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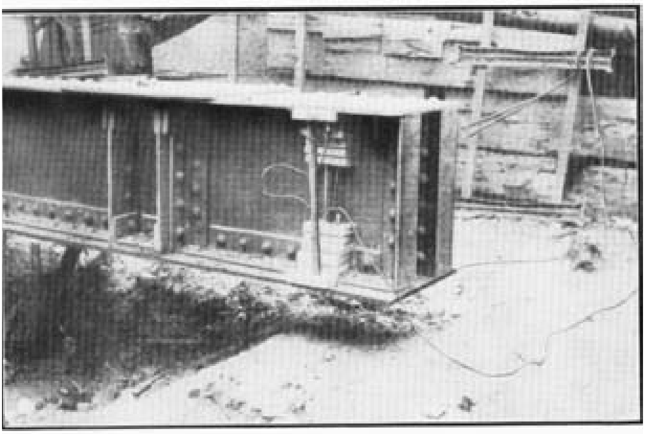


Fig. 21.

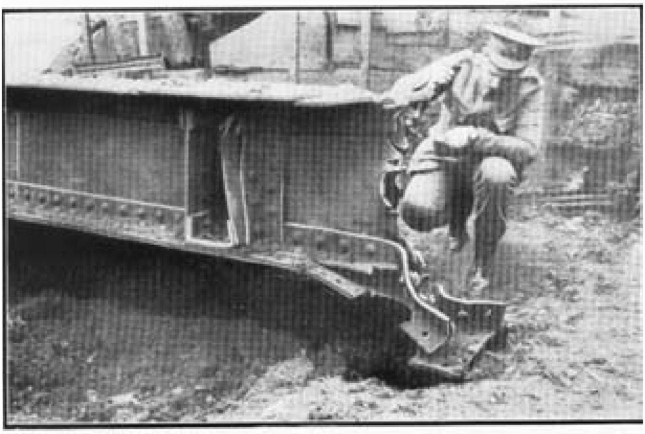


Fig. 22.

SOME NOTES ON FIELDWORKS.

By MAJOR J. C. MATHESON, R.E.

THE following notes are obtained from various sources, most of them being taken from the reports on the Annual Fieldworks Courses of R.E. Units from 1909–11 or from work done at the S.M.E.

I. ENTRENCHMENTS.

(i.). An example is given of the details of two posts in an extended position in *Fig.* 1 (see *Plates*). The working party table for one of these posts is also given. This shows the distribution of the work between the infantry and the engineers. The local reserves of the sections are not shown on *Fig.* 1.

In the case of No. 9 post the works shown are such as could have been done in 10 hours actual working time. One section field company, R.E., was assumed available in the case of both posts.

(ii.). *Noise of Work at Night.*—On a dark still night the thud of the pickaxe was heard up to about 150 yards distance. The scraping of the shovel was less audible.

(iii.). *Method of Dealing with Wet Trenches.*—Wet trenches on a particular low-lying site were dealt with by putting a layer of 6″ to 8″ of brushwood at the bottom and covering this with about 6″ of earth.

(iv.). *Loopholes.*—Loopholes in recesses of a trench should not be placed centrally but towards the right of the recess. This is necessary in order to give room for the firer's body when he is firing to the right front.

(v.). *Overhead Cover.*—*Fig.* 2 shows a method of utilizing corrugated iron sheets for the roof of overhead cover.

(vi.). *Mechanical Alarm.*—*Fig.* 3 shows a very simple and effective mechanical alarm which will act whether the wire is cut or pulled This has been devised by Capt. E. E. B. Holt Wilson, D.S.O., R.E.

II. USE OF SPARS.

(i.). With reference to *Military Engineering*, Part III., para. 79, a variation of the method there described for fastening the top of the lever to the guy is shown on *Fig.* 4. In this case the lever will not drop from the guy until the derrick is vertical.

(ii.). *Pull of Men on a Fall.*—Experiments were recently carried out at Chatham to determine :—

(*a*). The pull of varying numbers of men on the fall (horizontal) of a tackle.

(*b*). The pull exerted by a field capstan of service pattern, with varying numbers of men at work.

In both series of experiments, the point of application of the pull was allowed to move forward at an approximate rate, as it was found with a fixed point of application, abnormally high readings were obtained.

(*a*). The series consisted of varying numbers of men from 1 up to 60. It was found that the pull appeared to vary *directly with the number of men employed*, and, for men of average weight, the experiment gave a mean value of 82 lbs. per man. This can be taken in round numbers, as 80 lbs. or $\frac{3}{4}$ cwt. (according to the unit employed) per man up to 60 men.

(*b*). The series of experiments with the field capstan gave results a little less than those given in *Military Engineering*, Part III., para. 71, the average results were approximately as follows :—

1 man	12 cwt.		7 men	45 cwt.		12 men	66 cwt.	
2 men	20 „		8 „	50 „		13 „	70 „	
3 „	25 „		9 „	54 „		14 „	74 „	
4 „	30 „		10 „	58 „		15 „	77 „	
5 „	35 „		11 „	62 „		16 „	80 „	
6 „	40 „							

(iii.). *Swinging Derricks.*—The pattern given in the textbook has several disadvantages. Some of these are eliminated in that described below.

Jib.—Length as required by circumstances but should be as short as is convenient. Call its length "A." It is formed by two spars lashed together at their tips, and each lashed to a stout cross-piece about 1′ or 1′ 6″ from their butts, sufficiently far apart comfortably to encircle the standing spar.

Other cross-pieces can be added, if thought necessary (*Fig.* 5).

The blocks of the lifting and the connecting tackle at the tip of the jib are lashed opposite one another with the same rope.

The jib is slung to the standing spar by a chain, made fast by a clove hitch in its centre well up on the standing spar, above a rope collar, and each end secured to an arm of the jib, just outside the butt cross-piece.

