manner of its presentment.

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

(Continued).

Memorandum by Sir H. Clinton on the "Movements of the 6th Division at the Battle of Salamanca."

When the attack was made by the 3rd, 4th and 5th Divisions, the 6th, which with the 7th were in the second line, supported it, in columns of Battalions with intervals for formation.

When the 6th Division had arrived abreast of the Ampila height its left was vigorously attacked by a body of cavalry which had been concealed by the height, and at the same moment that part of the first line in front of the centre of the 6th Division was repulsed and a Column of the enemy was advancing with rapidity; there was just time to form the two right Battalions (Queens and 36th) of the 6th Division the immediate advance of which in line, drove back the enemy who had already been checked by the 32nd Regt., halted in close column.

After the enemy had been driven from his first position, the troops halted, and the 6th Division subsequently received orders to attack a considerable body of the enemy who had formed upon a rocky ridge backed by wood about ¾ mile distant, the Fusilier* Brigade belonging to the 4th Division advanced with the 6th Division to this attack, being exposed during the whole advance to a very severe fire of Artillery and then of Musquetry, to which no return was made; the loss sustained by the 6th Division and Fusilier Brigade was necessarily severe, but the enemy was drawn from his position and the success was complete; darkness prevented the enemy from being followed, but the 9th Caçedores pursued for a short distance and took two pieces of cannon.

At the Battle of Orthes, and in pursuing the Enemy to Barcelona.

On the 25th February† the troops under Sir Rowland Hill, the 6th and Light Divisions were assembled on the high ground opposite to

* *Marginal Note.*—If any corps was intended to turn either flank of the enemy's second position the movement was not made in time, or not sufficiently near to be perceived by either of the contending parties. No troops advanced to the attack with the 6th Division save the one brigade of the 4th Division and Maj.-Genl. Clinton was obliged to detach the 9th Caçedores under Lt.-Col. Brown to cover his own right from the enemy's skirmishers.

† *Marginal Note.*—Sir Harry Clinton's report of the movements of the 6th Division at the Battle of Orthes, and to the 2nd of March inclusive, did not reach Lord Wellington at St. Sever until after he had made up his despatch for England.

Orthes, but from the want of artillery the passage of the Gave could not be effected. Early in the morning of the 26th the enemy made a second attempt to destroy the bridge, the work for which object he was able to proceed with under the cover afforded by the suburb on the left of the Gave, and by a Tower on the extremity of the Bridge. In the course of this morning two fords were discovered above the town, below it there are none above the bridge of Bereux which had been destroyed.

Not receiving any intelligence of Marshal Beresford, who was to pass the Gave near Peyrehorade, Lord Wellington resolved to attempt to force the passage at the two fords above Orthes, though at this time neither of the brigades of nine pounders had arrived. It was about two o'clock when Sir Rowland Hill, Maj.-Genl. Alten and I received orders to march, leaving one brigade of my Division opposite to the bridge of Orthes; at this moment Lord Wellington received information of Marshal Beresford having effected the passage of the Gave, and General Picton had also passed below Bereux. Upon the receipt of this intelligence the movement was stopped, and the sixth and eighth Divisions received orders to march by their left while the second, etc., remained opposite to Orthes.

I arrived at the ford at which the 3rd Division had crossed at half-past five, and, as there was now not time for completing the passage before dark, Lord Wellington desired me to cross the next morning at daylight.

(27th). The 6th Division began to cross the Gave before daylight by a bridge of boats which had been thrown over in the night, at eight o'clock the Light Division began to pass, and joined the fourth and seventh, forming the left Column. The third and sixth Divisions were formed in parallel columns on the great road leading to Orthes.

The attack having commenced on the enemy's right by the 4th and 7th Divisions, the 3rd and 6th were ordered to advance about 10 o'clock. As soon as the 3rd Division which was upon the left of the 6th formed for the attack, I sent two Battns. under Lt.-Col. Coglan to turn the left of the enemy, and directed him to cover the further advance of the 6th Division against any body of troops the enemy might still have in Orthes. The Highland Brigade supported by the Portuguese advanced against the left of the enemy's position, Maj.-Genl. Lambert's brigade remained as a reserve. While this was going on the enemy made an effort, and for a moment drove back a part of the 4th Division, but a part of the Light Division advancing in support of the 4th, order was restored. Our advanced position on the right enabled me to place our guns in a situation greatly to annoy the enemy by firing into one of his reserves formed in 3 solid Columns. He still however continued to occupy opposite to us some very strong ground, and, under cover of musquetry, the 21st Regt. of Hussars crossed a deep hollow and attempted to make a charge. Part of the Regt. of Infantry to my left, surprized at the sudden

appearance of the Cavalry gave way; the Cavalry were repulsed after sustaining a very heavy loss from the fire of the 42nd Regt. and the Portuguese Brigade. The 6th Division was ordered to advance on the right of the road by which the enemy had commenced his retreat. This was along a ridge the ground falling in deep vallies on each side so that it was not possible for troops moving upon the flanks to keep pace with those upon the road. The 42nd Regt. gained the road and drove the enemy very handsomely through the village of Sallespipe, which was the last point at which he attempted to maintain any order, and so far the two battalions of the 6th Division under Lt.-Col. Coglan kept up with him. Here a part of the 2nd Division which had advanced by the great road from Orthes came up and joined in the pursuit. The 6th Division encamped near Sault de Navailles.

On the 28th we followed the enemy by the St. Sever road as far as Gatas rivulet, behind which he was strongly posted, having his right on St. Sever. The difficulties which Sir Rd. Hill had met with, prevented his reaching beyond Condures, and the attack was postponed until the following day, but the enemy crossed the Adour in the night.

On the 1st of March the 6th Division forded the Adour and followed the body of the enemy which had retired by the Barcellonne road, and was ordered to encamp between La Grenade and Cozeres. It was necessary to dislodge the enemy from the village of Borderas where he had established a post of Infantry with 3 pieces of cannon. This was effected with the loss of only one man of the 9th Caçedores.

On the 2nd at ten o'clock, the 6th Division still leading, the Column received orders to march. The enemy with the Divisions of D'Erlon and D'Armagnac occupied Cozeres, having his right on the village of Samansans, which he also occupied, and his left on the Adour. I sent General Lambert with his Brigade to turn the enemy's right and attacked Cozeres with General Pack's Brigade, supported by the Portuguese. The defence was not obstinate; the enemy retired on Barcellonne with the loss of between 30 or 40 killed and wounded and of 30 prisoners: the 6th Division had 2 officers and 40 men killed and wounded. The enemy having continued his retreat to Barcellonne the 3rd and 6th Divisions cantoned in the neighbouring villages.

At the Battle of Toulouse.

In the night of the 9th April the 6th Division received orders to march at 3 on the following morning to Lameergrat, where it joined the 4th Division. At 6 Lord Wellington arrived and gave us orders for the attack of the Enemy's position to the eastward of Toulouse. The 4th and 6th Divisions were to cross the Ess rivulet at the bridge of the Croix d'Orade, and as soon as they should have passed, to form 3 columns of a Brigade each, ascend the left bank of the Ess, and attack the Right of the enemy on the height of Montanotau, while the Spanish Division which had arrived on the great road near Croix

d'Orade should attack the left. The enemy occupied the village of Mt. Blanc through which the 4th and 6th Divisions necessarily must pass, but was presently dislodged by the advance of the 4th Division. During this flank movement the Columns were exposed to a severe cannonade, but the loss was inconsiderable. As soon as the rear of the 6th Division had cleared the enclosures of the village of Mont Blanc, it was menaced by a body of the enemy's cavalry which had descended the height. By this time too the Spaniards had been repulsed in their attack and were in flight, so that the enemy was able to reinforce, by a considerable body of Infantry, the point of his position, menaced by the march of the 4th and 6th Divisions. When opposite to the post they were ordered to attack, these Divisions halted, formed 3 lines and instantly began the attack. No sooner did the lines begin to move than the enemy's cavalry advanced upon the right flank of the 6th Division. To meet this I ordered the 79th Regt. to form Column at quarter distance on its inward flank. As the Cavalry approached it halted and formed square, in which shape a few rounds of musquetry induced the retreat of the Cavalry. The assault was steep, the height however was carried without a check though not without a severe loss to Maj.-Genl. Lambert's Brigade which was in the 1st line. The works on this part of the position not being in a defensible state were immediately abandoned, and as soon as I had gained the height, I advanced my left in order to carry on the attack of the works to the right where the enemy still held their redoubts; but the Artillery attached to the 6th Division having been detained by Major Beresford to cannonade the enemy's works from the village of Mont Blanc, we were constrained to remain for a considerable time on the defensive, during which the troops were partially exposed to the fire of several pieces of cannon from the enemy's works and the musquetry from a building in the nearest of them. As soon as two of our guns were able to open, the attack went on, Genl. Pack's Brigade supported by the Portuguese under Colonel Douglas drove the enemy from two redoubts, and afterwards maintained themselves in the unfinished works though the enemy made a powerful effort to recover that situated nearest to Toulouse and within reach of its guns. It was now again necessary to wait the further advance of the guns to prosecute the attack of the last remaining work in the enemy's possession. In this the Spaniards who had been collected after their first repulse were ordered and ready to co-operate, but the enemy having withdrawn his artillery, on the approach of the troops abandoned his works and they were taken possession of without further contest.

A LADY'S EXPERIENCES IN THE GREAT SIEGE OF GIBRALTAR (1779–83).

BEING THE DIARY FROM 1ST JUNE, 1779, TO 13TH JUNE, 1781, OF MRS. GREEN, THE WIFE OF LIEUT.-COLONEL GREEN, CHIEF ENGINEER OF GIBRALTAR (AFTERWARDS LIEUT.-GENERAL SIR WILLIAM GREEN, BART., CHIEF ENGINEER OF GREAT BRITAIN, 1786—1802).

(*Continued*).

NOTE.—From 1st January, 1780, until 15th January, 1781, there are two versions of the Journal, both in Mrs. Green's handwriting, but not identical. Frequently they are word for word the same, but sometimes one and sometimes the other has additions, omissions, or slight variations of language. Perhaps both were prepared from a rough original, such as the pocket book referred to in the entry following October 14th, 1799, or the one in two volumes (commencing on June 1st, 1779) may be the original, while the other (in one volume, commencing January 1st, 1780) may be the transcript referred to on February 2nd, 1780. The following is therefore a compilation from these two MSS. :—

1780.

Saturday. January the First. 1780. Easterly wind. Cold Morning. The Gov^{r} did not receive any Compliments in Form. He was as Usual upon the Grand Parade. We had only 8 Friends at dinner by Way of keeping up an Old Custom; the Times were too bad to allow any family to entertain; not only that but I was greatly indisposed and totally out of Spirits. The two Spainish Frigates went from Algezira. A Vessel in the course of last Night went to Cork. Several Persons call'd as Usual this forenoon; but not near so many as on former Occasions, indeed most people now began to look rather Unhappy at our Uncomfortable Situation. The Troops are in good Health and Spirits, and have been so during the whole Blockade. 1st January, 1780.

Sun^{d} 2. Easterly Wind. A Dull Cold Morning. We call this with good Reason the *Coolest* New Year that was ever experienced in Gibraltar. Find myself not quite so lame or ill as I was yesterday.

Mond^{y} 3. Easterly wind. Began raining just at Guard Mounting. The Enemy Seem Busily employ'd in covering themselves from the Wet. Their whole Camp seems under Water. We heard they are Sickly. Admiral Barcelo remains quiet over at Algezira with some Xebeques.

4th January, 1780. *Tues*[d] *4th.* Westerly wind. Tolerable looking Morning. Col and Mr Holloway dined at Capt Loyd's. Find myself a little better.

Wed[y] *5th.* Easterly wind. Col dined at the Convent, not Mr Holloway. The Enemy the same way employ'd. Many Tents taken down and very large Hutts erected. No firing now. A General Court Martial ordered for to Morrow to Try a Soldier of the 58th for Theft. Two Deserters came In from the Wolona Guards Infantry.

Thursd 6th. Easterly wind. Cold Day. The man who was Try'd yesterday is Sentenced to be Hang'd. No firing today.

Fry[d] *7th.* Easterly wind. Had company to Day—all Gentlemen. The man is to Suffer on Monday next. He is and has been an old offender. The Troops are a little inclin'd to Break out at this Season.

Sat 8th. Westerly Wind. Very Dull Morning. It began to Rain in the forenoon; Continued to do So all Day. At Noon came into the Mole a Vessel from the East brought to by the Guns at Europa—a Neapolitan loaded with Barley—said to be intended for Spain; it is supposed the Gov[r] will detain the Barley for this Garrison; it is looked upon as a very great Blessing at this time, as it will help the poor Inhabitants and the Soldiers Families who now begin to Want.

Sun[d] *9th.* Westerly wind. Clear Morning, but soon began to Rain; and at Guard Mounting it was Violent. Continued bad the whole Day. The Man of 58th would not go to Church; or even allow our Clergyman to go to him!

Mon[d] *10th.* Westerly wind. It left off raining in the course of the Night; and it was a clear fine Morning. The Man went out at South Port at 11 oclock, the Usual Ceremonys being observed. The Party was Commanded by Lt Col Cochrane of the 58th Regt. The man appeared perfectly Stupid and had refused to have any Clergyman till at the very hour of his Suffering. He then allowed of the Prayers that our Clergyman offer'd to read for him; but said he was a Quaker, had deserved Death on Many former occasions he said,—an Irishman. This Day at Noon 5 Ships of the Line went through to the East, supposed to be part of D'Estaing's Fleet from Cadiz. The Ship which seemed to belong to the Commodore appeared to be Under Jury Masts. This Day turn'd out pretty fair. The Enemy appear Busy at their New Raised Batterys upon the Sea Coast, of which they now have nearly completed 3. They now seem to shew as if they intended to act upon the Offensive as well as Defensive. Barcelo's Ship is Closer into the shore than it has already been, and there are people who say He is Unloading part of his Stores and some of his Guns. However it is so Much the Stile to say every thing that Sounds like *Information* that I never depend on anything that I hear except form our Corps, who have good *Reasons* for all they Say.

Tues[d] 11. Westerly wind. Fine Day but Cold. About 3 oclock in afternoon the Enemy Fired 4 Shott towards the Garrison from Fort St Philip, supposed to get the Range. One Shott fell into the Gardens, another into the Governor's Meadow, and one into the Inundation, the other not known. There was a Funeral Party going out at the time, and as the Burying Ground is very near to where the Shot fell it greatly alarmed Them. They only Staid to put the Corpse hastily into the ground and the Clergyman &c hastened back, since which no Soldier or Inhabitants are to go out to Landport to be Bury'd. A place is to be appointed out at Southport, near to the Jews Burying place.* The Working Partys and the Mules were all order'd In directly. Captain Sowerby was upon the Batterys and Fired from Williss. We were Engaged to pass this Evening at Capt Evelegh's. I own I was half afraid. A large party. We passed a very cheerful Evening. One of their youngest children appeared not very Well. All Remaining very quiet. A very fine clear Night. 11th January, 1780.

Wed[y] 12. Westerly wind; fine Morning. At half past 8 the Enemy Fired 2 Shott; one a twenty four pounder; the other Grape Shott, which Grazed the Battery at Water Port. The other (viz., the Grape Shott) fell between Bay Side and the Glacis. At half past 10 they Fired 3 Shott from Fort St Philip, one of which Grazed a Centry Box and went into the Spur Guard at Landport. It was supposed that this was meant for the Flagg Staff as there was a great Many of our Artillery officers there. They also hurt a Mule who was in a Working Cart. The Colonel was looking over the Ramp at Landport when this happened; and one of the twenty four pounders fell within 3 feet of him! The third Shott came into the Town and fell upon the Roof of an Inhabitants House in a Back Lane in a Line with the Spainish Church—(there was not any Persons living in the House, they having Quitted it and gone into Spain upon the first of the Troubles). A Woman who keeps a Milliners Shop happened to be going by at the same time; had her Leg struck by some part of the Splinters of the Roof or by some of the Shell Work out of the front of the house. She was thrown down and insisted upon it both at that time and since that it was the Ball that hitt her Leg. However that was impossible as it must have broke her Leg. She was more alarm'd than any real hurt. It put Us all into a sort of Bustle and the same kind of Fears took hold of the Jews as did upon the 12th of September. Some of the Shopkeepers had taken away their Goods upon that Sunday's Firing, but as they found all had remained so long quiet they had about a Month agoe begun to bring them back to their Shops! So They now began to hurry them away

* Drinkwater says "A part of the Red Sands behind the Princess of Wales's Lines was appropriated to that purpose." The "Lady Augusta's Battery" is a part of those Lines; so that this is probably the origin of the Sand Pits Cemetery.

12th January, 1780. for the Second Time. Indeed it now look'd to be more Necessary than at the first, for it was now most reasonable to expect the Enemy would come on. I had a further supply of Family Matters sent to the Mount, but as the Weather was cold I did not Stir myself. I sent the child out this Day.

Thurs^{d} 13. Westerly wind; it began to Rain very early, and continued to do so all Day. Everything quiet from the Enemy, but the Garrison in a Bustle. Much talk at this time about the Provisions,—as it certainly must be nearly Reduced. Thundered in Even.

Fry^{d} *14th.* Westerly wind, raining at Guard Mounting. Colonel Ross of the 39th came out to the Parade this morning for the first time since He was so very ill, which was in the Month of October. He called upon us after Breakfast. Had a Meeting of Colonels and Field officers at his quarters in forenoon, relating to the Provisions for the Troops. Their allowance is to be in part Lower'd. It is from the Beef and Pork they have been obliged to Reduce this. We hope that by this Regulation there is remaining in the office enough for 3 Months. The Troops all Seem Satisfied and are in good Health and Spirits. Some few Friends in the Evening. This Evening a Man of the Artillery, Capt Loyd's Company, was Drownded at the New Mole. He was in Liquor and fell off a Plank. I was taken ill again in the course of the Evening, a Cold Shivering and a pain in my Left Arm.