Connecting Tackle.—The connecting tackle should be secured to the head of the standing spar by a fairly long sling, to allow the jib to be easily swung round as required.

Standing Spar.—The length of the standing spar should be about $\frac{2}{3}$ "A."

The leading block of the lifting tackle should be lashed on the standing spar below the jib and the leading block of the connecting tackle, just above the jib, both on the side to which it is required to swing the jib.

If it be required to swing the jib to both sides, alternative leading blocks should be provided both sides of the standing spar.

Struts.—The standing spar is supported by two struts, each about "A" in length.

The standing spar and struts are lashed with a gyn lashing and erected in a similar manner, so that the standing spar is vertical and the struts, in plan at an angle of about 90°, placed symmetrically with regard to the edge of the wharf, etc. (*Fig.* 6).

The struts should be butted well back to a plank abutment and picketed down (*Fig.* 7).

Guys.—Three or two may be employed.

(*a*). If three, one should be in plan at right angles to the edge of the wharf, and the two inside ones should make an angle of about 20° with the edge.

(*b*). If two, they should be above the struts in plan.

In any case, the slope of the guys should be the normal 1 in 2. Each guy should be made of wire rope if possible to avoid undue stretching, which would let the standing spar lean forward and the struts come away from their abutments.

It is also desirable, particularly if cordage is used, to put a small tackle on each guy for tautening purposes.

Holdfasts are required for each guy and it is also convenient to provide one for the running end of each tackle (*Figs.* 8 and 9).

(iv.). *Stresses in Derricks, etc.*—The following table gives the greatest stress in terms of the weight to be lifted on all members of derricks, etc. These results include an allowance for converting a live load to its equivalent dead load. In the case of the swinging derrick, the stresses are calculated on the assumption that its proportions are as given in (iii.) above.

Lifting Tackle in all cases	...	1·6 W.
Derrick.—Spar	...	2·3 W.
	Guy (that takes weight)...	·8 W.
Sheers.—Spar with leading block of tackle...	...	1·3 W.
	Other spar ...	1·0 W.
	Guy (that takes weight) ...	·9 W.
Gyn.—Spar with leading block	...	·9 W.
	Other spars ...	·6 W.
Swinging Derrick.—Jib	...	2·8 W.
	Upright spar ...	3·5 W.
	Strut ...	2·5 W.
	Connecting tackle ...	3·0 W.
	Guy ...	2·8 W.

III. Bridging.

(i.). *Framed Trestle of Round Spars with Trenail Fastenings.*—*Figs.* 10 and 11 show a very serviceable trestle of this nature, which has been tried on service and on training. The details are sufficiently shown by the figures. A carpenter can fit together one of these trestles in about three hours.

(ii.). *Trenails.*—A method of making trenails from green timber by means of a die plate. The die plate consisted of a $\frac{5}{8}''$ iron plate screwed to an elm block. The die hole in the plate was $1\frac{1}{8}''$, while the block was bored with a $2''$ auger. The plate was so fixed that the holes in plate and block were concentric. The block should be $6''$ thick and the plate should be very securely fastened, or it will soon work loose. An oak tree was felled and cut into $18''$ lengths. Each length was cleft with the grain into triangular pieces by means of a felling axe and a maul. Each triangular piece was roughly whittled to size with a hand axe, and then driven through the plate. The hole in the block acted as a guide and a straight trenail resulted. The diameter of the trenail was slightly greater than the diameter of the plate hole, due to the slight expansion of the green wood, after passage through the plate.

It was found that short strokes with a heavy maul were more effectual than full strokes with a light fascine mallet. The latter caused a great deal of brooming in the head of the nail.

The plate was made by a blacksmith in 25 minutes.

After cutting and trimming it was found that four men (two at the plate and two whittling) could produce 13 sound straight trenails in 30 minutes. At the same time it was found that two men whittling could not work quite fast enough to feed the men at the plate; and the rate of output would be accelerated if three men whittled. The rough whittled pieces should be $6''$ longer than the desired trenail to allow of the broomed ends being cut off. The die plate should be at such a height above the ground that the trenail when driven through the plate can fall clear.

(iii.). *Comparative Trials of placing Trestles in Water.*—The methods tried were :—

(*a*). From bridge head by means of ways.
(*b*). By the Belgian method (see *Fig.* 12).
(*c*). By using a swinging derrick on a raft.
(*d*). By floating to site and up-ending by ropes.

The conclusions arrived at were that (*a*) and (*d*) were possible in sluggish streams only, that (*b*) was a slow method at first but when men got used to it, it was as good as any, that (*c*) was a very good method being quick and accurate.

For rapid work in a long bridge it will be best to work from both sides, if possible, and also to put in one or two 4-legged trestles in mid-stream and work from these as well by the method (*c*).

(iv.).—*Placing Trestles by Means of a Distance Frame.*—An adaptation of this method, whereby only one footrope is required, is shown on *Fig.* 13, which explains itself.

(v.). In these days a very important question is the passage of mechanical transport over bridges. *Fig.* 14 shows an arrangement whereby the present pontoon equipment can take the service lorries and tractors. In this the pontoons are placed at half intervals, *i.e.* 7′ 6″ and the baulks break joint. Altogether 14 baulks are used, five being grouped under each wheel track. No extra equipment is required except 14 half baulks per bridge and some means of keeping the ribands in place. These are used as wheel guides a few inches outside the wheel tracks, their attachment to the roadway should *not* be rigid. The attachment shown seems to act well. The ends of the chesses should be laced down. This bridge will take vehicles of 5 tons on rear axle and 2½ on front with a wheel base of 7½′. It has been tested by a vehicle weighing 10 tons, 6½ on rear axle and 3½ on front.

It will be observed that the waterway is below textbook requirements. These are however laid down too rigidly and the bridge as made will probably stand a current of 4 miles per hour.

(vi.). *Light Cantilever Bridge.*—*Fig.* 15 shows a light bridge of this type, all the joints being lashed. The upright frames and the inclined frames below the roadway were braced diagonally.

(vii.). *Light Cask Bridge.*—In order to economize lashings the method shown on *Fig.* 16 was used with success with some short piers.

(viii.). *Cask Footbridge.*—*Manual of Field Engineering, Plate* 49. Information derived from two independent sources shows that this bridge is formed more easily if the ends of the chesses come over the casks, instead of as shown on the plate.

(ix.). In many places bamboo poles are available for bridging and other purposes. The Chinese use lengths of the outside fibre of the bamboo as lashings and figures are available as to the strength of these fastenings. They are finished off by twisting the two ends together close against the pole and jamming them between one set of returns and the pole. The following table gives the strengths :—

Nature of Test.	Breaking Strain in cwts. Lashings made by Sappers.	Breaking Strain in cwts. Lashings made by Chinese Bamboo Workers.
1. Single lashing 4 turns	4⅞—5	6
2. Double „ 4 „	Rather over 5	8¾
3. Two single lashings crossed	8¼	10½
4. Two double „ „	—	19
5. Single lashing 8 turns, 3 frapping turns	—	8½
6. Double „ „ „	—	15

The work is hard in the hands of untrained men and in the case of 2, 4, and 6 it is difficult to get the double lashings made evenly. Care must be taken not to cut the hands with the edges of the fibre.

The lashings should be well soaked before use. They will not last longer than three or four months.

(x.). *Ramp for Embarking Guns, etc.*—*Fig.* 17 shows a seesaw for embarking vehicles of all kinds. This has the advantage of saving time and of allowing the end of the ramp to be put well on to the raft.

(xi.). *Trussed Chesses.*—*Figs.* 18 and 19 show methods of forming light footbridges for infantry in single file with trussed chesses. The 30′ span bridge was made by eight men in 45 minutes, materials being at hand.

IV. DEMOLITIONS.

(i.). *High Wire Entanglement.*—The *Manual of Field Engineering*, Section 48, 2, (ii.), (*a*) gives a method of clearing a way through wire entanglement by means of an elongated charge of explosive. It has now been found that the best results by far are obtained by placing the charge on *the top* of the wire. If the explosive is well lashed to the pole, the latter can be easily thrown across the wires. The detonator should be fixed, after the charge is in position, in the end slab nearer the attacker.

(ii.). *Demolition of Arch by Charge under Crown.*—*Military Engineering*, Part IV., *Plate* 33, *Fig.* 3, and *Manual of Field Engineering*, *Plate* 60, *Fig.* 2, show a method of destroying an arch by placing a charge of guncotton under the crown. It should be noted that proper contact can only be obtained rapidly when it is possible to strut the charge from underneath. When this cannot be done the trussing of the board supporting the charge will take at least one or two hours and is a difficult piece of work. The method of trussing shown on the second plate mentioned will not give proper contact in any but the very narrowest bridges.

(iii.). *Demolition of Wire Cables.*—With reference to *Military Engineering*, Part IV., para. 277, it is probable that the best results will be obtained by placing the whole charge concentrated on the top of the cable.

(iv.). A case recently occurred of the failure of a No. 14 fuze in a mine when fired by the service exploder. Subsequent trial proved that the circuit had been broken, pointing to the rupture of the bridge in the fuze. An officer present had a motor-cycle on the spot, and joined the magneto to the circuit. The spark given was sufficient to bridge the gap and the mine fired.

(v.). *Demolition of Box Girder.*—A type of girder not infrequently met with is the box girder. It is possible that the best place in which to place the charge is between the webs but it is often impossible to get at the ends of the girder. In any case the charge could only be placed near an end. It is more likely that the charge will have to be placed on the outside. An example of successful demolition with the charge so placed is given below.

The section of the girder is shown on *Fig.* 20. The charge was calculated in a manner similar to the example given on *Plate* 38, *Military Engineering*, Part IV., except that the portions of top and bottom flange between the webs were taken separately. The charge as calculated came to 20 lbs., actually 21 were used in 24 halves of $1\frac{3}{4}$-lb. slabs. Six halves were placed in each angle as shown on *Fig.* 21, clay being used between the rivet-heads to give a flat surface. The result of the explosion is shown on *Fig.* 22. By a very slight increase in the total amount of guncotton the two charges on each side can be joined. This eliminates two detonators and consequently chances of failure.

This demolition has been repeated several times with success.

V. Siege Works.

(i.). *Construction of Blindage to Parallel in the Close Attack.*—After the parallel had been sapped the blindage was added without exposing the men. Sandbag headers were thrown out in front of the trench, leaving loopholes. On these bags rails, parallel to the trench, were placed by means of sandbag forks. Stout planks were then pushed up, a few at a time, from the bottom of the trench and rested on the rails in front and the natural surface in rear. These formed the roof and on them earth was thrown up over the shoulder.

(ii.). *Sapping.*—With reference to *Military Engineering*, Part II., para. 54, the following rates of progress for deep sap were obtained in various places. In all cases the length of sap was considerable.

(i.). 112′ in 104 hours. (Hard tenacious soil).
(ii.). $1\frac{3}{4}'$ per hour.
(iii.). $1\frac{1}{2}'$ to $2\frac{1}{2}'$ per hour.
(iv.). $2\frac{1}{3}'$ per hour.