Sat^{y} *15th.* Westerly wind; Raining all Morning. Find myself exceedingly ill; pains all over. Doctor Baynes call'd in the forenoon and greatly alarmed me, by telling Us of the Small Pox being again Broke out, upon a Child of Captn Evelegh of the Corps of Engineers; this is a fine Boy, about Six Years old. He did not seem very Well when We sup'd there on last Tuesday Evening. They have two Younger to have this Disorder. It hurt me to hear of this: and also the whole Garrison as it is not a thing to be wished, just at such a Juncture as this, when we can only Manage People in Health. We were in hopes that by the great care that was taken in Nov^{br} last and by every appearance at the close of the year that it was all over,—however it could not be so, as Undoubtedly this little Boy had taken it by having been at play with the Spainish and Jew Children after they had returned home. We hear that the Gov^{r} will not allow of any Innocculation. Whilst I was thinking of the Unpleasant Prospect that Presented itself and supposing everything that is bad would follow,—behold at 2 oclock we heard of a most Interesting piece of News! A Vessel appear'd coming round Caberitta point, which proved to be an English Store Ship! Oh! What a Joyful Sight! The Sloop of War was sent out, likewise the Cutters and Arm'd boats. They brought her into the New Mole—with more than half the Garrison looking at Her! We find it to be a Brig, in the Ordnance Service, call'd the *Sophia*, bound for Minorca, with 3 Artillery officers for

that place. As Soon as the Admiral's Boats went on Board, we heard three cheers, which was answered on board the *Admiral* &c., &c. We now hope for Good news, which, thank God we had. She brings information that she is one of a Grand Fleet coming to this Garrison, consisting of Three Admirals and 21 Sail of the Line and that one of the young Princes is on board the *Prince George*, Admiral Digby, that they all left Portsmouth upon Christmass Day, were separated five Days after they had left Eng^{d}, in a Gale of wind. This news you may be well assured was truely Welcome. We find there is a Post Chariott on board this Brig for Us, but that is a Mere Trifle in comparison to any one word of good News that is brought to this Garrison. The pleasing hopes of a happy relief to this place is too great to express. I strive all I can to get well and to partake of this happiness, but I grew so bad with my Left Arm in the Evening that I was almost Distracted. It Rain'd hard in the Evening. A man of the 58th Deserted this Morning. We are in Earnest expectations, laying for the next Day, in hopes some of the Convoy may be coming In, as the Master of this Vessel thinks they must be near at hand. 15th January, 1780.

Sun^{d} 16. Westerly wind. Blowing and raining. We grow Uneasy about the Fleet. These 3 officers of Artillery are very Young Men, and They do not exactly agree in their Accounts, and for the most part say they do not know whether all, or only a part of the Convoy is for this place, or even who they all are. All this makes Us full of eager hopes and fears. I am a little Easier. A Spainish Deserter came In this forenoon, of the Wolona Guards. Nothing appeared all Day from the West! At last, about 7 in the Evening we heard some Signal Guns from our Admiral. They were made to a Vessel which was going up too high in the Bay. She was order'd into the New Mole, and proved to be a Ship belonging to Merchant Anderson, Loaded with Flour, and had left the Convoy 5 days agoe. She brings an account (this rather a Confused one) of an Engagement. Oh! how we all long'd for Morning to know more. It was blowing very hard. We had a Number of different Reports brought In between 7 oclock and Bed time. We hardly know what to think.

Mond^{y} 17. Westerly wind, very windy and raining hard. Find myself still very bad, and my anxiety great. The Troops were this Day put upon a Shorter allowance, as to Beef and Pork. They still appear Satisfied. Capt Evelegh's Son very ill. At Noon it Blew a perfect Storm. Every one is Uneasy about the Fleet. No News all Day! Let any one Judge of our Anxiety,—but that is not possible, except by those who have experienced the like Circumstances. No Firing on either Side at this time. Barcelo still nearer the land.

Tues^{d} 18. Westerly wind, a more Moderate Morning. About 10 oclock a Joyful Sight presented! A Prize brought In, taken by

18th January, 1780. Some of our Convoy, a fine Rich Ship Loaded with Oil, Tobacco, Soap, and Bale Goods. At Noon a much larger and more Valuable one came In, a Prize to one of our Men of War. She was brought In by a Lieut of the Man of War who had taken Her, is Loaded with Brandy and Masts. Now We are certain of our Good News. There has been an Engagement indeed! The Particulars are not well known, any how We now expect more Ships. This is the Queen's Birthday, but no Notice is taken, any otherwise than by the Royal Standard being up. It began to Rain hard and to Thunder in the Evening. Several large Ships in Sight, and in the Close of the Day an English Frigate came In, which proved to be the *Apollo*, Capt Pownoll. He was greatly surprized when going on board the *Panther* to find that Admiral Duff was not on board at such a Juncture as this! but He was inform'd the Admiral was a *Quiet Man!*

Wed[y] 19. Westerly wind; at Day Break our Governor ordered 21 Guns to be Fired into Fort Barbara, and the Royal Standard was up. At Guard Mounting the Admiral also hoisted the Royal Standard and Fired 21 Guns, the Drums all Beating, the Men of War giving 3 Cheers, and the Parole was "*Victory*." The *Edgar*, 74 Guns, Capt Eliott, came In this Morning. She brings great and Glorious news; our Fleet in their passage first fell in with a Fleet of Carraco Ships, took 7 of them, Estimated at £400,000! sent them all except one to Eng[d]. Then upon Sunday the 16th they fell in with part of the Spainish Fleet. They had a very hot Engagement off Cape St Vincent, a kind of running fight. The *Bedford* ran 80 miles during the Engagement! It Ended by our taking 7 of their Line of Battle, and one 80 Gun was Blown up; every Soul on board Lost except one poor Wretch who Died in a few Days. We took their Admiral, Don Juan Langara, in an 80 Gun Ship, the *Phœnix*. We hear the whole Fleet are expected In here. They consist of 21 Sail of the Line, besides Frigates. The whole place is now full of Joyful Confusion. I find myself Something better; and Even Strive to appear more so than I am in reality. We do not hear as yet of any Material hurt to our fleet. The Spainish Admiral is now coming In, on board his own Ship; a good deal wounded. He wished not to be removed from his Ship, and gave his Word to our Admirals that his Men should bring his Ship In Here, or any Port they chose. He was Trusted, and is now coming In. He has lost more than 200 men. It was to the *Edgar*, Capt Eliott, and the *Defence*, Capt Cranston, that the *Phœnix* struck. It Rained and Thundered all this Evening. Several Men of War coming In. This Evening Don Juan Langara was brought on Shore and taken in a Sedan Chair to a House prepared for his and his officers Reception. He was allowed to bring all his *Suite* and Baggage. He is not Mortally Wounded, but his first Captain is. We also hear that a very fine

Young Man in our Service has had his Leg Shott off, Lieut Forrest, on board the *Ajax*, and a Lieut of Marines Kill'd. No others as yet that We hear of. Lt Forrest has a Brother; a Lieut in the 58th Regt in Gibraltar. 19th January, 1780.

Thurs[d] 20. Westerly wind. Early in the Morning The *Prince George*, 90 Guns, Admiral Digby came In, on board of which was His Royal Highness Prince William Henry. The Royal Standard up in the Garrison for the third Day. The Prince came on shore at Noon, had no particular Honors paid him. He went to the Convent; from thence He was attended by the Gov[r] the other Generals, and the Chief Engineer up the Hill as far as Williss. This is the King of Spain's Birth Day, and it has been said it is the Enemy's Intention to Fire upon this Day. Barcelo's ships are all Dress't, and He fir'd three times as is their Custom. He is Certainly Drawn Nearer the Shore; and We See there is a Work going on over at Algezira. Some of his Guns are likewise taken out. More of our Fleet coming In, and several officers calling. The Highland Regt also are arrived. The Colonel was Taken not Very Well this Evening and fear He is going to be indisposed. We hear there is a great quaintity of Provisions and Stores come to the Garrison. All now is Joy and Bustle.

Fry[d] 21. Westerly wind. More of the Convoy coming In. The Prince on Shore again, Walking about. He dined at the Convent. This Day at 3 oclock 6 officers belonging to a Spainish Man of War who was wrecked upon the Coast of Spain were allowed to pass into Spain, in order to Settle about Exchange of Prisoners. They went out with the Town Major and a Drum. No Firing from us Now. Several of our old acquaintances calling. Lt Trigge of the *Bedford* here in the Even[g]. At 12 this Night we were all alarm'd by a Firing from the Enemy from the Forts near the Sea,—Point Negro, Fort St Philip, &c, Algezira. We naturally concluded it was now their Intention to begin, and I declare I did expect to see the Shells in the Town any moment; it was now that I really was alarmed. It was at 4 of our Men of War which had come in, and by the Current was hurried up near to the Lines; it alarm'd the Enemy more than Us, as no doubt they expected it was an attempt to set Fire to their camp. They fired an amazing Number of Balls and one Shell. It Wounded the Rigging of the *Terrible* which was one of the 4 ships and hurt a few Sailors, also one Spainish Sailor who was on board the *Terrible*. They all got back to the New Mole. It was a very fine Moonlight Night. The appearance of the Enemy's Firing was a Grand, tho' alarming Sight, and I own I suspected it was their full Intention to throw Some shells into the Town. Thank God they did not; and we all went quietly into our Beds at 3 oclock. There was no Confusion or any Bustle in the Garrison; the Picquets were out, as usual at these times,—and always are upon any particular firing.

22nd January, 1780. *Satur*[d] 22. Westerly Wind; a Cold Raw Day. Many of the Convoy not as yet come In. The Colonel was not better for having gone out in the Damp last Night, indeed he grew very ill in the Evening. We got 2 English Sheep from our old Friend Admiral Digby. This Morning more of the Small Pox appear'd, at an Inhabitant's house. Capt Evelegh's 3 children are all Lay'd down in the Disorder. He is obliged to leave his House for the time, not being able to stay from his Respective Duties at such a Busy Period as this. No Persons are allowed to go to his or any Inhabitants Houses, except the Doctors. The General will not allow of Innoculation as yet, but Says He will as soon as it gets amongst the Troops. This Day we get a Box of Things from on board one of the ordnance Ships which had been on board Six Months, consisting of Family Matters for myself and child. Also We Receive 3 sheep and a cask of Butter from Mr Veale at Portsmouth. The Colonel grows much Worse in the Even[g]. The *Nottingham* Store Ship, with Colonel Picton, Lt Col Craig, and Several others arrived this Day,—all hurry. Get some oranges as a Present from Capt Pownoll who has been over to Barbary. We hear that Admiral Sir George Rodney is over there. The *Childers* Sloop is cruizing about the Bay.

Sun 23. A Dull Morning. The Col: not worse. Began to rain after Breakfast. A good deal of company of the new comers &c this Day at Dinner. This evening after orders,* relating to the Commanding Officers, to give In a Return of the Troops fit for Service, by which it is supposed that the Highland Regt is to be Left here. At 10 this Night the Colonel grew exceedingly bad. It was a very Stormy Night. The *Childers* Sloop of War that went out two days ago returned from Barbary with expresses from Sir G. Rodney who is over at Tetuan but will not Venture In till all the Convoy is Safe. We hear that the *Royal George* Admiral Sir J. Ross is behind the Hill. This Day I experienced both pleasure and pain; Joy for Good news; and Vexation at the Colonel's Indisposition,—So very Unlucky.

Mon[d] 24. Westerly wind. The Col very ill, did not get up till after dinner, obliged to send excuse to Admiral Digby for not being able to dine with the Prince today. Great hurry and much Confusion in the Garrison, Unloading the Stores and Provisions; every place towards the South is to be made use of for the King. Get 4 Sheep from on board the *Nottingham*.

Tues[d] 25. The Colonel still very indifferent. This Morning Admiral Sir George Rodney arrived in the Bay. In the forenoon 5 of the Wolona Guards made an attempt to Desert from the Lines. They were followed close by a Party of Horse as far as the Gardens, and some even as far as our late Burying Ground. There they killed one

* *i.e.* "After-Orders" were published.

Man and Mortally Wounded an other who died just as our People got him into the Bayside Guard. The other 3 got safe into the Garrison. We fired both Grape and Round Shot at them from Williss, but did no other Execution than killing one Horse and hurting an other. In the Course of this afternoon most of the Convoy got In and also Sir John L. Ross. No sort of Supply of Fresh Stock as yet from Barbary, by which means the Garrison was as badly off as before; only with this difference,—We were all in Spirits and had frequent presents of Mutton &c from our old acquaintances in the Fleet. This forenoon I received a Small Box from on board the *Nottingham*, Under Care of Lt Col Craig, Containing letters, papers, Books, &c,—our last dates 18th Dec^{br}. I was obliged to write Cards of excuse from the Colonel to Several Gentlemen who were to have dined here as to Morrow, he being too ill to See Company. Raining all this Evening. Have been writing this Evening to my Friends in England, and have begun to Transcribe from my long Journal a few Articles which I intend for my Son; as I understand the Convoy may go Unexpectedly. Also I have begun some letters to go by the *Childers* Sloop which is to go the very first Instant the wind will allow. 25th January, 1780.

Wed^{y} 26. Westerly wind, fine Morning; the Colonel something better. At 8 oclock Capt Evelegh came to ask for two Mules to bring Sir G. Rodney from the Landing place, as he was expected to come on Shore, and the Gov^{r} had a Litter ready for him. The Prince on Shore today, but the Colonel could not attend upon him. Several Persons call'd. All in great hurry Still.

Thurs 27. Easterly wind. The Colonel still very Indifferent. Doctor Baynes thought it better to Bleed him. All Busy in the Fleet. Flaggs of Truce all day going about in the Bay, and Parleys from the Lines. We sent away the Sick and Wounded Prisoners. I finished one long letter to my Sister which Sir John Ross enclosed in his Pacquet. The Sloop expected to go to Night.

Fry 28. Easterly wind; Raining and a bad Morning. The Sloop not yet gone. Several Promotions in the Navy. Capt Macbride is going home in the *Childers* Sloop with Dispatches. He has changed from his former ship the *Bienfaisant* to the Spainish Admiral's, the *Phœnix*. A Lt is to command in Capt Macbride's absence. Capt Conway has got the *Bienfaisant*, and Capt Peacock who had the *Childers*, has got one of the Large Spainish Prizes, called the *Diligenta*, and a Lt of the Admiral's (Sir G. Rodney) goes home in the Sloop, taking Capt Macbride as Express. This Day turn'd out exceedingly bad. Blowing and Raining very hard. The Colonel not Worse. We had two Hampers of Sugar brought on Shore this Day, which was on board the *Nottingham*. We Understand they were for us, being in the Bill of Lading, tho' the Directions were off. They are totally destroyed, and not one pound will ever be used in the house; they are wet and have also been

28th January, 1780. destroyed by all sort of Vermin. It is believed it was all owing to Carelessness. This is a Loss, but a greater disappointment than even the Value at such a time as this. This Day more Flaggs of Truce and Parleys. All Firing has ceased now. At 8 at Night it Blew exceedingly hard. The Sloop has attempted to get out but We are doubtful, as it Seems coming to the West. All this time Don Barcelo seems busily employ'd in getting out his Guns, and it is beyond a doubt that there is a Battery on the Shore near to Algezira. The Report is that the Camp is exceedingly out of Spirits, and Don J. Langara has declared to our Gov^{r} and Admirals that the French has deceived Them!

Sat 29. Westerly wind, Raining and Blowing a perfect Storm. The Sloop was obliged to return in the Course of the Night, after being forc'd to throw over 3 Guns. Lt Howe* of the 12th was the only officer of the Garrison allowed to go home; and he was sent for from England upon account of his having got a Company in a new raised Regt. This forenoon a Spainish Frigate came from the West, most certainly a Stranger to what was in the Bay. She was chased by one of our Line of Battle and a Frigate, but Unluckily They were too Late. She got too close into the Shore. Our 2 Ships of War keep up a Smart Firing upon her, particularly the *Edgar* (the Line of Battle Ship). She (the *Edgar*) got under their Guns and all the Battys and Pigeons Island† &c, all fir'd. The Frigate seem'd greatly hurt by our firing; and was Tow'd into Algezira by all the Boats from Barcelo in the Evening. A very bad evening. The Fleet for Minorca getting ready. Sir William Draper is going to his Lieut Government. It is Settled for the Highland Regt to remain here, and They are getting all ready at the Bomb proofs under the King's Bastion for their Reception, and at the Picquet Yard under the Grand Battery.

Sund 30. Westerly wind, raining exceeding hard all Night and this Morning. N.B. It is just now the very worst Weather we have had this Season, which is Unlucky as it in Some degree retards the publick business; at least it makes it Uncomfortable to every Body, particularly those who are employ'd in Unloading Stores and Provisions. The Minorca Convoy sailed this Evening. The Colonel getting better every hour. Intended going out today but was persuaded to stay at home; it turning out so wet. I finished a letter to my Son and gave it to Captain Macbride who expects to sail as soon as ever it is in the smallest degree favorable.

Mond 31. Westerly wind. Indifferent Morning. Col at Guard Mounting. The whole Morning but very Dull; and the afternoon Still Worse. The Col sent cards for company on Friday next.

* Or How.

† Another name of *Green Island*, off Algeciras.

Flaggs of Truce all Day. 3 men of the Wolona Guards came In, which makes *22* in all. They are to go on board our Fleet. The two first which came In (viz., 11 Nov^br^) have remained in the Gov^rs^ Gardens at Work. 31st January, 1780.

February 1st. Tues^d^. Westerly wind and a very Dull Morning. Col at G. Mounting. It Thundered all Morning, poured with Rain all Day. The *Childers* got away last Night, but we fear is drove behind the Rock. Sir J. Ross call'd here. This Night turn'd out the worst We have as yet had,—Thunder, Rain, and Wind,—the Ships all driving about and Several Signal Guns firing. Every body is anxious for our friends in the Bay, and all long for Morning.

Wed 2nd. Westerly wind, bad weather still. Col better, dined with Col Ross and passed the Evening.* I am as busy as I can spare the time in Transcribing a Small Journal for my Son, but am frequently broke In upon, by the Number of Visitors that are constantly calling; Not only that but the Daily Necessity I have in attending to all sorts of Family business, makes it almost impossible to go on in the Writing Way. I shall at last get into a Total disregard to Method, Stile, or Sense I fear; for as I wish to write to the *Very Moment*, so it can never be the Effect of a Studied writer.

Thurs 3. Westerly wind, a very Wet bad Morning. The Colonel better and able to go to Parade; and out upon the Hill. The Prince did not come on Shore this Day, it turn'd out too bad. Very Busy this Day in Settling the Manner of Exchange of Prisoners. Barcelo is quite close In Shore; and it is now observed that There is a Boom making over at Algezira against Landing, such as ours at Water Port. We do suppose He is half afraid of our Men of War. There is also a Battery completed, near to Algezira.

Fry 4. Westerly wind; Raining Still. The Col kept waiting to See if the Prince would come, tho' it appear'd too bad; however at 12 He came, and the Colonel attended him upon the mountain. Flaggs of Truce in the Bay. We had a very Large Company, of the Navy chiefly, at Dinner. The Colonel returned very late to Dinner, exceedingly wet from his walk. He brings Word that the Admirals and the Prince would Breakfast at Mount Pleasant to Morrow. I accordingly order'd everything Proper; and mean to go myself if the Day will admit. A great deal of Company this Evening. Lt Forrest of the *Ajax*, who as I mentioned before was Unfortunately Wounded, and who had been brought on Shore Some Days to his Brother's Quarters, of the 58th Regt Died this evening, very much Regretted. He had got Promotion, Sir G. Rodney having just appointed him Master and Commander, in the hopes He would Recover. He was

* Here ends the entry for this date in the single-volume version of the diary, which renders it probable that it is the transcript referred to in the following sentences.

4th February, 1780. just 20 years old; a very fine Young Man; Universally Esteemed. The *Childers* Sloop got through yesterday.*

Sat 5. Westerly wind; a clear and fine looking Morning, and luckily continued So all Day. It was the only tolerably pleasant one that has been since the Fleet came In. I went in my chair to the Mount. The Prince &c came on Shore about 9, and walked first to the Cave &c, the Colonel with him; and Ended the Walk at the Mount where everything was in proper Readiness. He was Delighted with the Gardens and Walks; it was favorable, so pleasant a Day. I was as much pleased with Him. He is a very fine Youth and must be liked in any Situation. His Questions were proper; they all wore the face of being the Result of a proper Curiosity. After the walk was over the Colonel went on board the *Prince George* to Dinner, and I return'd to Town that Evening, very well Satisfied with the Day.

Sun^{d} 6. Cold Indifferent Morning. The Col: busy in writing till Dinner at General Boyd's. This Day Capt Robinson in the *Shrewsbury* arrived to the Satisfaction of Many; that Ship and the *Dublin* being mis'd. The last is obliged to Remain at Lisbon to be made fit to go to Sea. The *Shrewsbury* has taken a tolerable prize; and Sold Her at Lisbon. Neither She nor the *Dublin* were in the Engagement upon the 16th Jan, having been Separated in a Gale of Wind before that Day. Sir J. Ross here today.

Mond 7. Westerly wind. Busy writing for the Fleet as it is expected They will soon leave Us. We have a very large Party at dinner this Day, Sir J. Ross and many of our Navy Acquaintances; and also of the Highland Regt. In the forenoon the Colonel went on board the *Sandwich*, and gave an invitation to Sir G. Rodney to go to the Mount as He has expressed a wish to Lay a few Nights on Shore. Sir J. Ross has pressed me exceedingly to go on board the *Royal George* and to take a Rough Dinner with him on Wednesday; also to take my own Party, all which I have promised to do, tho' at the Same time, think it will not be possible; as it is very likely the Wind may be Easterly; in which case I Understand it is likely that Division may have orders for Sailing. I should very well like to see so fine a Ship, particularly as Sir John is so pleasing and so cheerful an old Man. A very large Party at Night. N.B. Colonel Ross quite in Spirits now his Friend is here. We all wish, for his own sake, He could go home with the Admiral.

Tues 8. Westerly wind. The Colonel out all the Morning with the Prince and Admiral Digby &c. The Fleet in a hurry. At noon I heard that some part of the Fleet was to sail directly. I employ'd most of the forenoon in getting Journal and all *Writings* ready, tho' as I observed before, it is no Easy Matter to gain the time; as it

* "This Day" in the two-volume version.

is quite impossible to be *Denied*, our Situation will not allow it ; our House is Constantly full. I find it rather too much for my Strength or Spirits but can not help it. The young gentlemen very Busy in the Plan way. 8th February, 1780.

Wed 9. Easterly wind, fine morning, but think I shall not be able to go on board ship to Day, as Some of the Ships seem getting Ready. At 11 a Signal gun was Fired from Sir G. Rodney for Admiral Ross and his Division to go to Sea directly. I received a Message of excuse from Sir John, and they were off before one oclock. This Day Don Juan Langara received an express from Madrid, informing him of the King having appointed him a Rear Admiral, with the Rank of Lieut General. N.B. He was only before Brigadiére de Marina. We send off some more Spainish officers and Sailors in a Flagg of Truce. N.B. We have not had any in return yet. Mr Raleigh, the Govrs Secry is appointed Commissary for Exchange of Prisoners, and goes at all times in the Flag of Truce Vessels. Many of the Spainish Sailors are mortally Wounded.

Thurs 10. Easterly wind. It is now Settled that the Spainish Admiral is to go back into Spain in consequence of letters which has passed between our Admiral in Chief and the Court of Spain.

I have omitted to mention that Admiral Duff went on board the *Royal George* on Saturday last with an Intention not to come on Shore any more. He goes home as Passenger with Sir J. Ross. There was no Ceremony Used at his going. He call'd upon a few Persons only. We were of the Number. He seem'd a good deal discomposed and Disconcerted.

Fry 11. Easterly wind. All Bustle in the Garrison. Unloading ships and getting ready for the Fleet. The Colonel every moment employ'd. Many Parleys every Day, and letters from the Commander in Chief in the Camp, Don Martin Alvares, and our Governor, and between Marquès Gonzales de Castejon, Secretario de Estado y del Despacho de Marina, and Admiral Sir George Rodney. Don J. Langara dined this Day on board Sir G. Rodney, as did the Prince &c. Don J. Langara is to go away in two Days. N.B. He had dined at the Convent before and was exceedingly politely Received. He was highly pleased with the Young Prince ; and made him a Number of Genteel Speeches. He spoke in French, which His R.H. speaks very well.

Saturd 12. Easterly wind. The Prince took leave of Me and was again at the Mount. They talk of sailing either to Night or in the Morning. All Bustle, all Confusion. My letters going by different Hands. The Colonel Dines on board Sir G. Rodney, finds the Store Ships will not be able to go, it being impossible to get Ready. This Day the Spainish Admiral went away. Great Civility shown him. He went in a Vis-a-Vis of the Genls was drove quite close to the Gate at the Spainish Lines. Several officers attended him to our out

12th February, 1780. Guards, but no further; only as Usual the Town Major and one Drum as with a Parley. Great Compliments at parting, and a very great Cavalcade meet the Spainish Admiral with Led Horses &c at the Lines. Langara went away fully convinc'd that He had met with the utmost politeness He Ever could have wish'd for and much more than He could have expected. He Seemed a good sort of man; was Very highly displeased with the French. This Day Several Vessels came In, some from Cork and from other places; also one was brought In Loaded with Barley, intended for Cadiz. We have not as yet had any Live Stock from Barbary; nor do I hear of any Mode Settled about getting any! Several Town Market Boats are over there, and the *Apollo* Frigate went over to Barbary this Evening.

Sund 13. Easterly wind. The Signal made for Sailing. The Colonel went on Board both Admirals with plans &c, &c, and took Leave of the Prince. A most fortunate Event took place this Morning, viz., the Men of War that went up to Minorca with the Convoy (this Day fortnight) return'd Just as our Fleet was getting under sail! Nothing could have happened more favorably. The chief part of the Fleet got out this Evening with a very fine Wind. Great hurry just now all over the Garrison. All those that could were getting off as fast as possible. All the Family of the Powndes going &c &c.

Mond 14. Easterly wind. The whole Fleet left Gibraltar this Day. It will not be amiss if I make a few remarks on some fortunate events that has attended this Fleet from the Day they left England, which was upon Christmass Day 1779. Some Days after they left Portsmouth it was not known whether the whole or a part was coming to this place. However after they had obey'd the Signal from Sir G. Rodney and had received his orders they proceeded on their passage here. They fell In with the Valuable Fleet of Carraco Ships, took them to the amount of £400,000! Then they met with part of the Spainish Fleet, took 7 of their Line of Battle. The rest of that Fleet under command of Don Luis de Cordova had gone only Six Days before into Cadiz, not suspecting any such Fleet as ours, which indeed shews how greatly the Spainish Court had been deceived by the French; for it is very certain had they keep a look out it must have been known. Our Fleet had the Satisfaction to get all the Convoy for this Garrison Safe; and relieved us to the utmost of our wishes; from thence sent off to Minorca all that Garrison stood in Need of, viz., Money and cloathing for Troops. The Wind carried all that Convoy up, and was so much favor'd in returning that it was only barely possible to form such a wish with any degree of success! Not only that, but what made it still more fortunate, they came back upon the very Day the Admiral was getting out of this Harbour; it was indeed the very thing We all most wished for, tho' hardly

could have expected. They sailed with a fine Wind, which lasted as long as to carry Them where they wished, and by the Information of a Vessel from the West who came In upon the 20th We learn that the Fleet was met with in so favorable a Latitude that it gives all manner of prospect of a quick passage home, If so it may not be at all impossible for the whole of these Circumstances to have happened in the course of Ten Weeks! to Say Nothing of what may fall out in their passage home, or indeed of other matters which I have not taken notice of in form, all adding to the peculiar favor of Providence,—and Surely never was a more Remarkable Period in History; of a Succesful Passage and a fortunate Supply to a Blockaded Garrison. 14th February, 1780.

We now hear by the arrival of some English officers and other Prisoners belonging to our Fleet who are sent In from Cadiz that when the Spainiards which were in Brest Harbour heard of our Grand Fleet and of our having taken Don Juan Langara, they directly left Brest and with 20 Sail of Line sailed for Gibraltar, in hopes to meet our Fleet or to Force this Harbour. A Violent Storm attacked them and has in a great degree drove them to destructiom; they are getting as fast as they can into Cadiz, but for the most part Unfitt for service, Those that are not as yet arrived may very likely meet with our Fleet home. If they do they will Stand a bad chance. The report now is that the Spainiards are so totaly displeased with their French Friends and so provoked at what has happened to themselves that it is pretty Certain they mean to Try all their Efforts to gain this place, for they have repeatedly told our English officers, they only want and wish for Gibraltar! "Give up that to us, they say, and all will be Well."

From the 14th of Feb, the Day on which our Fleet left us, Nothing very particular Happened till the 25th, except the whole attention of the Garrison to get into safe places all the Stores and provisions. The Boom which Barcelo made over at Algezira has been taken up ever since our Admiral and Fleet Left Gibraltar. They have hang'd Several Soldiers in their Camp, but that has not hindered more of their Wolona Guards to come to Us.

Fry 25. Westerly wind. A Vessel arrived from Farro, Loaded with Wine &c for this place, but the most Valuable part was a Number of Letters of different dates to many persons in the Garrison I had the Satisfaction of Receiving one letter of 12th Nov from Mrs Green, and one of same date from Mrs Nicolls and one of 12th Dec from her. It afforded great Satisfaction. We had a large Company at Dinner, Genl and Ladies, the Davies, Gledstanes &c. The Weather fair but cold. Barcelo seems busy. A Vessel arrived to Day with wine and other articles frome Minorca. The Small Pox is beginning to be very fatal to the Children. All Means are tried to obtain Leave to Innoculate but as yet to no purpose.

26th February, 1780. *Saturd* 26. Easterly wind. We all begin to get letters wrote in hopes the Store Ships will be soon going. I try all Means to get Charlotte inoculated but cannot obtain leave.

Sund 27. Easterly wind, very fine morning, and continued so all Day. I did not stir out being not well. 3 Line of Battle Ships and other Ships are gone over to Barcelo this morning. A Neapolitan Ship came into the Bay, was brought to by a Gun from Kings Bastion, She sent off a Boat and said she was last from Minorca, Loaded with Oil and Honey, bound to London. She anchored near the Old Mole; and afterwards sent off a Boat to Fort St Philip. This should make Us doubt if she is a Friend. However in the Night she went from her Station, and was seen at Algezira the next Morning!

Mond 28. Easterly wind. Colonel engaged all forenoon at Col Ross, and the rest of the Colonels, relating to the Circumstances of the Rank between Lt Col Trigg, Lt Col Craig and Lt Col Mackenzie. N.B. It is to be referred to the Commander in Chief in England.

Tuesd 29. Easterly wind, very fine Day. Nothing very particular all this Day. Several People in Evening. A great many Northern Lights in air. No News of the Prisoners that were expected. Yesterday the Troops had for the first time Salt Fish delivered to them instead of Meat and some Rice and Peas, not any Butter; which occasioned great discontent; as it seems hard to oblige them to take the fish in place of Meat and not to give them a little Butter with it. We hear it is to be changed. N.B. This Evening they all Received a Small Allowance of Butter, but they are dissatisfied.

March 1st. Wed^{y}. Westerly Wind, and very fine Day. It was in Orders this Day that Capt Lt Witham of the Royal Artillery is to be Aid de Camp in the room of Capt Patterson of the Same Corps.

Thurs 2. Westerly wind, fine Day. This Morning 2 Sailors came over from Barcelo's Fleet in a little Boat. They belong'd to this place, and were taken some Weeks agoe from out of a Towns Vessel which Used to cruize about. They have been kept on board one of the Spainish Men of War. They bring Word that there is 3 Battalions of the Spainish Troops gone from the Camp, which indeed we have known, by finding Many of their Tents struck. It is also said They are gone to Strengthen some part belonging to the Spainiards.

Fry 3rd. Westerly wind, fine soft Day. We had a large Company at dinner and more in Evening,—Gen Boyd, Phipps, &c, and Faucourt in evening,—all very well. No change in any publick Business.

Saturd 4th. Easterly wind. A good deal of wind. The Col: Rode out, The Day continued fine. Find I have got a great cold and some other complaints. Mr Holloway dined at the Convent. We were quite alone in Evening.

Sun 5. Easterly wind and a Dull looking Morning. At Noon it blew exceedingly hard and continued so for more than an hour. At

last it began to Rain which abatted the wind. N.B. The New Moon was about this time. We had a good many Gentlemen at Supper. The Small Pox raging very much and very fatal. 5th March, 1780.

Mond 6. Easterly wind. Hear that an Inhabitant, Mr Brooks, is going away this Night on board a Swedish Vessel. I send one letter to Mrs Green and one to Mrs Nicolls. Not very well this evening and out of Spirits.

Tuesd 7. Easterly wind. The Ship did not go last Night. The Col: writes this Day to Mrs Boddington and to Fisher, also to Genl Skinner. Genl Boyd sent us a hind Qr of Wild Boar. The Col and Mr Holloway Sup't out at Capt Loyd. Our letters went under care of Mr Brooks who went on board this even.

Wed 8. Easterly wind. Find the Ship is gone last Night. This Day we find that the Enemy are sending away Many Articles from the Camp, and loading Vessels at the Orange Grove. Likewise it was observed that the officers Baggage was taken away as fast as they could send: Trunks and all Sorts of Camp Equipage. We had a very large Party in the Evening, Mrs Booth and Family, &c, &c, 16 in all.

Thurs 9. Easterly wind, fine Day. Nothing more than a Parley from the Enemy today. Went out to Capt Phipps at dinner; the Col Rode out all forenoon. Hear that Commander Elliott had sent out to the Enemy to know why those English Prisoners were not sent In, and to request the Don J. Langara would be return'd into Gibraltar, unless we had our own People sent.

Fry 10. Easterly wind, fine Day. Dull and Cold. The Col walked out. At Home in the evening, quite alone. A Parley from the Enemy this Day.

Saturd 11. Easterly wind, fine at first but turned Dull and Cold in forenoon. The Colonel dined at Convent. At home in evening, only ourselves. A Parley from the Enemy to Day.

Sund 12. Easterly wind; fine in the forenoon, but Dull and Cold at Night. I walked out before Dinner and called upon Several Persons. Hear that the English Prisoners are coming In from Spain. There are two Flaggs of Truce gone from Us, and three Row Galleys are coming from the Orange Grove to Us. The Windmill is moving from where Capt Evelegh first fix'd it. It is to go to Windmill Hill.

Mond 13. Easterly wind, fine clear Morning. The Prisoners came last Night and are going on board the Men of War this Day. 3 men of the 72nd Regt Deserted from off the Hill last Night, and one of the same Regt went off 2 Days agoe. This Day the Provisions were first delivered out by the Month to each officer. Each Man's Share is as follows; I mean each officer's Ration. I shall set down by Way of Mem^m^ the Order that was given on this subject. N.B. There is some small difference between the officers and the private

13th March, 1780. men's Provisions. N.B. Upon the whole this order has not given satisfaction. The Fish, tho' very good is objected to; at least the being obliged to receive it for so long a time, particularly as it is supposed there is such a quaintity of Provisions in Store. This evening 2 of the Deserters of the 72nd taken, the other not known.

Plan for Victualing the Garrison for one Month; to Commence on Monday the 13th March. Officers of the Army and Civil department, to draw for a Month's Provisions at one time, and in one order. (Bread excepted, which will be Issued weekly) and if they leave any in the office it must be entire Rations, which will be accounted for every three Months.

It is conjectured this will be thought Disagreable, for as yet no Method has been found which Way those Provisions are to be paid for which may now Remain due to Individuals in the office. The whole of this department is now in the Hands of the Q.M. Genl.—New Lords, New Laws, the Agent Victu^er^ has nothing now to Do!

One Month's Single Ration for an Officer.—Beef 3 lbs; Pork 2 lbs; Fish 9 lbs; Pease 8 pints; Wheat 5 lbs; Rice 4 lbs; Oatmeal 6 pints; Butter 40 oz.

N.B. Colonel Green has Ten Rations.