(iii.). *Air Spacing in Tamping.*—The following table gives the data of various mines in which air spacing was tried :—

Charge of Gunpowder in lbs.	L.L.R. in feet.	Solid Tamping next to Charge.	Proportion of Air Spacing to Total Tamping.	Number of Air Spaces.	Successful or not.
60	8	$\frac{5}{8}$ L.L.R.	·156	1 of 2′ 6″	Yes
40	Camouflet. Distance to surface 18′.	5′	·350	1 of 3′ 1 of 4′	No
60	about 8	$\frac{3}{5}$ L.L.R.	·207	3 of 2′	Yes
An over-charged mine.	7	$\frac{6}{7}$ L.L.R.	·095	1 of 2′	Yes
50	8	$\frac{1}{2}$ L.L.R.	·272	1 of 3′	No
50	8	L.L.R.	·277	1 of 5′	Yes
50	8	$\frac{3}{4}$ L.L.R.	·333	2 of 3′	Yes
22	6	$\frac{5}{6}$ L.L.R.	·250	1 of 3′	No
Example in	Part IV., *Mil.*	*Eng.* ...	·294	2 of 5′	Yes

It is difficult from these results to deduce accurate rules for the proper amount and situation of air spacing, but there seems some justification for the following :—

If tamping is carefully done air spacing up to $\frac{1}{3}$ of the total amount of tamping may be introduced, provided there is solid tamping next the charge equal to $\frac{3}{4}$ L.L.R.

It still remains to determine whether it is better to have all the air spacing in one length or in several. The former would save time.

VI. ENCAMPMENTS.

(i.). *Washing Benches.*—A good type of washing bench for standing camps is shown on *Fig.* 23.

(ii.). *Huts.*—The thickness of the rafters, given in the table in *Military Engineering*, Part V., p. 25, for the roof of a hut covered with 6" of earth, is insufficient. The figures 3" to 4" should be $4\frac{1}{2}$" to 5".

WORKING PAR

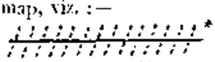
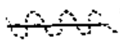
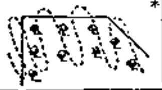
DISTRIBUTION OF WORK AT

Works.—Trenches for :—½ company at **Z**.
½ company at **Y**.
Section at **W**.
Section at **V**.
½ companies in and behind building **S**.

(See map supplied).

Working Party :—2 compa
1 sectio
40 civili

Tools :—Those (

1. Labour. Infantry.	2. Labour. R.E.	3. Where at Work.	4. Nature of Work.	5. Hours at Work.	Wo
½ A Co....	—	Along front, as shown on map, viz. :—  *	Felling hedges..	18. 10. 11. 2.30 p.m.—6.30 p.m.	1 yd. i 10 min
Section A Co.		Behind hedge at **Z** ...	Excavating trench	do.	8' run
Section A Co.	—	Behind fence at **Y** ...	Excavating trench	do.	7' 6" ru
Section B Co.	—	On right flank at **W** ...	Excavating trench	do.	Varie
	—	On road by **W**	Making sangar in road from heap of large stones close at hand.	do.	3' ru
	—	On road at **V** behind hedge	Improving ditch into trench ...	do.	7' 6" ri
½ B Co.	—	Field **T**	Collecting hop poles for wire entanglement.	do.	—
	—	Along front, as shown on map, **P**.	Commence making wire entanglement similar to R.E. sample.	do.	2 yds. 1
Section B Co.	Group.	Farm buildings and demolished houses.	Collecting materials for overhead cover (corrugated iron, planks, bricks, etc.), and distributing behind trenches **Z** and **Y**.	do.	—
—	Group.	In front of **Z**	Making sample of wire entanglement.	do.	2 yds.
—	Squad.	Forsham, Brook House...	Demolishing houses and collecting materials for overhead cover from them.	do.	—
—	Section.	Houses, **S**, in post ...	Loopholing, etc.	18. 10. 11. 7 p.m.—10 p.m.	—
Section A Co.	Squad.	Trenches **Z** and **Y** ...	Making overhead cover ...	19. 10. 11. 6 a.m.—12 noon.	10' ri
Section A Co.	—	On right flank, **R** ...	Felling tall hedge. } Shown thus—  *	do.	—
		On left flank, **Q**	Felling hedges.	do.	—
Section A Co.	—	In post	Improving communications ...	do.	—
Section A Co.	—	Hedges to front and flanks	Cutting 20-yard gaps to prevent unseen approach of enemy.	do.	
B Co. ...	—	As shown on map ...	Making wire entanglement ...	do.	3 yds.
—	Squad.	Houses, **S**.	Loopholing and preparing for defence.	do.	
40 civilians	—	Orchard north of Brook House.	Felling trees and hedges. } Shown like this— * 	do.	20 tr

After noon, infantry cease work. At 1 p.m. civilian party continue felling hedges, etc., and R.E. comp ete
round flanks, communication trenches made up to front trenches, more clearance done, and possibly some dum
Local reserve will cut gaps in the hedges on either side of post and behind it to facilitate their counter-attac

* *Dotted lines show*

'Y TABLE.

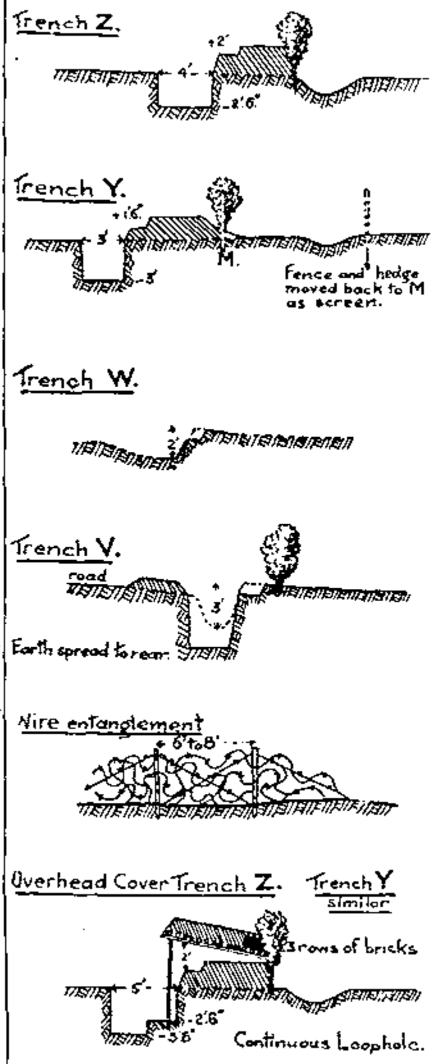
. 7 POST, SPARKS HALL.

ies infantry.
Field Company, R.E.
s on 19. 10. 11.