One Month's Ration for a Soldier.—First and third week as follows:—Pork 1 lb; Fish 2½ lbs; Pease 2 pints; Rice 1 lb; Oatmeal 1½ lbs; Butter 5 oz; Wheat ½ lb; Raisons ¼ lb.

Second and fourth week as follows:—Beef 1½ lbs; Fish 2 lbs; Rice 1 lb; Wheat 1½ lbs; Oatmeal 1½ pints; Raisons ¼ lb; Butter 5 oz.

Each Hospital Per Week as follows:—Beef 2 lbs; Fish 2 lbs; Rice 1 lb; Flour 1 lb; Oatmeal 3 pints; Raisons 1½ lbs; Butter 5 oz.

N.B. All the above took place Mond 13th March 1780.

Tues 14. Easterly wind. Dull Morning. I went out to the Mount in the Post chaise for the first time,—took Charlotte. The Day did not turn out quite so fine as I wished. Hear there was a man of La Motte's deserted from Forbes last night. The Town Boat, call'd the *Fly*, came over from Barbary, brings a few Fowls and Eggs, also a packet of letters, none for Us—says there is an English Vessel now at Tangier from Eng^d^ in 15 days from Portsmouth. In the afternoon there was firing from Europa at a Xebeque that was trying to Attack a Brig that was bringing In a small Prize. She proves to be an English privatter, call'd the *Maidstone*. She was In here and went away about three weeks agoe. Has brought In a little Boat and got safe to the New Mole. The *Enterprize* fired at the Xebeque but did not reach Her. It is this Day reported that there is a large Army of French intended to come into the Spainish Camp to attack this Garrison, and that they are Daily expected.

Wed 15. Easterly wind, a very Dull Morning. It rained very early. Find myself exceedingly indisposed, could not get up to Breakfast. This Day a Court Martial sitting upon the two Deserters of 72nd: Colonel Picton 12th Regt, President, 4 Field officers, 8 Captains. In the afternoon a Cutter came from the West; she came from Scilly, had fallen In with a Spainish Frigate of 36 Guns off Cadiz and had Received Some damage. N.B. The beginning of this Month Mr Raleigh Secy to the Gov^{r} was appointed Commissary for the Exchange of Prisoners. The hurry and Daily hopes and Expectations which now prevailed, particularly in Weak Minds, began to Affect me, and I grew exceedingly ill. My Head and Eyes very bad, hardly indeed am able to write this, and fear I am going to be very ill. It was the same with me some weeks ago, but as I only write for the Amusement of myself and if ever it so happen for my own family's Information in a few points,—so I am the less anxious about the Stile or Manner. No one in evening. 15th March, 1780.

Thursd 16. Easterly wind, tolerable Day. Find myself rather better but not in spirits. Nothing new this Day. Very little to be got in the Market this Day. The child and two of the Maids went to the Mt in afternoon. Fine Night. A Cutter came In from the West, call'd the *Alert*. She was bringing In a prize. She is a fine Privateer. She lost the prize. It was taken into Algezira.

Fry 17. Easterly wind, very fine Morning and continued so all day. Hear that the two Deserters were to be shott, the time not yet fix'd. Several Signals up at our Look out; from the East; and in the afternoon a Large Number of Vessels going through, supposed to be a Dutch Convoy. Find myself very much indisposed this Day with a Severe Cold; which has affected me for above a Month past.

Saturd 18*th*. Easterly wind, fine Day. Capt Loyd upon Batterys to Day. Fired in the Evening. I was not Well this Day or in Spirits, find the Smallest Vexation hurts my Health, and I feel pains in Consequence of it.

Sund 19. Easterly wind, fine Day. In the afternoon the Enemy fired a Feu-de-Joye in their Camp, as did likewise all the Men of War over at Algezira. The whole Line turned out and appeared a large Body. Various opinions formed. Both yesterday and to Day we fired more shott than for some Weeks past. The Gov^{r} has also given orders to the captains upon the Batterys to fire at the Patroles in the Night. Capt Shands upon the Batterys to Day. One of the two soldiers lately Try'd is Reprieved this afternoon. The other is to be Shot Tomorrow.

Mond 20. Easterly wind, a very fine Warm Morning. Hear that the Rejoicing in the Camp was on occasion of a Son Born to the Prince of Asturias, Son to the King of Spain. One of their officers told one of ours, when they met on a Parley that such an event was hourly expected and wish'd for. This is the first Son. We find by

20th March, 1780. the appearance of their Men Under Arms that there is still a large Number of Troops in the Camp, and also a Battalion over at Algezira. Notwithstanding it has been said They had sent away a great many Regts. This forenoon the Man of 72nd was shott. He had formerly belong'd to 58th and had married the Daughter of the Sergeant Major of that Regt who was sent for to the Gov^{r} of this Garrison some years agoe by Sir Will^{m} How who had a great regard for the Sergeant Major. He made him an officer and he is now a Capt in a Regt in America. This Soldier's Wife is in England. His Name is Traverss. He seem'd to feel for his Wife and Her Father.

Tuesd 21. Easterly Wind, pleasant Day. We Kill'd a Small Cow this forenoon for the Use of the Family, and sent away as presents the following Pieces. The Cow weighed 400 lbs. A Sir Loin to General Boyd; a part of the Ribs to Colonel Godwin; a piece of the Loin to Roast and a small piece to Boil for Capt Phipps; a part of the forequarter and a little piece for Soup for Colonel Gledstanes; a part of the Sir Loin to Doctor Baynes; a part of the Ribs for the Engineer Mess; a piece for Boiling for Mrs Skinner; a piece for Roasting for Mrs Booth; a piece for Roasting, Capt Evelegh; a Round for Mrs Power; and a Shin or two for some Sick families; the Head and Liver between Serjeant Grant and one of our Married Servants. N.B. We had been offer'd 25 Guineas for it and I daresay might have had £30, for Every Body was Selling as Dear as they thought proper, but I detested the imposing practice. This Cow Turn'd out exceeding Good Meat and was very Acceptable at this Juncture. It was the 2nd of my Cows. I have now 2 Cows and a young Heifer left. This is the first Field Day this season. The Colonel went out at Landport this afternoon. He saw the Captain of Landport Guard, as he was Walking out, near the Meadow, with two Gentlemen that are Here on their way to Algiers, one of them Brother to Mr Wilks. The Col thought it wrong to go so far with strangers, particularly leaving the Guard. The Captn ought always to be at his Post.

Wed 22. Easterly wind, a Dull looking Morning. The Captain that was at Landport yesterday was put Under arrest this morning at Gun Fire; by order from the Gov^{r} for leaving his Guard yesterday and going as far as the Devil's Tower with those two Gentlemen. It is Captn Duff of 58th.

Thursd 23. Easterly wind; a Dull Day. Had Company to Dine. I write a long letter to My Sister and sent it by the Sloop Privateer, the *Alert*. Find myself much indisposed.

Fry 24. Easterly wind. Dull Day. The Sloop sailed last Night. 2 Line of Battle Ships and 1 Frigate gone from Algezira. Capt Duff out of Arrest, no consequences having follow'd, except a Caution given to all captains at Landport Guard for the Future.

(To be continued).

TRANSCRIPT.

SUBMARINE CABLES FOR LONG-DISTANCE TELEPHONE CIRCUITS.

Extracts from a paper by MAJOR W. A. J. O'MEARA, C.M.G., LATE R.E., *and read before the* INSTITUTION OF ELECTRICAL ENGINEERS.—*Reproduced by the Courtesy of the* INSTITUTION.

(*Concluded*).

Messrs. A. W. Martin and J. G. Hill, of the Post Office Engineering Department, recently carried out a series of comparative speech tests on a number of cables of this type by the kind permission of the late Mr. C. E. Krarup, Engineer-in-Chief to the Danish Telegraph Service. The results obtained on one of these cables are shown graphically in *Fig.* 1.

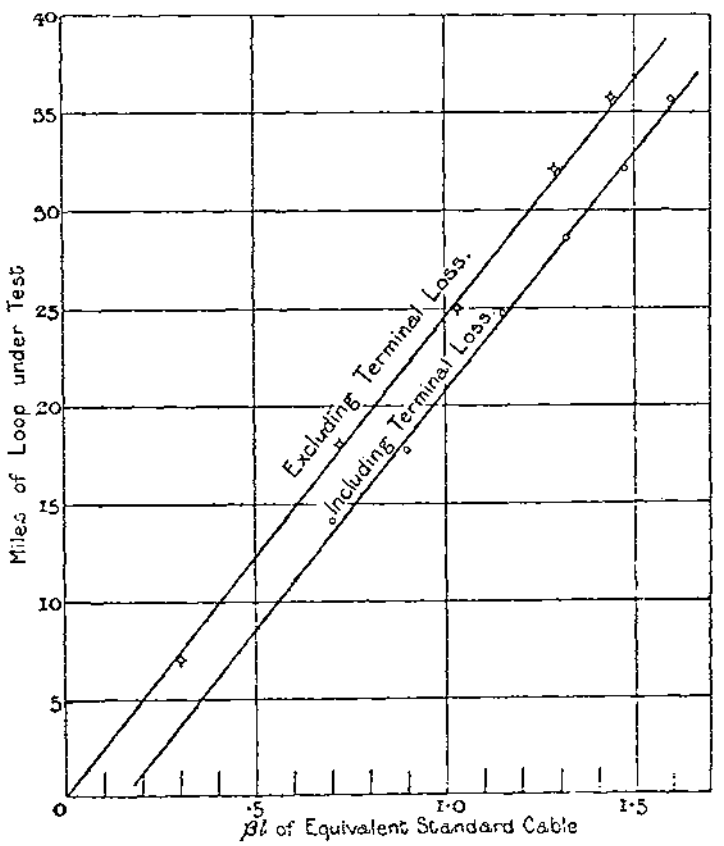


FIG. 1.—*Efficiency Tests of "Continuously" Loaded Cable.*

Length, 1·78 miles. Type, 4 quads + 12 pairs.
Copper, 2 m.m.². Iron, 1 layer 0·37 m.m. wire.
Loop resistance per mile, 27·64 ohms.
Wire-to-wire capacity per mile, 0·08 microfarad.
Inductance per mile, unknown.

The observed attenuation constants of another of the Danish cables is given in Table A, and for comparison therewith, the attenuation for the same cable as found by calculation, and the attenuations calculated for ideal cables with the same copper conductor are also shown (1) unloaded, and (2) loaded with inductance coils. The details for these calculations are tabulated in Appendix IX. The data given in Table B relate in a similar manner to a cable actually loaded with inductance coils, the attenuations when unloaded and when "continuously" loaded being calculated from the particulars in Appendix IXA.

TABLE A.

Based on actual "continuously" loaded cable.
Overall diameter of copper, 126 mils.

Loading.	Outer Diameter of Gutta Percha. Mils.	$\beta \frac{1}{\text{Knot}}$	
		Observed.	Calculated.
Three layers of 7·88 mils iron wire	355	0·0296	0·0197
Unloaded	355	—	0·0369
Coils of 100 millihenries every 1·075 knots ...	335	—	0·0148

TABLE B.

Based on actual "coil" loaded cable.
Overall diameter of copper, 106·2 mils.

Loading.	Outer Diameter of Gutta Percha. Mils.	$\beta \frac{1}{\text{Knot}}$	
		Observed.	Calculated.
Coils of 100 millihenries every knot	390	0·0166	0·0166
Unloaded	390	—	0·0520
Three layers of 7·88 mils iron wire	405	—	0·0230

A wide difference is seen to exist between the ascertained values for attenuation of "continuously" loaded conductors and those which theory seems to predict. The expressions for inductance and eddy-current loss take cognizance of the air-gaps necessarily present in the wire winding, but the eddies are considered as existing in each circular cross-section of the wire alone, thus assuming that no current flows from one wire of the winding to its neighbours. This is a possible source of discrepancy, but the errors so introduced are probably small. Perhaps a more important source of error lies in the somewhat indeterminate value of the permeability of the iron after it has been wound on the conductor. Change of permeability due to overstrain during the winding of the iron is known to occur, and this may be large. The disagreement between observed and calculated values of the attenuation of cable loaded in this manner requires, and is receiving, further investigation.

The development of telephonic communication by means of conductors in comparatively long lengths of subterranean cables during the past few years has afforded the Post Office Engineering Department a valuable opportunity for making a close study of telephonic transmission under various conditions. In this way very much useful information has been accumulated and considerable practical experience has been gained. Mr. H. R. Kempe has gone very carefully into the method of calculating the attenuation of telephone circuits and the cost aspect in regard to the design of gutta-percha cable. The results are valuable, and some of them will be found in Appendix X.

Our investigations clearly indicated that it was possible to obtain more appreciable improvements in long-distance telephone cables by employing loading coils than by resorting to the "continuous" loading of the conductors. Therefore when the matter of the provision of additional submarine cables between this country and France was referred to the Engineering Department, enquiries were at once made to ascertain whether it would be practicable to provide, lay, and maintain in a satisfactory manner, a submarine cable of the "coil" loaded type. It was known that a lead-covered cable provided with loading coils had been laid across Lake Constance from Friedrichshafen to Romanshorn; the several features of the problem involved in this case and the method adopted in actually laying the cable have been fully described.* The conditions under which this cable was laid, however, were entirely different from those requiring the consideration of the Post Office Engineering Department, and it will be recognized that, in view of the difficulties which would arise in the event of the lead sheathing being punctured, it would have been a costly and hazardous experiment to provide and lay a lead-covered cable across the English Channel.

Whilst our investigations were in progress an article appeared† which was somewhat disturbing. As will be seen from the extract given below‡ doubt was thrown on the possibility of improving transmission in gutta-percha-covered cables by means of the so-called Pupin coils, on account of the low effective insulation of gutta percha to currents of high frequency. In order to settle the point definitely, it was decided to carry out some experiments. The Department had a large stock of No. 7 gutta-percha-covered wire (weight of copper, 40 lbs. per mile; of gutta percha, 50 lbs. per mile; resistance, 44 ohms per loop mile; electrostatic capacity wire to wire, 0·13 microfarad per mile), and also a number of inductance coils (inductance, 83 millihenries; resistance, 13·4 ohms at 750 periods per second), which had been used originally for carrying out some experiments in connection with the improvement of transmission of speech in subterranean cables between Liverpool and Manchester. Calculations were made to ascertain the best disposition of the coils in this particular type of cable—although neither the coils nor the cable were really of the

* *Electrician*, Vol. 59, p. 217, 1907.

† *Elektrotechnische Zeitschrift*, Vol. 29, 1908, p. 588.

‡ "Es ist danach fraglich, ob man überhaupt Leitungen mit sehr geringer Dämpfung als Guttaperchakabel mit Pupinspulen bauen kann, wenn nicht die dielektrischen Eigenschaften der Guttapercha erheblich verbessert werden."

most suitable type—and it was found that in order to provide 55 millihenries per mile they should be inserted at intervals of 1½ miles. A large number of speech tests were made on loaded circuits formed by means of the No. 7 gutta-percha wire, by myself, Messrs. H. Hartnell, A. W. Martin, and other members of my staff. It was gratifying to find that the actual improvement in transmission was in complete agreement with the estimates based on the calculations that had been made. (By calculation the attenuation was 0·0436 per mile, and the observed result was 0·0419 per mile). We found that commercial speech was certainly practicable on 105 miles of this particular type of "coil" loaded gutta-percha wire, and our doubts as to the feasibility of the "non-uniform" loading for submarine cables of moderate length were set at rest. The question of providing a "non-uniform" loaded type of cable was therefore proceeded with.

In order to be absolutely on the safe side, however, when preparing the specifications for this new Anglo-French cable, it was decided that the general design of the new telephone cable in respect of the copper and the dielectric should be exactly similar to the type already in use, which it was known would provide telephonic transmission of a certain quality, and that the improvement desired could be obtained by the contractors either by means of "continuous" loading or "coil" loading, the Department simply stipulating in the specification that the attenuation constant should not exceed a certain definite value. The main reason for this was that if it had been discovered after the cable had been laid that coils introduced effects not foreseen, the coils could easily have been cut out at a small cost and the Department would still have had a cable as good as the existing one. It is known that under certain conditions of design in the relation of the weight of gutta percha to that of copper per knot, an effect is created referred to colloquially as "drumminess." "Drumminess" is a property which causes speech to be muffled, and therefore renders it less distinct. In an unloaded circuit "drumminess" is generally unmistakable, when the ratio $\frac{K^*}{R}$ per mile is equal to 0·003. The greater this ratio the more marked is the "drumminess."

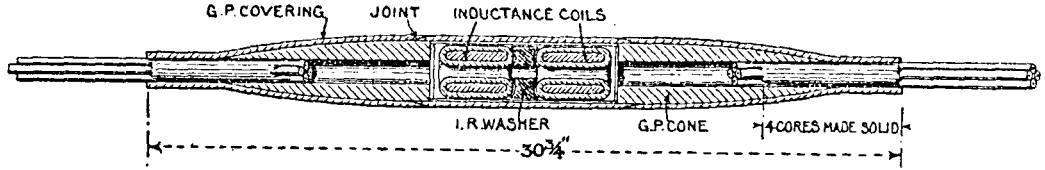
Selected firms were asked to tender for the additional cable to be provided by the British Administration. No tenders were received for the "continuous" type of loading, but three tenders were received for the "coil" type of loading.

The features of the device for loading in the accepted tender are as follows:—

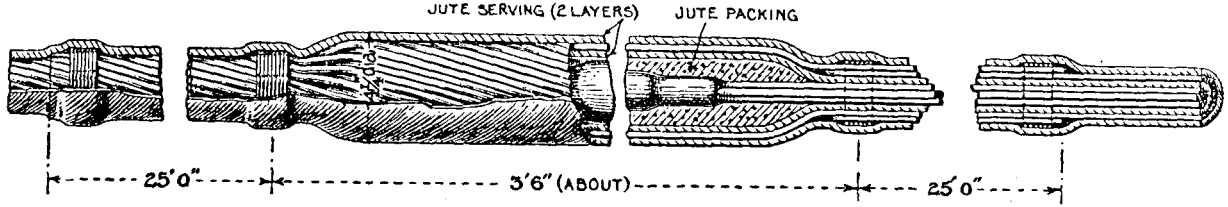
The two double coils required for the four conductors of the cable, each coil being of slightly less than 6 ohms resistance and having an inductance of 0·10 henry at 750 periods per second, are inserted at intervals of 1 knot (1·153 miles), but the two coils nearest the ends of the cable are inserted at a distance of only half a knot from the terminal apparatus, as experiments have shown that in this arrangement reflection losses are considerably reduced. Each double coil consists of two windings on the

* K = microfarads, and R = ohms.

FIG. 2.—*Section of Cable containing Loading Coils, complete with Sheathing Wires.*



ARRANGEMENT OF COILS IN CABLE
(Scale about one-sixth)



METHOD OF SHEATHING OVER COILS
(Scale about one-sixth)

FIG. 3.—*Anglo-French Cable*, 1910.

same iron core, and one winding is connected in series with each conductor. By this means the gradual change in permeability in the iron core due to aging will not affect the balance in the two limbs of the telephone circuit. Each coil is protected with a sheet of metal foil in order to exclude all possibility of the silk covering of the wires of the coils absorbing moisture from the cylindrical envelope of gutta percha in which they are contained. The cores of the cable are connected to the envelope at its two ends by tapered solid gutta-percha joints. The diameter at the centre of the envelope is 3", and at the cores where the joints terminate 1". An annular rubber distance-piece is inserted between the two coils of a set to give greater flexibility. The total length of the joint in 30·75". As the diameter of the cable at the points where the coils are inserted is increased, a larger number of sheathing wires are required at those points than over the conductors alone. This difficulty is ingeniously overcome by starting a second layer of sheathing wires over the cores, about 27' from the centre of the coil envelope and gradually working them into a single layer with those over the bulge. Finally they are terminated as a second layer again over the cores at a distance of about 27' from the centre of the coil envelope. The method adopted in inserting the coils (Patent Specification No. 5,547 March, 1907) will perhaps be understood from the diagrams (*Fig.* 3).

It will be recognized that the mechanical problem in connection with this type of cable was more difficult to solve than the electrical problem, as it was necessary that the part of the cable containing the coils should be so designed that it could be paid over the sheaves of the cable-ship without any risk of damage to the coils themselves. However, I am glad to say that the manufacturers succeeded in solving this problem in a most satisfactory manner.

The cable was under the constant supervision of the Post Office Engineering Department during the period of its manufacture, and electrical tests were carried out from time to time. On January 18th, 1910, after the completion of the cable, measurements to determine its attenuation constant were made at the works of Messrs. Siemens Bros. & Co. at Woolwich. The conductors of the cable were joined up so as to provide a metallic circuit of 41·704 knots, and in order to get rid of terminal effects artificial cable was joined to the ends of the loaded cable thus :—

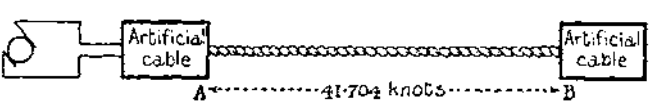


FIG. 4.

Current was supplied to this circuit by a generator giving 1·585 volts at a frequency of 750 alternations per second. Readings were taken on a thermo-galvanometer placed successively at A and B, and the attenuation constant was calculated by the formula $C_B = C_A \cdot \epsilon^{-\beta d}$.

With 10 miles of "standard" cable* (attenuation constant 0·1187 per

* Sir John Gavey, Inaugural Address, *Journal of the Institution of Electrical Engineers*, Vol. 36, p. 26, 1905.

knot) at each end of the circuit the current values at A were found to be 0·327 milliampere, and at B 0·172 milliampere, β therefore being 0·0154.

With 15 miles of "standard" cable at each end of the circuit the current values at A were found to be 0·212 milliampere; at B, 0·110 milliampere, from which we similarly obtain $\beta = 0{\cdot}0158$.

The volume of the speech transmitted over the loaded cable was also compared with that over an artificial "standard" cable, the electrical constants of which are known. The result of these tests indicated that the attenuation constant of the loaded cable was 0·0147.

If the electrical constants of the Anglo-French loaded cable are substituted in the formula—

$$\beta = \frac{R + \frac{S}{K} L}{2} \sqrt{\frac{K}{L}}$$

it will be seen that the attenuation constant obtained by the sent-and-received current test requires that the value to be assigned to $\frac{S}{K}$ in the above formula must be approximately 99, whereas the value of the attenuation constant indicated by a comparison with the artificial "standard" cable requires the value of $\frac{S}{K}$ to be 80. There is no doubt that leakage plays a very important part in the transmission of telephonic speech. Recently whilst in America, I found that one of the principal difficulties which had been encountered in that country in connection with the loading of long-distance aerial telephone circuits consisting of the larger gauges of wire was chiefly due to leakage. However, the difficulty has been largely overcome by the substitution of more efficient insulators for the glass ones which have hitherto been in general use in the United States.

We have long been aware of the great importance the ratio $\frac{S}{K}$ plays in the design of long-distance telephone circuits. In the case of gutta-percha cables there is certainly no noticeable leakage arising from faulty insulation as in the case of aerial wires; still the dielectric currents in such cases are appreciable, and practically represent an effective leakage. Dr. Breisig has informed me that he has carried out various tests on dielectrics and has confirmed the existence of such losses. For viscous dielectrics he finds the value of $\frac{S}{\omega K}$ (where S is the effective leakage, K capacity in farads, and ω is equal to $2\pi n$) is independent of the value of K; in the case where $\omega = 5{,}000$ the value is found to be 0·018.

In dealing with the maintenance of "coil" loaded cables after they have been laid, the degree of importance to be attached to the uniform spacing of the coils has to be considered. In repairing cables, intermediate lengths have to be inserted at times, but fortunately if repairs of this character have to be effected in the "coil" loaded cable, no noticeable impairment in the quality of the speech will result if the coil spacing is disturbed to an extent not exceeding 5 per cent. on either side of the

best location from the theoretical point of view. It has been found that when physical conditions impose a variation of not more than 50 per cent. of the spacing for a single coil, no appreciable impairment in the quality of the speech will result provided the deficiency in loading is made up within the next ten loading sections. The frequency with which repairs have been carried out on the existing telephone cables, as shown in the chart Appendix XI., will convey some idea of importance of this matter.

The investigations that have been made left little doubt concerning the balance of advantages in favour of the "coil" loaded type of cable from the electrical standpoint, but as the expenditure involved was very great, and as it was felt that the main difficulty in connection with this type of cable would be in safely laying the cable at the bottom of the sea, it was considered that special precautions were necessary to ensure that the responsibility for any defects that might be disclosed after it had been laid, should be definitely traced to the responsible party. To afford the necessary protection to the Department, it seemed desirable to stipulate in the specification that the manufacturers of the cable should also undertake to lay it, and to hand it over *in situ*. This course was approved by the Postmaster-General, and the invitations to tender were issued on these lines. The conditions were accepted by Messrs. Siemens Bros. & Co., who were the successful tenderers.

The routes of the land lines serving the telephone cables to continental countries are shown in *Fig.* 5.

The cable has been under continuous observation since it was laid and a large number of tests have been carried out. Particulars of some of them are given in Appendix XII. It has fortunately been possible to obtain independent testimony on the question the increase in the range, and in the improvement in the quality of speech transmitted by means of the loaded cable as compared with a similar cable unloaded. Speech tests were made in July last by Messrs. W. R. Cooper, W. Duddell, F.R.S., W. Judd, and J. E. Kingsbury, and the results are interesting. The cable was looped at the French end (Cape Grisnez), and the English ends were connected to two telephone sets—one installed in the cable hut at Abbot's Cliff, and the other in the coastguard look-out shelter some 100′ distant. Graduated artificial cables were provided so that the listener at the cable-hut could insert various values of the "standard" cable into the circuit, until his own limit of satisfactory audibility was reached. It was possible to insert the "standard" cable values equally at the two ends of the cable (*i.e.*, so as to form a symmetrical circuit in relation to the submarine cable), or unequally, as desired. The results shown in the table on page 192 were obtained.

The mean gain by the use of the new cable is therefore 17 miles of "standard" cable for the standard of audibility accepted as commercial by the four observers named. When the cables were alone in circuit some of the observers noticed that in the case of the new cable there was a distinct improvement in the quality of the speech as compared with the old cable.

The employment of unloaded 800-lb. copper aerial conductors such as

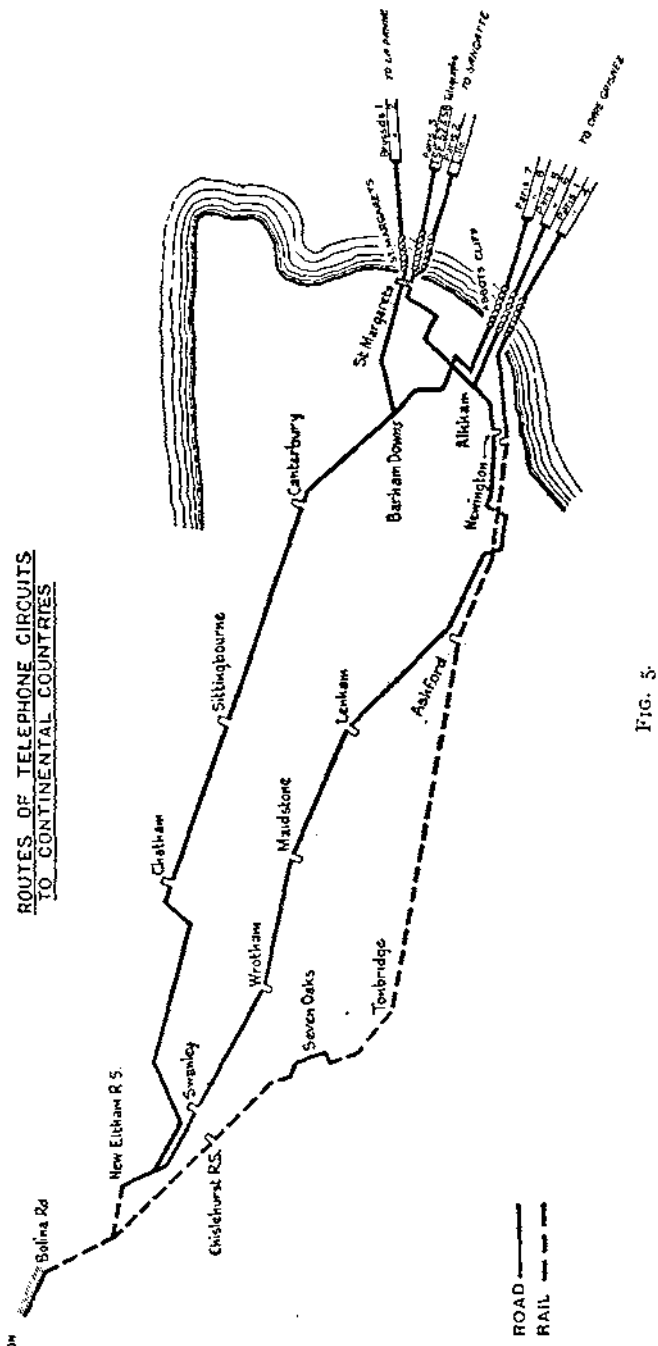

ROUTES OF TELEPHONE CIRCUITS
TO CONTINENTAL COUNTRIES
London
Bolina Rd
New Eltham R.S.
Chislehurst R.S.
Swanley
Wrotham
Chatham
Sittingbourne
Maidstone
Canterbury
Seven Oaks
Tonbridge
Lenham
Ashford
Barham Downs
Newington
Alkham
St Margarets
Dover's Cliff
ROAD
RAIL

FIG. 5.

are in use for the most important long-distance trunk circuits in this country, will render it possible for very satisfactory conversations to take place from call-boxes between centres in England and on the Continent when the added distances from the ends of the cable do not exceed 1,700 miles: that is to say, with land-lines of this description well-maintained conversations between London and Astrakhan on the Caspian Sea would be possible. In his inaugural address to the institution,* Sir John Gavey included a table of equivalents of the various types of unloaded conductors. It may be assumed that in practice aerial conductors of the smaller gauges can be improved by loading twofold, and the conductors in cables threefold, so that it is not difficult to determine the centres between which the new Anglo-French telephone cable will provide communication, assuming that a particular type of conductor is employed to complete the circuit.

Observer Listening.	Old Cable.	New Cable.	Gain by New Cable.
	Added Length of Standard Cable.	Added Length of Standard Cable.	
			Miles.
W. R Cooper ...	24 miles symmetrical ...	48 miles symmetrical... ...	24
		40 miles symmetrical... ...	16
W. Duddell	24 miles symmetrical	‖50 miles symmetrical... ...	26
		‖55 miles at one end	21
W. Judd	26 miles symmetrical ...	40 miles symmetrical... ...	14
J. E. Kingsbury ..	26 miles symmetrical ...	40 miles symmetrical... ...	14

‖ As breakdown limits of hearing.

CONCLUSION.

Although great improvement in speech transmission has resulted from this latest type of cable, yet the new Anglo-French cable cannot by any means be regarded as the last word on submarine telephone cables. An attempt has been made in this paper to place on record some of the steps taken in developing the art of long-distance telephony, but many problems remain to be solved, and they do not appear to be of a character likely to yield a ready answer to those seeking their solution. As in the past, the co-operation of the mathematician, physicist, engineer, and manufacturer are still needed if an announcement is to be made in this theatre twenty years hence that the progress in the art of telephony has resulted in an increase of efficiency comparable with that which has been achieved during the past twenty years, and which it has been my pleasure to record here to-night.

The practical engineer recognizes fully how much he is indebted to the mathematical investigations of Heaviside, Pupin,† Perry,‡ Kennelly,§ and

* *Journal of the Institution of Electrical Engineers*, Vol. 36, p. 28, 1905.
† *Transactions of the American Institute of Electrical Engineers*, Vol. 16, p. 93, 1899.
‡ *Philosophical Magazine*, Vol. 36, p. 222, 1893.
§ *Transactions of the International Electrical Congress*, St. Louis, 1904, Vol. 1, p. 68.

others, in respect of the progress made in the past. There are to-day a number of earnest workers, both in this country and in foreign lands, who are sparing no efforts to render possible the transmission of speech from any one point of the habitable globe to any other.

I feel that the most important matter to which attention should be turned at the present time is that connected with the measures which should be adopted to ensure that the scientific and practical results obtained by the investigators in these widely separated centres shall be in such a form as to be easily comparable. A scientific spirit is abroad, and it has been agreed to abandon standards of commerce and to adopt those of the laboratory to record values affecting the efficiency of telephone circuits. So far so good. The problem, however, is one containing many complexities, and the final results, I think, must be measured from the point of view of the non-scientific user. It would appear, therefore, that it is not possible to deal with telephonic transmission from the consideration of the attenuation constant in its mathematical aspect alone, but it is necessary to take into consideration its practical aspect as affecting audition. In the early part of September, 1910, I had the privilege of taking part in experiments at Paris arranged by Dr. Breisig and M. Devaux-Charbonnel, which consisted in talking over actual telephone circuits, into which, in turn, artificial cables were introduced of three different types designed to reproduce conditions representing—

(*a*). Aerial wires.
(*b*). Unloaded cables.
(*c*). Loaded cables.

The talking circuits were so arranged that in each case the total attenuation was by mathematical calculation exactly the same. These experiments showed that the quality and volume in audition under the three different cases were by no means in agreement. Clearly then, for comparative purposes, it seems to be most desirable not only that the conditions with regard to the circuit arrangements, including terminal conditions, shall be identical, but that all those who are engaged in this important investigation should employ, in connection with their experiments for measuring audition, apparatus manufactured to the same specification and compared with an international standard. It is hoped that this result may have been attained as a consequence of the recent International Conference at Paris.

APPENDIX I.

MAP OF ENGLAND AND PART OF IRELAND SHOWING IMPORTANT SUBMARINE TELEPHONE CABLES IN BRITISH WATERS.

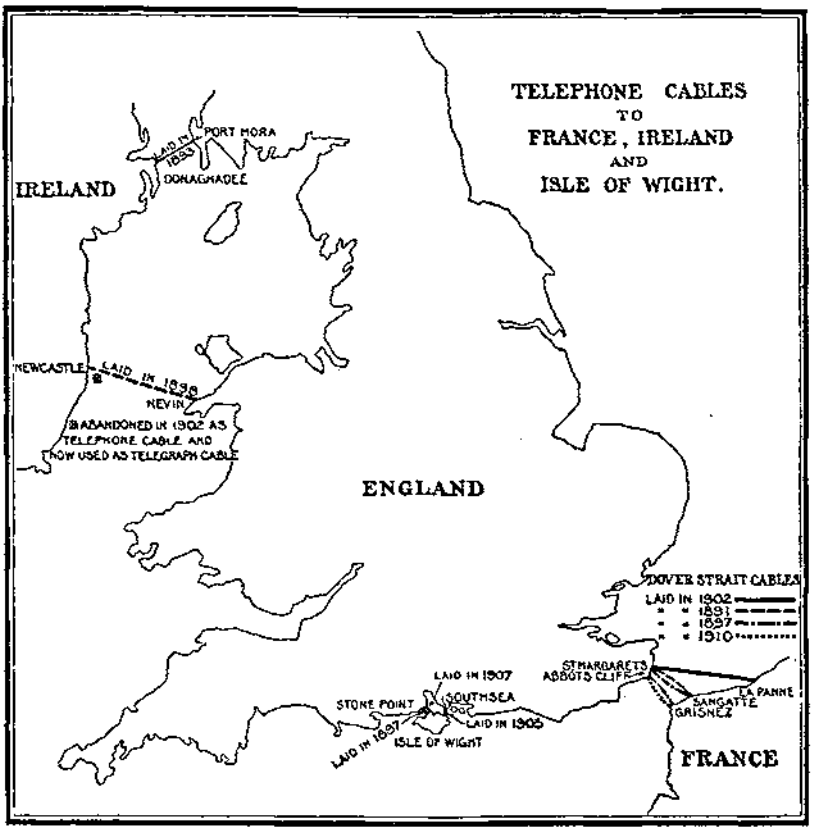


FIG. 6.

APPENDIX II.

SHORT DESCRIPTION OF THE FIRST ANGLO-FRENCH TELEPHONE CABLE.