After work on 18. 10. 11, R.E. must go round Sutton Valence and farms, and obtain the services of 40 men with cutting tools to report at 6 a.m. on 19. 10. 11 at Sparks Hall.

... on spot.

.	7.	8.	9.
Done.	Tools.	Remarks.	Sections.
1100 yds.	With own cutting tools and 12 borrowed from R.E.		
67 yds.	With own tools ...	Traversed on flank.	
60 yds.	With own tools ...	Traversed on flank.	
25 yds.	With own tools and 5 shovels found on spot.	Improving depression 15 yards run, and 10 yards communication trench back to road.	
5 yds.	No tools required.		
25 yds.	With own tools.		
—	No tools required.		
50 yds.	With own tools ...	Picks used as mauls. Wire brought out specially by troops.	
—	With R.E. tools.		
16 yds.	With own tools.		
—	With guncotton.		
—	With own tools ...	By artificial light.	
380'	With R.E. tools.		
220 yds.	With own tools and the 12 borrowed from R.E.		
360 yds.			
—	With own tools.		
—	With own tools.		
300 yds.	With own tools.		
—	With own tools.		
00 trees.	With own tools.		



...or ... n post. Should more time become available, the entanglement should be widened and lengthened ...enches made on either flank.

...nd possibly assist in the defence works of the posts in their sub-section.

...red on Plan.

A PONTOON BRIDGE FOR STEAM TRANSPORT.

By CAPT. W. L. DE M. CAREY, R.E.

SINCE steam power may in future be expected to replace animal draft to some extent in the transport of an army in the field, it has become necessary to design a pontoon bridge capable of carrying greater and more concentrated loads. As the present equipment becomes worn out, it may be better to replace it with a heavier type more suited to these loads, but in the meantime, a design must be found to utilize the pontoon equipment, as now carried in the field, with as little alteration or addition as possible.

To construct a certain length of bridge, it will be necessary to use a great deal more material than hitherto, and consequently a longer time will be necessary. These two considerations bring in a new factor in the design of a heavy bridge, namely, that the ordinary type of bridge shall be convertible into the heavy type with as little labour and interruption of traffic as possible. It is certain that there will often be occasions when the commander of a force will wish to get his troops over a river as quickly as he can, when a bridge has to be constructed under fire, or when extra pontoon equipment has to be brought up from the rear of a column to provide enough for heavy bridge, and it will then be necessary in order to avoid delay to first construct a bridge for the fighting troops and to convert it to a heavier type of bridge afterwards. It follows that whilst one design may be best when a heavy bridge is to be built in the first place another one may be better when a "medium" bridge has to be converted.

DESIGN.

The present heavy bridge with three pontoon sections to a bay of 15′ does not give sufficient buoyancy.

There are four ways possible in arranging the structure of a bridge with four sections to each 15′ namely :—

I. Pontoons at 7′ 6″ centres ; half the baulks arranged to break oint with the other half ; loose or pliable racking.

II. As above but with stiff racking or with all baulks secured to the saddles they rest on.

III. Pontoons at 7′ 6″ centres, baulks not breaking joint, ordinary racking.

IV. Double pontoons at 15′ centres.

The advantages of the several designs are :—

Design I. Distribution of load and consequent limiting of vertical motion.

Design II. Increased distribution of load and a minimum of vertical motion.

Design III. Reduction of stresses in baulks caused by distribution of load. Can be constructed from rafts or from medium bridge.

Design IV. Absence of stresses in baulks caused by distribution of load. Can be constructed from rafts, or medium bridge.

It now remains to investigate the various designs in order to discover which is the most economical of material. In all calculations unless otherwise stated the load assumed is a steam tractor with $2\frac{1}{2}$ tons on the front axle and 5 tons on the rear, having a wheel base of 7′ 6″. Superstructure (double baulks and chesses) is taken as 1,500 lbs. per bay of 7′ 6″ and where a number of baulks has to be assumed for calculation, 14 is taken.

Modulus of rupture for baulks (kaurie pine) 9430. A factor of safety of 2 is given for conversion of moving to dead load, and a further factor of safety of 2 for dead load.

The following notation is used :—

- L. Immersion in inches of a pontoon below normal level of unloaded bridge.
- I. Immersion in inches of a pontoon below its floating level when free.
- B. Buoyancy in lbs. due to immersion L. (500 lbs. to 1″).
- P. Amount in inches a pontoon is raised above normal level of unloaded bridge by any distorting force, *i.e.* a negative L.
- P′. A negative B corresponding to P.
- R. Reaction in lbs.
- D. Deflecting force in lbs.
- Δ. Deflection in inches.
- *a*, *b*, *c*,—... Pontoons in the bridge. These are used in conjunction with the above as :—D*a*—Deflecting force at *a*; B*h* buoyancy of pontoon *h*.
- *ab*, *ef*,—... Baulks.

To minimize work in calculating bending moments and deflection the following table for the strength of one baulk is made up by means of the usual formulæ:—

Position of Load.	Span.	Safe Dead Load. In lbs.	Safe Live Load. In lbs.	Deflection per each 1,000 lbs. Load.	Deflection per each 500 lbs. Load.
1. Centre ...	15′	1886	943	1·68″	—
2. Centre ...	7′ 6″	3143	1571	·21″	—
3. End ...	7′ 6″ one end fixed	943	471	—	1·68
4. End ...	3′ 9″ one end fixed	1571	785	—	·21

It is often convenient in calculating deflection and bending moment to consider the points of load as points of support, and the force B as the deflecting force.