(*Fig.* 8, Appendix VI.).

Opened to the Public April 1, 1891.

This was a 4-core cable differing but little from those in use at the time for telegraphic purposes, except in the size of the cores. Each core consisted of a stranded copper conductor formed of 7 equal wires, having a total weight of 160 lbs. per knot, covered with 300 lbs. of gutta percha per knot. The extreme diameters of the copper strand (d) and of the gutta-percha covering (D) were 0·108 and 0·390″ respectively, giving a ratio $\frac{D}{d} = 3{\cdot}61$.

The measured resistance of the conductor at 75° F. was 7·453 ohms, and the measured electrostatic capacity 0·275 microfarad per knot. The sheathing consisted of 16 galvanized iron wires, each 0·280″ in diameter, put on with a lay of 18″, and the external diameter of the finished cable was about 2·2″.

BOOKS RECEIVED.

SPONS' ARCHITECTS' AND BUILDERS' POCKET BOOK, 1912. Memoranda Section. Edited by Clyde Young, F.R.I.B.A., and Stanford M. Brooks, L.R.I.B.A. Price 2s. 6d., post free 2s. 8d. E. & F. Spon, 57, Haymarket, W.

SPONS' ARCHITECTS' AND BUILDERS' POCKET PRICE BOOK AND DIARY, 1912. Edited by Clyde Young, F.R.I.B.A., and Stanford M. Brooks, L.R.I.B.A. Price 2s. 6d., post free 2s. 8d. E. & F. Spon, 57, Haymarket, W.

ETUDES TACTIQUES D'ARTILLERIE. M. Blaise, Capitaine d'Artillerie Breveté. Préface de M. le Général de Lastours, Commandant la 3e Division de Cavalerie. Les desiderata et les possibilités.—La convergence des efforts.—Organisation du Commandement.—Centralisation et décentralisation.—Actions convergentes et actions parallèles.—Les prévisions.—La liaison des armes et les groupements mixtes.—Le renforcement.—Les emplois spéciaux.—Librairie Chapelot, 30, Rue Dauphine, Paris.

THE COMING TRIUMPH OF CHRISTIAN CIVILISATION. Capt. J. W. Petavel, late R.E. London, Geo. Allen & Co., Ltd., 44 and 45, Rathbone Place.

A B C OF HYDRODYNAMICS. Lt.-Col. R. de Villamil, R.E. (Ret.). Price 6s. net, 6s. 4d. post free in the U.K. Messrs. E. & F. Spon, Ltd., 57, Haymarket, London, S.W.

THOMASON CIVIL ENGINEERING COLLEGE CALENDAR, 1911–12. Allahabad, 1911.

HANDBOOK OF THE LAND FORCES OF BRITISH DOMINIONS, COLONIES AND PROTECTORATES (OTHER THAN INDIA). Part I. THE DOMINION OF CANADA. General Staff, War Office, S.W. H.M. Stationery Office, Westminster, S.W. (*For Official use only*).

HISTORICAL PAPERS ON MODERN EXPLOSIVES. By George W. MacDonald, M.SC. (MELB.), with an Introduction by Sir Andrew Noble, Bt., K.C.B., F.R.S. Price 7s. 6d. net. Whittaker & Co., 2, White Hart Street, Paternoster Square, E.C.

CORRESPONDENCE.

A PONTOON BRIDGE FOR STEAM TRANSPORT.

SIR,

With reference to the paper of Capt. Carey, R.E., in the February number of the *R.E. Journal* on heavy pontoon bridging may I call attention to one or two points. This question is one of great importance at the present time and we should be much indebted to Capt. Carey for throwing some light on it by his investigations. But I should like to point out that he is hardly fair on the present equipment in one or two particulars. These are:—

(i.). The allowance for superstructure of 200 lbs. per foot-run is needlessly high.

(ii.). An allowance of 100 per cent. for impact is not required for the baulks of a bridge of which the supports rest on water. 50 per cent. has always been considered to be sufficient and when the elasticity of a floating bridge is taken into account, it seems as it even this allowance were too great.

(iii.). The safe dead central load in pounds of a pontoon baulk over a span of 15′ is 2,043 and not 1,886, since the width is $3\frac{1}{4}''$ and not 3″.

Further, in Design I., which is the really important one, it is stated that the pontoons *b*, *c* and *d* "will sink evenly" under the load on *c*. This cannot be the case since the baulks deflect under the load.

However Capt. Carey's calculation of the number of baulks required gives a total of just over 14, after the necessary corrections have been made for (ii.) and (iii.) above, *i.e.* altering the 1,886 lbs. to 2,043 and the 943 to 1,362. This confirms the calculations for, and the practical experience of, the bridge designed in the Fortification School and tested at Upnor, where it was found that 14 baulks *will* take the specified load without any damage or permanent deflection in the baulks. This bridge is shown in *Fig.* 14 of the first article in the *Journal* for February.

I am, etc.,

J. C. MATHESON,

Major, R.E.

Chatham, February 19th, 1912.

The Editor, *R.E. Journal*.

To prevent appreciable reflection-effect at the far end of the circuit it was found that rather more than 20-m. standard cable must be inserted. Actually 60-m. standard cable was used.

The ammeters C_1 and C_2 were Duddell thermo-instruments. Their heaters had resistances of roughly 170 and 4 ohms respectively.

There was some difficulty in obtaining a uniform supply from the alternator, and consequently accurate measurements could not be made. The table below includes the only results on which, owing to the unsteadiness of the supply of high-frequency current, any reliance can be placed.

Frequency p.p.s.		C_1 Milli-amperes	C_2 Milli-amperes.	$\therefore e^{\beta l}$ $(=C_1/C_2)$.	$\therefore \beta l$.	$\therefore$ Me βl.
Readings.	Mean.					
1,720	—	8·92	2·23	4·00	1·390	
—		6·42	1·80	3·56	1·270	1·33
1,232	—	7·97	3·09	2·57	0·940	
—		8·98	3·38	2·65	0·970	0·96
1,060		6·20	2·54	2·39	0·870	0·87
762	—	7·83	4·28	1·83	0·605	
—		7·02	3·91	1·80	0·590	0·60
744		5·76	3·09	1·85	0·615	
752		4·06	2·33	1·72	0·540	
774	756	5·76	3·09	1·84	0·610	0·59

The following graph is plotted between the mean values for frequency and for βl. l, the length of loop under test was 40·0 knots.

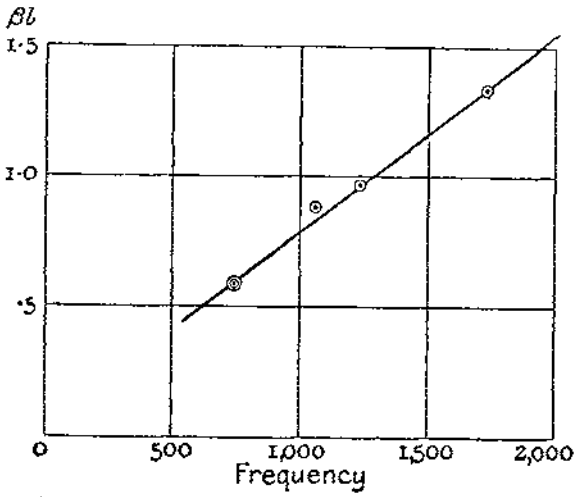


FIG. 14.

To compare these results with the value of β as indirectly obtained by speech tests we proceed thus. That single frequency which best represents the voice, so far as volume of sound is concerned, has been found to be about 800 p.p.s.*

From the graph, for this frequency

$$\beta l = 0{\cdot}63.$$

i.e.,

$$\beta = 0{\cdot}0158.$$

Assuming 800 p.p.s. to be the simple equivalent voice frequency, the value of the attenuation constant as found by speech test comparisons with standard cable is

$$\beta = 0{\cdot}0169.$$

* F. Breisig, *Berichte der Deutsche Physikalische Gesellschaft*, Heft 5, 1910

APPENDIX XI.

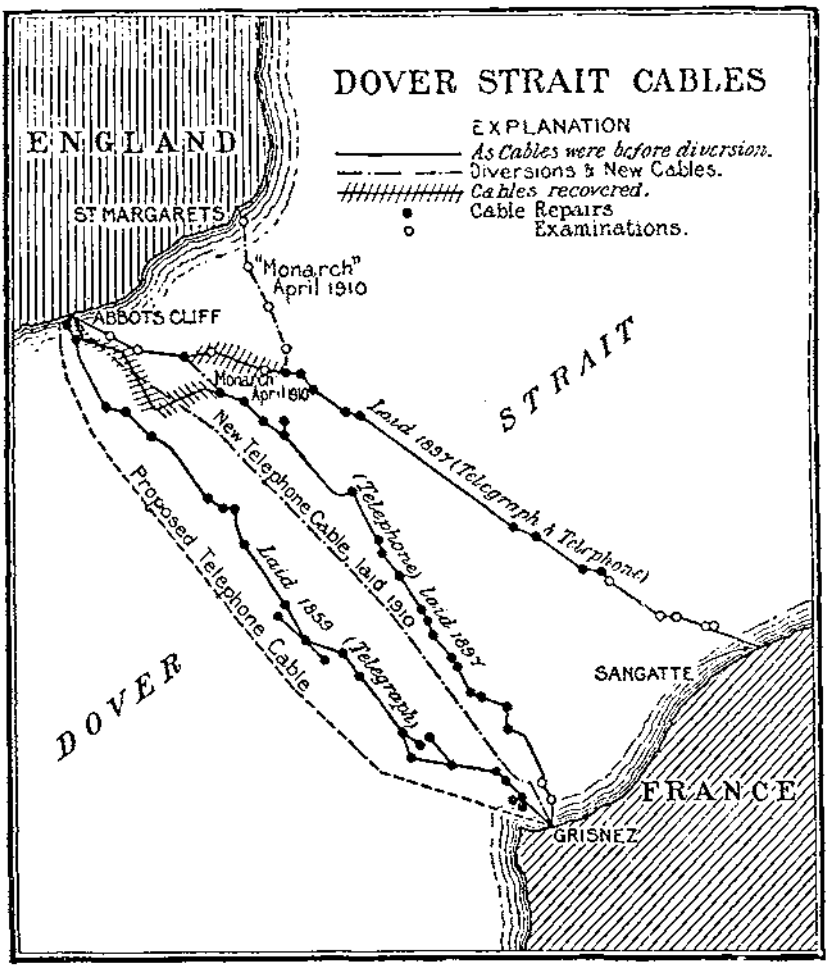


FIG. 12.

APPENDIX XII.

TESTS BY MR. L. B. TURNER ON THE LOADED CHANNEL CABLE, TO DETERMINE BY DIRECT MEASUREMENT THE SENT AND RECEIVED CURRENTS.

The experiments were made in the Abbot's Cliff Cable Hut on October 14th, 1910.

The high-frequency current used in the tests was supplied from the General Post Office, London, over a pair of telephone wires.

The arrangement of the apparatus was thus:—

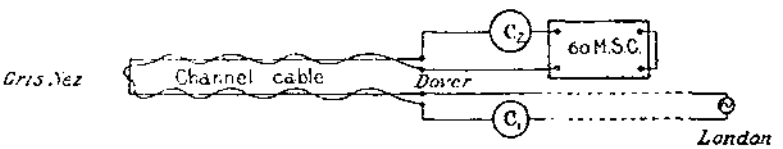


FIG. 13.

$$rk = \frac{1000\beta^2}{n_1 + 0{\cdot}08}$$

$$\beta = \sqrt{\frac{k}{\mathcal{L}} \frac{a + bn}{n} \times 1{\cdot}192\,(n_1 + 0{\cdot}08)}$$

$$\mathcal{L} = \frac{k}{\beta^2} \frac{a \times bn}{n} \times 1{\cdot}192\,(n_1 + 0{\cdot}08) \text{ or } = aW + bw$$

$$n = \frac{w}{W}$$

$$k = \frac{0{\cdot}320}{\log\left(\frac{9{\cdot}076}{n} + 1\right)}$$

$$W = \mathcal{L}\,\frac{n}{a + bn}$$

$$r = \frac{1192}{W} \text{ or } = \frac{1192}{\mathcal{L}\,\frac{n}{a + bn}}$$

$$l = \frac{R}{n_1 + 0{\cdot}08}$$

$$d = \sqrt{\frac{20}{kl}}$$

$$l_1 = \sqrt{\frac{20l}{k}} \text{ or } = \frac{d}{\sqrt{l}}$$

The cost, as regards the materials of the core (gutta percha and copper), of obtaining a low attenuation constant, increases as the inverse square of the constant, *i.e.*, if we double the length of a cable we double the cost and double the attenuation constant, and to halve this doubled constant the size of the conductor and the thickness of the dielectric must be increased; the cost of this increase would be double that of the original cable, length for length.

LENGTH OF COPPER WIRE LOOPS CORRESPONDING TO CENTIBETAS.

Centibetas.	10.	20.	30.	40.	50.	60.	70.	80.	90.	100.	110.	120.	130.
	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
200-lbs. wire	14	28	43	57	71	86	100	114	129	142	157	171	186
300-lbs. wire... ...	20	40	61	81	101	121	141	162	182	202	222	243	263
400-lbs. wire	25	51	77	102	128	153	179	204	230	255	281	306	332
600-lbs. wire... ...	36	72	108	144	180	216	252	288	324	360	396	431	467
800-lbs. wire	44	88	132	177	221	265	309	353	397	441	485	530	574

Centibetas.	140.	150.	160.	170	180.	190.	200.	210.	220.	230.	240.	250.	260.
	Miles.	Miles.	Miles.	Miles	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
200-lbs. wire... ...	200	214	228	243	257	271	285	300	314	328	343	357	371
300-lbs. wire... ...	283	303	324	344	364	384	404	425	445	465	485	506	526
400-lbs. wire... ...	358	383	409	434	460	485	511	536	562	588	613	639	664
600-lbs. wire... ...	503	540	575	611	647	683	719	755	791	827	863	899	935
800-lbs. wire... ...	618	662	706	750	794	839	883	927	971	1,010	1,060	1,100	1,150

1 knot of cable (Anglo-French loaded) = 1·67 centibetas.
1 statute mile (Anglo-French loaded) = 1·44 ,,
484 centibetas = limit of commercial speech.
Exchanges and subscribers = 216 centibetas.

Example.—With 100 miles of Anglo-French loaded cable, how many miles of 600-lb. trunk wire can be worked through?

100 × 1·44 = 144. 484 − 216 = 268.
268 − 144 = 124 = 445 miles of 600-lb. wire.

In the case of well-constructed inductance coils the effective resistance is 6 ohms for every 100 millihenries of inductance, *i.e.*, $\rho = 0{\cdot}06l$, so that $R = r + 0{\cdot}06l$. Formula (2) is a general one, but when l is larger than R (in numerical value), which is usually the case, then

$$\beta = \frac{r + .14l}{63{\cdot}2}\sqrt{\frac{k}{l}}$$

r being the conductor resistance exclusive of the resistance of the inductance coils.

A minimum value is given to β if $r = 0{\cdot}14l$, in which case

$$\beta = 0{\cdot}01183\sqrt{kr},$$

and

$$l = 7{\cdot}14r.$$

These two equations are all that is necessary for calculating the inductance which should be given to a cable to make it most efficient telephonically, and also to determine the value of β under this condition.

It may be remarked that the equation

$$\beta = 0{\cdot}01183\sqrt{kr}$$

indicates that a properly loaded cable, in relation to telephonic efficiency, does not follow a "kr" but a "$\sqrt{kr}$" law, and it also follows that the efficiency is inversely proportional to the length, and not to the square of the length.

The value of the leakance is an important factor, and could this be reduced tenfold, the value of β could be reduced about 40 per cent.; and further, if it were possible to reduce the leakance practically to zero, *i.e.*, to make the insulation practically infinite, then the value of β could be reduced 50 per cent., which is the minimum value which could be given to it without reducing the effective resistance of the coils below 6 ohms per 100 millihenries, a result which has so far proved not to be possible.

In comparing the improvement which can be obtained by loading a cable, the fact that there is a normal inductance must be taken into consideration. This normal inductance is about 1 millihenry per knot approximately, but a number of successful experiments have been made to determine its exact value.

The possible improvement from loading diminishes as the conductor resistance diminishes (since, as pointed out, for best conditions $l = 7{\cdot}14r$), thus, the possible improvement for a 1-ohm conductor is but one-half that for a 5-ohm conductor. For long-distance speaking in this country, heavy overhead conductors are necessary not only from the point of view of low resistance, but also in regard to the effect of low insulation resistance, which, owing to climatic conditions, it is impossible to avoid. Loading of such lines would, even if possible, be of comparatively little value.

The following formulæ have been developed, based on general principles, and enable various conditions to be calculated:—

Formulæ for Loading Coils.

β = attenuation constant per knot.
W = weight of gutta percha per knot.
w = weight of copper per knot.
u = ratio of weight of copper to weight of gutta percha.
£ = total cost of materials of core.
a = cost per lb. of gutta percha (in £s).
b = cost per lb. of copper (in £s).
k = capacity per knot in microfarads.
r = resistance per knot in ohms.
l = total inductance per knot in millihenries.
ρ = ratio of effective resistance of inductance in ohms to inductance in millihenries.
d = distance apart of inductances.
l_1 = inductance per coil.

APPENDIX IXA. (*Amended*).

CONSTANTS OF THE ANGLO-FRENCH COIL LOADED TELEPHONE CABLE COMPARED WITH THE CONSTANTS OF THE SAME CABLE WITHOUT LOADING AND CONTINUOUSLY LOADED.

Cable Core Details.			Constants per Knot of Loop.				Attenuation Constant.				
Overall Diameter of Copper.	Loading.	Diameter of Gutta Percha.	Resistance Ohms.		Direct Current.		Per Kilometre.	Per Statute Mile.	Per Nautical Mile.		Characteristic Impedance $=Z_0$.
			Direct Current.	750 p.p.s.	Inductance in Millihenries.	Capacity in Microfarads.			Calculated.	Observed.	
Mils.		Mils.									
106·2	Three layers of 7·88 mils iron wire 101·5 turns per inch ..	405*	14·95	16·06	22·00	0·181	0·0124	0·0200	0·0230	—	—
106·2	Unloaded ..	390	14·95	14·95	2·00	0·138	0·0278	0·0447	0·0520	0·0524	—
106·2	Coils of 100 m.h. every knot .. Steady current resistance, 2·25 ohms .. .. Resistance at 750 p.p.s., 6 *ohms*	390	17·20	20·90	102·00	0·138	0·0091	0·0147	0·0170	0·0166	$858\sqrt{0\cdot 51}$

* Weight of gutta percha same as in Cases 2 and 3. † Length of Channel cable = 20 knots.

APPENDIX X.

MR. H. R. KEMPE'S METHOD OF CALCULATING THE ATTENUATION OF LOADED CIRCUITS, ETC.

The formula

$$\beta = \sqrt{\tfrac{1}{2}\left[\sqrt{(R^2+p^2L^2)(S^2+p^2K^2)}+RS-p^2LK\right]}$$

is not a convenient one for general use, owing to the fact that the value of

$$\sqrt{(R^2+p^2L^2)(S^2+p^2K^2)}+RS$$

is, in the majority of cases, so very nearly equal to the numerical value of p^2LK that the equation cannot be correctly solved unless the terms are worked out to a very large number of places of figures; also it is perferable to express L, K, and S in millihenries (l), microfarads (k), and ohms (ω), rather than in henries, farads, and mhos; also for the cable manufacturer, it is more convenient to deal with a single than with a looped circuit.

The formula in this case becomes

$$\beta = \frac{\sqrt{k}}{20}\sqrt{\sqrt{R^2+(5l)^2}-5l+\frac{200R}{\omega k}+0\cdot 000128\sqrt{R^2+(5l)^2}} \quad \ldots\ldots\ldots\ldots(1)$$

The value of ωk for ordinary gutta-percha-insulated cores may be taken to be 12,500 approximately, so that

$$\beta = \frac{\sqrt{k}}{20}\sqrt{\sqrt{R^2+(5l)^2}-5l+0\cdot 016R+0\cdot 000128\sqrt{R^2+(5l)^2}} \quad \ldots\ldots\ldots\ldots(2)$$

R being the conductor resistance r, plus the "effective resistance" ρ of the inductance coils; *i.e.*, $R = r+\rho$.

Note.

In the tables of Appendices IX. and IXA. effective resistances are calculated. The following expression* has been used:—

Extra resistance due to eddies in the iron is

$$\Delta r = 10^{-9} 8\pi^4 \left(\frac{1}{R_1}+\frac{1}{R_2}+\ldots\frac{1}{R_n}\right)\frac{1}{\rho}\left(\frac{\mu}{1+a}\right)^2 n^2 \frac{r^4}{2r+g} \text{ ohms/km. of loop,}$$

where

ρ = specific resistance of iron in ohms/sq. cm./cm.
n = frequency in periods per second,

and lengths are in cms.

Further, the hysteresis loss is taken as half of the eddy-current loss in the iron. The reason for so doing lies in this: that Larsen† finds such is very nearly the value of the hysteresis loss at 765 periods per second for a cable whose separate cores are very nearly similar to those of the actual cable, but which lie close together, instead of being separated as in the quad-pair arrangement to which the tables of Appendices IX. and IXA. refer.

Finally, the capacity of the cable, used in the tables to calculate β, is found from the usual expression, substituting for the radius of the copper the other radius of the iron wrapping.

APPENDIX IX.

Constants of a "Continuously" Loaded Danish Telephone Cable compared with the Constants of the same Cable without Loading and with Coil Loading.

Cable Core Details.			Constants per Knot of Loop at 750 p.p.s.					Attenuation Constant β.			
Overall Diameter of Copper.	Loading.	Overall Diameter of Gutta Percha.	Resistance Ohms.		Inductance in Millihenries.	Capacity in Microfarads.	Leakance in Mhos.	Per Kilometre.	Per Statute Mile.	Per Nautical Mile.	
			Direct Current.	750 p.p.s.						Calculated.	Observed.
Mils.		Mils.									
126	Three layers of 7·88 mils iron wire 101·5 turns per inch ..	355	7·96	8·88	19·00	0·253	$2·4\times10^{-5}$	0·0106	0·0171	0·0197	0·0296
126	Unloaded ...	355‡	7·96	7·96	2·00	0·175	$2·4\times10^{-5}$	0·0109	0·0320	0·0369	—
126	Coils of 100 m.h. every 1·075 knots ... Steady current resistance, 2·25 ohms . Resistance at 750 p.p.s., 6 ohms	335§	10·66	13·55	93·00	0·186	$2·4\times10^{-5}$	0·0080	0·0128	0·0148	—

‡ Space occupied by iron in first example filled with gutta percha.
§ Weight of gutta percha same as in first example.

* Larsen, *Elektrotechnische Zeitschrift*, Vol. 29, p. 1032, equation 139'.
† *Elektrotechnische Zeitschrift*, Vol. 29, p. 1033, Beispiel 2.

APPENDIX VIII.

FORMULÆ FOR CALCULATING ATTENUATION CONSTANT OF "CONTINUOUSLY" LOADED CIRCUITS.

Values of the inductances obtained by the employment of a continuous solid iron envelope over copper conductors are calculated from the formula—

$$L = 4\left[\log\frac{2d}{r} + \tfrac{1}{4} + (\mu - 1)\log\frac{r+t}{r}\right] 10^{-4} \text{ per kilometre,}$$

where

L = inductance in henries.
$2d$ = distance between centre conductors in cms.
r = radius of each conductor in cms.
μ = permeability = 120.
t = thickness of iron covering.

In the case of the Danish cable tested by Mr. Martin (Cable E, Appendix VII.)—

$2d = 1{\cdot}275$ cms.
$r = 0{\cdot}16$,,
$t = 0{\cdot}06$,,

Then $L = 0{\cdot}016$ henries per kilometre.

The values of the inductances* obtained by the employment of a wire-wound continuous envelope over the copper conductors—

$$L = \left[2\pi\left(\frac{1}{R} + \frac{1}{R_2} + \ldots + \frac{1}{R_v}\right)\frac{r^2}{2r+g}\left(\frac{\mu}{1+a} + f\right) + 2\log\frac{2r_3 - r_2}{r_2}\right] 10^{-4} \text{ henries per km. of loop,}$$

where

$$f = \frac{4}{\pi} - 1 + \frac{2g}{\pi r},$$

and

$$a = \mu - \frac{r\sqrt{gr}}{8\pi R^2 \tan^{-1}\cdot\frac{r}{\sqrt{gr}}}.$$

r = radius of iron wire in cms.
v = number of layers of iron wire.
g = gap between convolutions of iron wire in cms.
R_1 = mean radius of first layer of iron wire in cms.
R_2 = mean radius of second layer of iron wire in cms.
R_3 = mean radius of third layer of iron wire in cms.

$$R = \frac{1}{v}(R_1 + R_2 + R_3).$$

r_2 = outer radius of iron wrapping in cms.
r_3 = half the distance in cms. between centres of conductors.
μ = permeability of iron.

In the case of the Danish cable tested by Mr. Martin (Cable E, Appendix VII.)—

$r = 0{\cdot}01$ cms.
$v = 3$.
$g = 0{\cdot}005$ cms.
$R_1 = 0{\cdot}17$,,
$R_2 = 0{\cdot}19$,,
$R_3 = 0{\cdot}21$,,
$r_2 = 0{\cdot}22$,,
$r_3 = 0{\cdot}6363$,,
$\mu = 120$.
$S = 12 \times 10^{-6}$

(This value for leakance is adopted as being 100 times the capacity).

Then $L = 0{\cdot}0102$ henries/km. of loop.

* This is from Larsen's formula (*Elektrotechnische Zeitschrift*, Vol. 29, p. 1031, equation (17)). The coefficient 2 is wanting in the expression as there found, because the author reckons inductance, etc., "für 1 km. einfache Leitung."

"Continuously" Loaded Cables.

(Krarup Type).

The first "continuously" loaded cable having the copper conductor wrapped with a layer of 0·008" iron wire on Krarup's plan appears to have been that laid by the Danish Government, in November, 1902, between Elsinore and Helsingborg.* Mechanical and electrical data of this cable are given in the table. The dielectric was gutta percha, and, except in respect of the iron wrapping, the cable did not differ materially from the ordinary type of submarine cable. This was followed, as will be seen from the table, by various paper-insulated cables having the conductors wrapped with a single layer of 0·012" iron wire. The cable shown in *Fig.* 11, Appendix VI., is that laid in July, 1904, and is distinguished by the letter E in the table. Each copper conductor consists of a central wire about 0·089" in diameter surrounded by three copper strips each 0·094" wide and 0·020" thick. The sectional area of the copper is approximately 0·0124 square inch, and the weight per knot 285 lbs. The iron wrapping consists of three layers of 0·008" wire, and the insulator is gutta percha having an external diameter of 0·354". The four cores are laid up with an inner serving of tanned jute and an outer serving of tarred jute yarn to a diameter of 1·18", and sheathed with 15 galvanized iron wires of roughly trapezoidal section. The external covering appears to be the usual tarred yarn and compound.

The electrical constants of the cable per knot from Mr. Krarup's figures are as follows :—

Resistance. Ohms per Knot of Conductor.		Capacity. Microfarads per Knot of Conductor.		Self-Inductance. Millihenries per Knot.	
Steady Current.	Alternating Current. $n=900$.	Steady Current.	Alternating Current.	With Iron.	Without Iron.
3·971	4·175	0·4983	0·4454	8·07	0·93

Of the paper-insulated lead-covered cables the Dano-German telephone cable laid between Fehmern and Laaland in 1907 may be taken as representative. The copper conductor with its triple soft iron wire wrapping is precisely similar to that used in the Seeland-Samsö-Jutland cable described above. The insulator consists of paper cord laid on in an open spiral followed by a close wrapping of paper ribbon up to a diameter of 0·303". Four of the cores so formed are stranded together with the necessary worming and then covered with paper to a diameter of 0·787". The diagonal distance apart of the cores, centre to centre, is 0·413". The core after being thoroughly dried is next sheathed with two layers of lead alloyed with 3 per cent. of tin, each layer being 0·055" thick. The lead sheath is seamless, water-tight, and continuous throughout the entire length of the core. Outside the lead sheath is a double layer of asphalted paper and a layer of jute and compound. The armour consists of 13 galvanized iron wires or strips of trapezoidal section $\left(\frac{0·315+0·252}{2}\times 0·157 \text{square inches}\right)$, and over this is a double layer of jute and compound.

To prevent the destruction of the cable by the puncture of the lead sheath at any point solid plugs 1 metre (3·28') long are inserted at every 150 metres (164 yards).

Resistance per knot of loop, 8·924 ohms ... ... } Continuous current.
Capacity per knot of loop, 0·0872 microfarad... ... ... }
Capacity per knot of loop, 0·0770 microfarad ... . Alternating current.
Inductance per knot of loop, 18·26 to 18·09 millihenries.

* *Moderne Telefonkabler*, by C. E. Krarup. *Elektrotekniker*, December 10th, 1904.

APPENDIX VII.

SOME FOREIGN "CONTINUOUSLY LOADED" SUBMARINE CABLES.*

	Cable.	Date of Laying.	Length in Knots.	Number of Conductors.	Copper Square Inch.	Wrapping of Iron Wire.	Insulation Thickness in Inches.	Lead Sheath.	Resistance in Ohms per Knot of Conductor.		Capacity Farads per Knot of Conductor.		Self-Induction Millihenries per Knot of Conductor.		Old Formula (Preece) $C\sqrt{\gamma}$.	β per Knot $n=900$.
									γ Continuous Current.	γ Alternating Current $n=900$.	C Continuous Current.	C Alternating Current.	Prepared (Wrapped with Iron Wire).	Without Iron Wire.		
						Mils.			†	†	†	†	†	†		
A	Elsinore-Helsingborg ...	Nov., 1902	2·85	4	0·0054	7·88	Gutta percha 0·323	No	8·49	8·79	$0·324\times10^{-6}$	$0·3030\times10^{-6}$	4·92	1·100	$2·750\times10^{-6}$	0·0340
B	Fehmern-Laaland ...	Jan., 1903	10·38	4	0·0155	11·82	Impregnated paper	Yes	3·18	4·79	0·301 ,,	0·2660 ,,	4·65	0·850	1·075 ,,	0·0184
C	Greetsiel (Emden) Borkum	Spring, 1903	15·85	4	0·0054	11·82	Air-space paper	Yes	9·03	11·08	0·138 ,,	(0·1243) ,,	7·41	1·240	1·338 ,,	0·0225
D	Cuxhaven-Heligoland ..	Autumn, 1903	40·50	2+2/2	0·0186	11·82	Solid paper	Yes	2·53	3·38	0·170 ,,	(0·1490) ,,	3·98	0·595	0·427 ,,	0·0104
E	Seeland-Samsö-Jutland ...	July, 1904	8·93+11·02	4	0·0124	3×7·88	Gutta percha 0·355	No	3·98	4·78	0·500 ,,	0·4460 ,,	8·08	(0·900)	1·970 ,,	0·0156

The figures in brackets are, however, interpolated or approximately stated.

* See *Elektrotechnische Zeitschrift*, Vol. 29, p. 586, 1908, and also *Journal Télégraphique*, Vol. 29, p. 187, 1905.
† The figures refer to single-wire values.

APPENDIX VI.

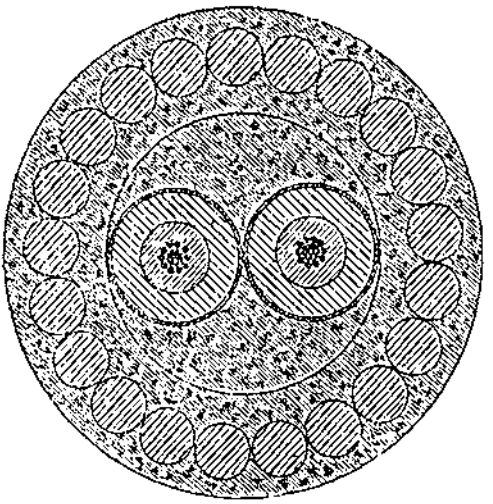


FIG. 7.—*Composite Core. Paper and Gutta Percha.*
500 lbs. copper, 572 lbs. gutta percha.
(Full size).

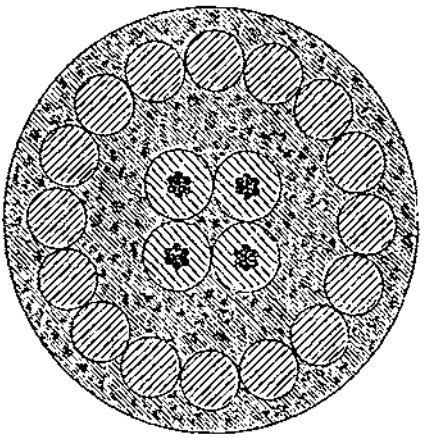


FIG. 8.—*Anglo-French* (1891) *Cable, Gutta Percha Core.*
160 lbs. copper, 300 lbs. gutta percha.
(Full size).

FIG. 9.—*Composite Core. Paper, Indiarubber, and Gutta Percha.*
900 lbs. copper, 280 lbs. indiarubber, 1,400 lbs. gutta percha. (Per knot).
(Full size).

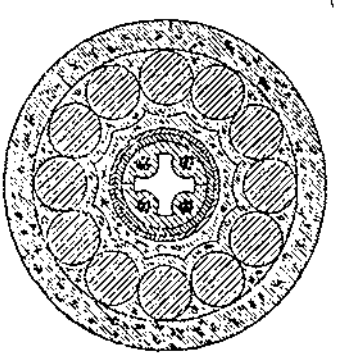


FIG. 10.—*Air-Space Gutta-Percha Core.*
552 lbs. copper, 552 lbs. gutta percha. (Total weights).
(Full size).

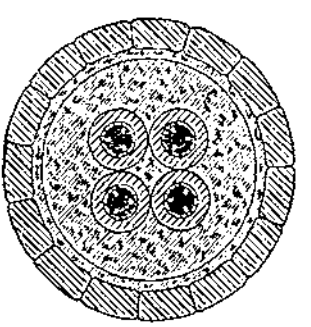


FIG. 11.—"*Continuously*" *Loaded Core. Gutta Percha.*
285 lbs. copper, 180 lbs. gutta percha.
(Full size).

SECTIONS OF SUBMARINE TELEPHONE CABLES THAT HAVE BEEN ADOPTED OR PROPOSED.

APPENDIX V.

PARTICULARS OF TYPES OF SUBMARINE TELEPHONE CABLES PROPOSED FOR THE ANGLO-FRENCH SERVICE.

I. Hammered Segmental Conductors with Protuberances: Paper Insulation for Core.

(*Fig.* 9, Appendix VI.).

Weight of conductor, 900 lbs. per knot.
Each conductor $\frac{7}{16}$ S.W.G. to be covered longitudinally with one layer of paper 1·75″ wide and 0·015″ thick.
Whipped with 15 lea 2-ply yarn $1\frac{5}{8}$″ lay.
The two conductors so insulated twisted together (about 3′ lay) with protuberances adjacent and opposite, with nine papers each $\frac{5}{8}$″ wide and 0·012″ thick between them.
The pair to be lapped with three layers of paper 0·005″ thick.
Six paper strings laid round $2\frac{1}{4}$″ lay.
Double proof tape one coat, $1\frac{1}{4}$″, $\frac{1}{4}$″ lap.
Layer of vulcanized indiarubber, 0·047″ thick.
Layer of double proof tape to a diameter of 1″.
Thin coating of Chatterton's compound and gutta percha $\frac{1}{16}$″ thick up to a diameter of $\frac{1}{2}$″.
One layer of brass tape, $\frac{1}{2}$″ lap.
Thin coating of Chatterton and covering of gutta percha 0·04″ thick.
Coating of hemp, 25 lbs.
Waterproof separation from gutta-percha covering.
Weight of gutta percha, 1,400 lbs. per knot.
Sheathed with 18/0·280″ Post Office wire.
Two coats 3-ply Post Office hemp.
Diameter overall, 2·22″.
Weight per knot, 298 cwt.