Design I.—There are two positions of the load to be considered.

Case 1.—When the axles are over pontoons (*Fig.* 1 on *Plate*) the pontoons b, c, d will sink evenly under the load over c and as the load taken by a ($\frac{1}{2}$ of 5600) is less than that taken by each of the former ($\frac{1}{3}\{11200+\frac{5600}{2}\}$), the baulk ac will rise clear of the pontoon b, as shown in *Fig.* 1.

To find the strain on the baulks, superstructure and deflection must be taken into account. Considering the baulks bd the concentrated load at c

$$=\underset{\text{(Tractor)}}{11200+\frac{5600}{2}}+\underset{\frac{1}{2}(ac+ce)}{3000\times\frac{3}{4}}+\underset{(\text{equivalent of } bd)}{\frac{3000}{4}\times\frac{1}{2}}$$

$$=14000 \text{ live load}+2625 \text{ dead load.}$$

$$3\ \mathrm{I}b+\Delta=\frac{\text{total load on } bd}{500}=\frac{17000}{500}=34.$$

From the table if there are 10 baulks in bd,

$$\Delta=\frac{\mathrm{I}b}{10}\times 1{\cdot}68,$$

whence $\mathrm{I}b=10\tfrac{3}{4}''$, $\Delta=1\tfrac{3}{4}''$.

∴ $\mathrm{I}c=12\tfrac{1}{2}''$ and c takes 6250 lbs. load.

The remaining load on bd at c is 8625 live load + 1750 dead.

From the table the number of baulks required is

$$\frac{8625}{943}+\frac{1750}{1886}=10.$$

∴ 20 baulks are required throughout the bridge.

In this case, the adjacent portions of the bridge cannot relieve *bd* of its stresses, neither can there be set up in them a strain as great. They may therefore be left out of calculations for maximum stress.

Case 2.—When the axles are between pontoons. The proof of this case is long and as the maximum stress in any baulk does not exceed that in Case 1, it is not included here. The positions of pontoons will be as in *Fig. 2*. The maximum immersion (I) is $13\frac{1}{2}''$.

Design II.—If the bridge is considered as stiffly racked the strains tending to deflect the bridge from the horizontal are borne only by the ribands and the baulks they are lashed to. It is therefore better to consider all baulks as secured rigidly to the saddles over which they pass.

Consider a portion of the bridge as in *Fig. 3* under two equal loads of 8,400 lbs. each. It is evident that there must be a point of contraflexure between *d* and *i* and therefore there must be a force acting downwards between *g* and *i*, that is, pontoons *h* and *i*, at least, must be above their normal level.

Then $\quad \mathrm{L}d - \mathrm{L}e = \Delta e$ of $d'e$ .... 1.

$\mathrm{L}e - \mathrm{L}f = \Delta e + \Delta f$ approximately ... 2.

$\mathrm{L}f - \mathrm{L}g = \Delta e + \Delta f + \Delta g$ " ... 3.

$\mathrm{L}g + \mathrm{P}h = \Delta e + \Delta f + \Delta g - \Delta h$ " ... 4.

$\mathrm{P}i - \mathrm{P}h = \Delta e + \Delta f + \Delta g - \Delta h - \Delta i$ " ... 5.

The deflecting forces can be found by calculating the forces acting on each set of baulks as shown in *Fig. 3*. The weight of the superstructure may be neglected in determining the levels of the various pontoons, as it has an even effect on all. From the table, line 3

$$\Delta = \frac{\mathrm{D}}{7} \times 1{\cdot}68 = {\cdot}24\mathrm{D} = \frac{\mathrm{D}''}{4} \text{ approx.}$$

when D is expressed in inches of immersion.

Subtracting equation 2 from 1

$$\mathrm{L}d - 2\mathrm{L}e + \mathrm{L}f = -\Delta f = -\tfrac{1}{4}\,(\mathrm{L}f + 2\mathrm{L}g - 3\mathrm{P}h - 4\mathrm{P}i).$$

From equation 1

$$\mathrm{L}d - \mathrm{L}e = \tfrac{1}{4}\,(\mathrm{L}e + 2\mathrm{L}f + 3\mathrm{L}g - 4\mathrm{P}h - 5\mathrm{P}i).$$

L*d* can be eliminated from these two equations. In turn L*e*, L*f*, L*g*, can be eliminated and an equation $\mathrm{P}h = \frac{43}{480}\,\mathrm{P}i$ is obtained.

By substitution, values of other unknowns in terms of Pi are :

$$\mathrm{L}g = 1\tfrac{20}{480}\,\mathrm{P}i\,;\quad \mathrm{L}f = 2\tfrac{3}{4}\,\mathrm{P}i.$$

$$\mathrm{L}e = 5\,\mathrm{P}i\,;\quad \mathrm{L}d = 7\,\mathrm{P}i.$$

Consider the part of the bridge under the load (e to e'). The resultants on pontoons d and d' must be equivalent to the loads on those pontoons.

$$\therefore \qquad 16800 - \mathrm{L}d - \mathrm{L}d' = 2\mathrm{D}e + 2\mathrm{D}e' - \mathrm{D}e - \mathrm{D}e' - \mathrm{D}f - \mathrm{D}f'.$$

Since the loads are equal $d = d'$, $e = e'$, $f = f'$.

$$\therefore \qquad 8400 - \mathrm{L}d = \mathrm{D}e - \mathrm{D}f \text{ whence } \mathrm{P}i = 1{\cdot}15''.$$

$$\therefore \qquad \mathrm{P}h = {\cdot}1'' \quad \mathrm{L}g = 1{\cdot}2'' \quad \mathrm{L}f = 3{\cdot}15'' \quad \mathrm{L}e = 5{\cdot}7'' \quad \mathrm{L}d = 8{\cdot}0''.$$

Then De = 4750 lbs. and the number of baulks required to take this strain is $\frac{4750}{470} = 10$.