II. Composite Core Submarine Telephone Cable (Paper and Gutta Percha).

(*Fig.* 7, Appendix VI.).

Each conductor 500 lbs. per knot, 12-strand { 1 × 0·104″. / 11 × 0·0385″.
One longitudinal air-space paper.
Six spiral layers of paper (with gap).
One spiral layer of paper (without gap) to 0·43.
Gutta percha ($\frac{1}{3}$″ thick) to 0·68″ (572 lbs. per knot).
Actual capacity, 0·139 microfarad per knot (wire to earth).
Each core brass taped, 2 cores stranded, wormed, and served jute yarn.
Sheathed 21 × 0·280 galvanized steel, double jute served outside.

APPENDIX III.

Description of the Air-Space Type of Submarine Telephone Cable.

In 1895 Messrs. Willoughby Smith and W. P. Granville took out a patent for a type of submarine cable core which was designed to combine the advantages of an "air-space" cable with low capacity, and of gutta-percha insulation with its well-known durability and impermeability to moisture. The method of building up the core will be obvious from Appendix VI., *Fig.* 10, which represents a section of the "air-space" cable laid in 1898 between Nevin, North Wales, and Newcastle, co. Wicklow. Each conductor consists of a central wire 50 mils in diameter surrounded by 10 wires each of 22 mils diameter. Two conductors were covered with gutta percha so as to form a crescent-shaped semi-circular segment, as shown in the *Fig.* Two such crescent-shaped strips were then "laid" together with a helical twist and doubly covered with gutta percha to a diameter of 0·580", forming a tubular core. The weight per knot of each of the four conductors was 138 lbs., and the total weight of gutta percha 552 lbs. per knot, that is, equal to the total weight of copper. The conductor resistance was 8·515 ohms per knot at 75° F., and the wire-to-wire capacity of diagonal pairs 0·1016 microfarad per knot. This capacity is about 19 per cent. less than the mutual capacity of two conductors in the ordinary Post Office type of submarine telephone cable. To prevent flooding of the whole cable in case of damage at any point the core was made solid at the joints.

APPENDIX IV.

Particulars of Three Submarine Cables connecting Nevin (Wales) and Newcastle (Ireland).

Cable.	Gutta Percha. Weight per Knot	Copper.		R. Standard Ohms. Per Knot	K. Wire to Earth. Per Knot.	I. Millihenries. Per Knot.	Insulation at 75° F.	Total Length of Cable.
		Weight per Knot.	No. of Strands.					
	Lbs.	Lbs.			Microfarads.			Knots.
No. 1 telegraph cable	150	107	7/22	11·145	0·3333	2·195	Not less than 500 nor more than 1,000 megohms	56·078
No. 2 telegraph cable	150	107	7/22	11·145	0·3333	2·195	Ditto	60·630
Air-space type of submarine telephone cable	552*	138	10 wires 22 mils diameter stranded round a central wire 50 mils diameter	8·515	0·1974	2·96 diagonal wires 2·13 adjacent wires	988	57·123

* Total weight per knot for the four conductors.

A PONTOON BRIDGE FOR STEAM TRANSPORT.

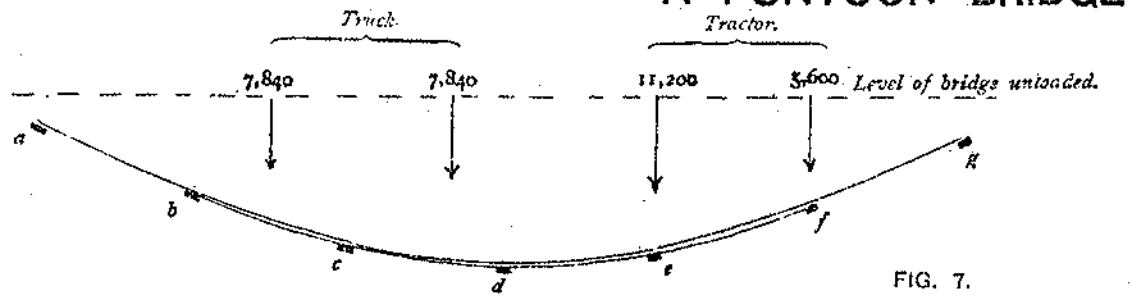


FIG. 7.

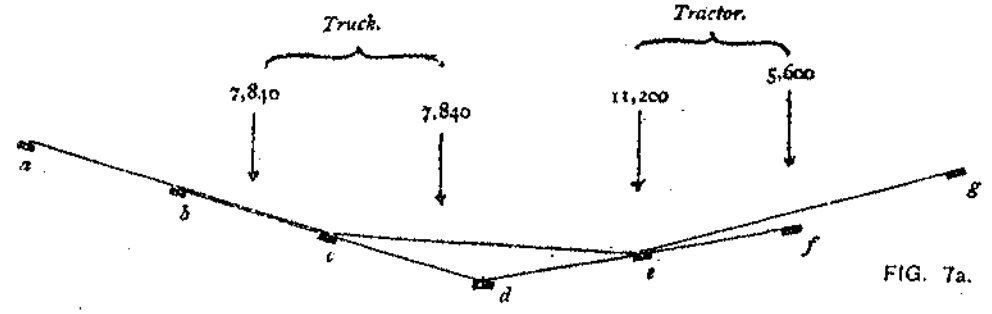


FIG. 7a.

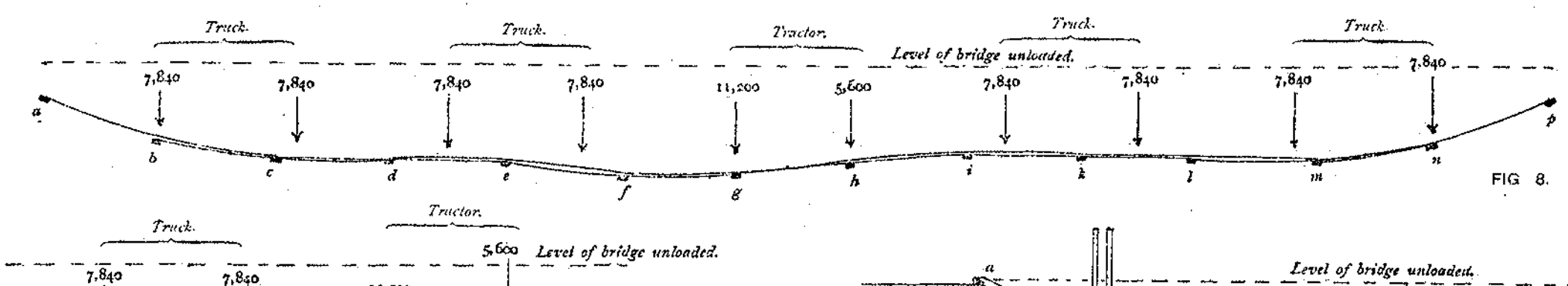


FIG. 8.

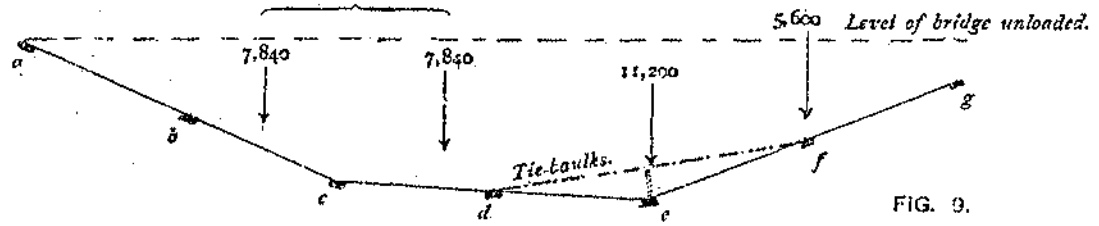


FIG. 9.

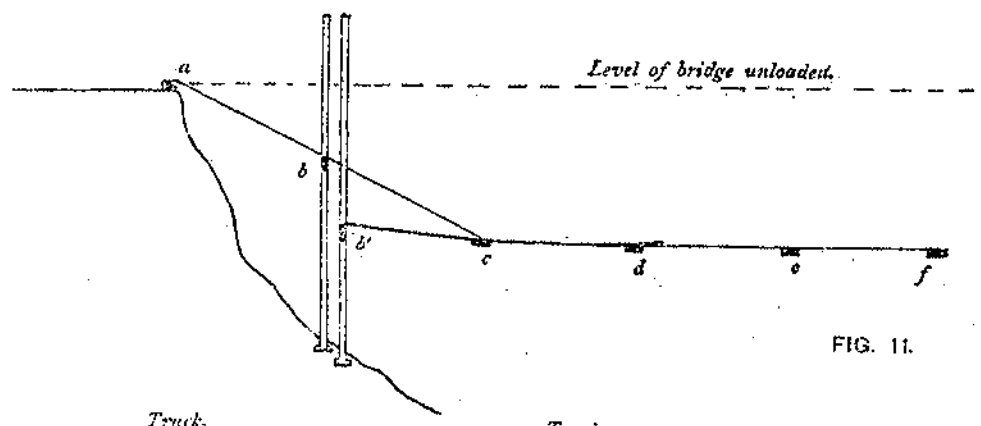


FIG. 11.

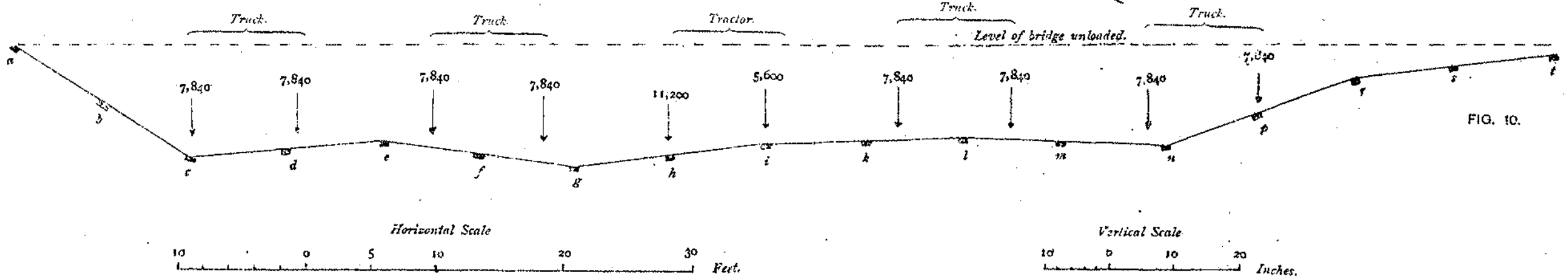


FIG. 10.

Horizontal Scale

10 0 5 10 20 30 *Feet.*

Vertical Scale

10 0 10 20 *Inches.*

THE BEST WAY

TO QUALIFY FOR THE **ARMY AIR BATTALION**

Is to LEARN TO FLY at

The 'BRISTOL'

FLYING SCHOOLS

AT

SALISBURY PLAIN and BROOKLANDS.

No other School possesses such Magnificent Equipment, Tuition Staff or Methods, and

No other School can point to such a long list of Certificates obtained.

MORE ARMY & NAVY OFFICERS HAVE QUALIFIED AS AVIATORS AT THE . . "BRISTOL" SCHOOLS THAN AT ALL OTHER SCHOOLS COMBINED.

THE FEE TO ARMY AND NAVY OFFICERS FOR TUITION ON MONOPLANE OR BIPLANE AND INSURANCE AGAINST BREAKAGES AND THIRD PARTY RISK IS £75 (THE AMOUNT OF THE GOVERNMENT GRANT TO SELECTED OFFICERS TAKING THE BREVET).

THE AVERAGE TIME OCCUPIED IN TUITION IS 3 WEEKS.

THE EQUIPMENT CONSISTS OF A PLENTIFUL NUMBER OF THE NEW "BRISTOL" MONOPLANES —THE MOST SUCCESSFUL MACHINE PRODUCED— AND "BRISTOL" BIPLANES, BOTH OF WHICH ARE WORLD-RENOWNED FOR RELIABILITY, . . STRENGTH & STABILITY.

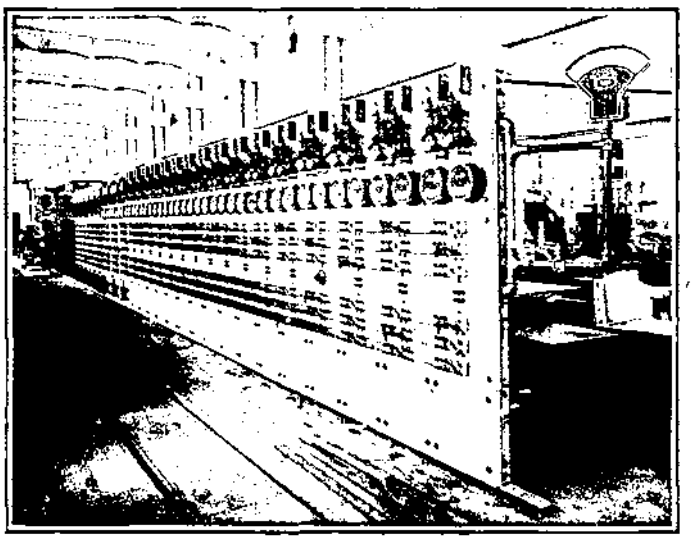
For full Particulars, write to—

THE BRITISH & COLONIAL AEROPLANE CO., Ltd.,

FILTON HOUSE, BRISTOL.

SIEMENS

SWITCHBOARD



used at

DELHI DURBAR,

under construction at our Stafford Works.

SIEMENS BROTHERS DYNAMO WORKS LIMITED.

Head Office: CAXTON HOUSE, WESTMINSTER, LONDON, S.W.

Telephone: Gerrard 860. *Telegrams: "Siembralos, London."*

Works: STAFFORD.

BRANCHES:

Birmingham	Newcastle	Sydney	Rangoon	Tokyo
Bristol	Sheffield	Melbourne	Calcutta	Valparaiso
Cardiff	Constantinople	Singapore	Bombay	Buenos Ayres
Glasgow	Johannesburg	Bangkok	Madras	Mexico
Manchester	Cape Town	Penang	Shanghai	Toronto

SUPPORT BRITISH INDUSTRIES.

ASBESTOS
CEMENT-SLATES & TILES

Registered
'POILITE'
Trade Mark.

'POILITE' Roofing Tiles

'POILITE' ASBESTOS Cement Sheets

'Poilite' is manufactured in accordance with the patent specification of Mr. L. Hatschek, and is in all respects similar to the material sold under the name Eternit.

The characteristics of this indestructible material, both for Roofing purposes and for the lining of walls and ceilings, are well known to Engineers, Architects and Surveyors.

Prompt delivery, speedy fixing by experienced workmen, and immunity from repairs are warranted. Inclusive Tenders submitted on receipt of Plans.

BELL'S UNITED ASBESTOS Co. LTD.

(Contractors to the Admiralty, India Office, War Office and other Government Departments.)

SOUTHWARK ST., LONDON, S.E.

THE SILICATE PAINT COMPANY,

J. B. ORR & Co., Limited.

CHARLTON, LONDON, S.E.,

— *Manufacturers of* —

DURESCO. Washable Water Paint; damp-resisting; cheaper than Oil Paint or Wall Paper.

SILICATE OIL PAINT. Ground stiff in Oil, or ready mixed for use; non-poisonous; finely ground; greater body than White Lead.

ENAMEL PAINTS. High-class Varnish Paints.

"ANCHOR" LINE.

Passenger and Cargo Services.

LIVERPOOL to BOMBAY & KARACHI (*viâ* Bombay). Fortnightly.

LIVERPOOL to CALCUTTA. Fortnightly.
All Vessels call at Egyptian Ports.

Large New Steamers. Splendid Accommodation for Passengers. Electric Light and Fans. Excellent Cuisine. Every Comfort. Moderate Fares, both Single and Return

Apply—"ANCHOR" LINE (Henderson Brothers), Ltd., Liverpool, London, Glasgow, &c.

NOTES

FOR THE

TACTICAL FITNESS EXAMINATION,

With Sample Schemes and Solutions,
By Major A. T. MOORE, R.E.

PRICE
TWO SHILLINGS AND SIXPENCE,
Post 3d. Extra.

Obtainable from the Secretary, R.E. Institute, Chatham, and Rees, Limited, 119, Pall Mall, S.W.

EXPLOSIVES. BEST QUALITY ONLY.

DYNAMITE,
GELIGNITE,
GELATINE DYNAMITE,
BLASTING GELATINE,
DETONATORS,

GUNPOWDER,
SAFETY FUSE,
ELECTRIC FUSES,
WARMING PANS,
FIRING CABLES,
Etc., Etc.

CHEDDITE contains no Nitroglycerine. Cannot freeze or exude.

BLASTING AND SPORTING EXPLOSIVES OF ALL KINDS.
CORDITE AND OTHER MILITARY POWDERS.

CURTIS'S & HARVEY, Ltd.
Head Office: 3, GRACECHURCH STREET, LONDON, E.C.
AGENCIES AND STOCKS IN ALL PARTS OF THE WORLD.

TELEPHONE 195. TELEGRAMS:—BECKWITH, WINDSOR.

IMPERIAL SERVICE COLLEGE,
WINDSOR.

Chairman of Governors:
H.S.H. PRINCE ALEXANDER OF TECK, D.S.O.

Head Master: E. G. A. BECKWITH, M.A.
(Late Head Master, The Army School, Holyport, Berks.)

The College, which at present consists of just over 100 boys, is divided into two departments, Military and Civil.

On the Military side there are 45 boys, for whom are allotted 7 Resident Masters of long and successful teaching experience.

SUCCESSES IN 1911

Include 6 direct entries into Sandhurst, 2 into Woolwich, and 2 into Greenwich (Royal Marines).

The Civil side includes preparation for the Universities, Engineering, etc.

A SPECIAL FEATURE

Is that of the instruction given to boys intended for Colonial Life—the College Farm and Estates being applied to this object.

CHARACTERISTICS.

The three main objects of the College are:—

1.—**Teaching in Small Classes.**
2.—**A "Modern" Curriculum.**
3.—**Comparative Lowness of the Fees (£81 per annum for Sons of Officers).**

For further PARTICULARS apply to the Bursar.