∴ 20 baulks are required throughout the bridge. (With unequal loads this would be increased).

Design III.—With this arrangement, when the heavier load is over a pontoon on which are the ends of two sets of baulks, the immersion of this pontoon will be too great for safety and it is necessary therefore to add a device to distribute more of the load to the adjacent pontoons *after the former has sunk a certain amount below them.* The different methods of doing this will be discussed later. It is now assumed that tie-baulks (*Fig.* 4) are secured to the pontoon c, so that after c has sunk 7″ they will bear on b and d.

There are four positions of the load to be considered.

Case 1.—The loads as in *Fig.* 4.

In determining the positions taken up by the pontoons, the weight of the superstructure may be neglected as having an even effect on all, and to simplify calculation deflection is neglected at first and corrected for afterwards.

Let 2T be the tension on the fastening of the tie-baulks to c. Then T is the pressure of the tie-baulks on b and d.

Consider the equilibrium of eg

$$\mathrm{R}e = \mathrm{B}g \qquad 2\,\mathrm{B}g + \mathrm{B}f = 0$$

as eg is a straight line $\qquad 2\mathrm{B}f = \mathrm{B}e + \mathrm{B}g.$

Whence $\qquad \mathrm{R}e = -\tfrac{1}{3}\mathrm{B}e.$

Similarly Ra (from a bay to the left of a) $= -\tfrac{1}{3}\mathrm{B}a$.

Consider the baulks *ac* and *ce*.

$$2Ra+2Ba+Bb=T \quad \ldots\ldots\ldots\ldots \quad 1.$$

$$2Re+2Be+Bd=T+5600 \quad \ldots\ldots\ldots\ldots \quad 2.$$

As *ac* and *ce* are straight lines.

$$2Bb=Ba+Bc \quad \ldots\ldots\ldots\ldots \quad (3).$$

$$2Bd=Bc+Be \quad \ldots\ldots\ldots\ldots \quad (4).$$

As the tie-baulks are 7″ from *c*.

$$\tfrac{1}{500}(Bc-Bb+Bc-Bd)=2\times 7 \ldots\ldots\ldots\ldots \quad (5).$$

As the load is equal to the utilized buoyancy of all the pontoons

$$Ra+Ba+Bb+Bc+Bd+Be+Re=16800 \quad \ldots\ldots \quad (6).$$

The result of these equations in the four cases are given below.

Case 2.—When the loads are as in *Fig.* 5.

In this case the tie-baulks will not lock and they are omitted from the calculation.

Case 3.—As for Case 1, but the positions of the loads interchanged. In this case T works out at a small negative quantity showing that the tie-baulks do not quite lock.

Case 4.—When the loads are as in *Fig.* 6.

Pontoon.	Case 1.		Case 2.		Case 3.		Case 4.	
	B.	L.	B.	L.	B.	L.	B.	L.
a	−447	−1	−1223	−2½	−1412	−3	34	0
b	3535	7	2443	5	3053	6	3775	7½
c	7518	15	6108	12½	7518	15	7516	15
d	4501	9	4941	10	4984	10	4258	8½
e	1484	3	3774	7½	2450	5″	1000	2″
	T = 2,460 lbs.				T = −350		T = 1057	

The greatest *total* immersion of any pontoon will be 15″+6″=21″ leaving a freeboard of 8″. This latter can be increased by decreasing the clearance of the tie-baulks, but in so doing the strain on them will be increased.

The baulks in greatest stress in each case are *ce*.

Case 1.—Moment of deflecting force at *c* is

$(Bc+Rc)\ 7'\ 6'' = \frac{6}{5}\ 1484 \times 7'\ 6''.$

Case 2.—Moment of deflecting force at *c* is

$(Bc+Rc)\ 3'\ 9'' = \frac{6}{5}\ 6108 \times 3'\ 9''.$

Case 3.—Moment of deflecting force at *e* is

$(Be+Re)\ 7'\ 6'' = \frac{6}{5}\ 2450 \times 7'\ 6''.$

Case 4.—Moment of deflecting force at *c* is

Resultant at $c \times 3'\ 9'' = (11200 + T - Bd - Be)\ 3'\ 9'' = 7000 \times 3'\ 9''.$

From the table it is seen that Case 2 gives the greatest stress. Allowing for superstructure, the number of baulks required

$$= \frac{6}{5} \cdot \frac{6108}{785} + \frac{1}{2} \cdot \frac{1500}{3143} = 9\cdot5.$$

The deflection due to the stress in each case is respectively ·6″, ·3″, 1″, ·3″. In all except Case 3 the effect on the relative positions of the pontoons and stresses in the baulks is negligible. In Case 3 there is a deflection of 1″, causing *d* to take $\frac{2}{3}$ 500 lbs. more load and *c* and *e* each $\frac{500}{3}$ lbs. less and thus reducing slightly the stress in *ce*.

The number of baulks to bear the weight of one hind wheel in the centre of a span is $\frac{5600}{1571} = 3\cdot5$; if three baulks are placed together under each wheel track the balance of the strain may be assumed as communicated to adjacent baulks by chesses. The number of tie-baulks required will be $\frac{2460}{471} = 5\cdot2$ or, if they are secured over the gunwales, $\frac{2}{3} \times 5\cdot2 = 3\cdot5$. The deflection of the tie-baulks in the latter case will be $\frac{2460}{500} \times \frac{1\cdot68}{4} \times \frac{8}{27} = \cdot6''$, and they must therefore be fixed just over 6″ clear of the gunwales. In the former case the deflection will be 1·4 and they must be secured $5\frac{1}{2}''$ clear.

Design IV.—The greatest immersion (I) will be when the heavier load is over a pontoon and will then be 17″.

The strain on the outside pontoon-sections tending to force them upwards will be 4250 lbs. each. The difficulty of arranging baulks to efficiently take this strain renders this design impracticable.

The number of baulks required for the superstructure is 15.

COMPARISON OF DESIGNS FOR LOAD OF A TRACTOR ONLY.

Design I.—Requires 20 baulks but reduces the maximum total immersion to $16\frac{1}{2}''$ leaving a freeboard of $12\frac{1}{2}''$.

In practice, racking would not be very loose, and a type of bridge would result intermediate to Designs I. and II.

Design II.—(In the case of two equal loads of 8,400 lbs. each) requires 20 baulks with metal fastenings to secure them to the saddles and reduces the total immersion to 14".

Design III.—Can be constructed with 14 baulks (or ribands) *i.e.* with baulks in proportion to pontoons as now carried, but the greatest immersion is 21" leaving a freeboard of 8". By decreasing the clearance of the tie-baulks and increasing their number, this immersion may be decreased and still leave a saving in material compared with Designs I. and II. Also a medium bridge can be converted to this design of heavy bridge.

Design IV.—Is impracticable, but might be suitable for a new equipment of a heavier type.

In a following number of the *Journal*, the effect on the bridge of a tractor drawing loaded trucks will be considered, and also some practical points of construction.

*SUPPLY OF EXPLOSIVE STORES IN THE FIELD.**

By Capt. N. W. Webber, R.E.

The pamphlet *A Study of the Rôle of Engineers in the Field*, by Lieut.-Colonel Klein, translated by Colonel J. E. Edmonds, R.E., brings to light a question which is at present rather obscure, viz. :— the question of a reserve of explosives for Engineer field units.

In a British Division all the explosive stores available are carried in the first line vehicles of the field companies; there is no reserve with the Divisional Ammunition Column, and apparently the nearest point at which a fresh supply can be obtained is the Ordnance Depôt at the Advanced Base. This means that it will be no easy matter for a Field Company to quickly replenish its explosive stores.

In the French Army, a different system obtains.

In addition to the explosives carried in the wagons of the Field companies, a certain amount is carried in the infantry section of the Divisional Ammunition Columns. Behind these is the Army Corps Engineer Park with reserve explosive stores for the two divisions of the corps, and behind that again, an army park with a further reserve for the group of corps composing the army.

In the German Army a somewhat similar system to that of the French exists. An explosive wagon to cover the expenditure of explosives in the Field Companies, accompanies the Bridging Train of each corps.

There are two points to be considered in discussing the question :—

(i.). Under what circumstances will it be necessary for a Field company to replace its explosives quickly ? and,

(ii.). How are fresh explosives to be obtained ?

As regards (i.) it is not difficult to imagine circumstances.

Consider the case of a division taking up a position with a river running across the front. Only a day is available for preparation of the position. There will be a great demand for explosives; certain bridges must be demolished; others mined ready for demolition if necessary. Buildings in the defended localities which are not required for the defence, or which interfere with the field of fire, must be removed, etc. By the end of the day, the Field Companies would find their stock of explosives considerably reduced.

* It is understood that this subject is now under consideration at the W.O.

The enemy are expected to attack next day; the Field Companies will be required to accompany the counter-attack, to assist it when it reaches the supporting points which the enemy's sappers will have strengthened, in rear of their own attack. Explosives will be required, and in large quantities too, as Lieut.-Colonel Klein clearly points out on page 159 of his pamphlet. If the companies have not been able to replenish their expenditure of the previous day, they will soon find all their explosives used up.

In the case of a force retreating and destroying the communications in its rear, a still greater amount of explosives would be required, and it would be even more necessary to have a reserve in close proximity to the Field Companies with the advanced guard, who would have to prepare the different bridges, etc., for demolition.

As regards (ii.) *Field Service Regulations*, Part II., para. 52 (1), lays down that Engineer stores will be replenished by indenting on the Ordnance Depôt. But this depôt is not with the fighting troops, but probably at least two or three marches in rear, and it is unlikely that, on the eve of an action, when the ammunition supply would monopolize a large share of attention, any transport could be spared to bring up explosives.

The solution of the problem appears to be that explosives should be recognized as the Sappers' ammunition, and as such should be given a definite place in the arrangements for ammunition supply.

The French have already done this, by including a wagon for explosives in the infantry section of the Divisional Ammunition Column, and it would seem to be advisable to follow their example. The Field Companies would not then be chary of using explosives, as they may well be under the present system, as they would know that reserve supplies were within easy reach; and it would rest with the Officer Commanding Divisional Ammunition Column to ensure that supplies were forthcoming, and not with the Commanding Royal Engineer, who has plenty of other work to do.

Although this question has been considered chiefly from the point of view of Field Companies with the Infantry Divisions, it applies even more forcibly to Field Troops with the Cavalry Division, as they would still be further away from a reserve supply, unless it is carried in the Cavalry Ammunition Column.

It may be argued, that a reserve in close proximity to the fighting troops, is unnecessary for us as our units carry more explosives than French engineer units, but that is not the point. The reserve in the front line need not be large, but the machinery for rapidly replacing expended stores, is what is required.

MAP PROJECTIONS IN ACTUAL USE.

By ARTHUR R. HINKS, M.A., Chief Assistant, Cambridge Observatory.

THE subject of Map Projections has suffered as well as gained by the fact that it has interested many mathematicians. The mathematician has evolved projections that are of the highest theoretical interest and very little practical importance, while some of the comparatively few projections that are really in use are of so little mathematical interest that they receive scant treatment in textbooks, and their real value is almost ignored.

The first is especially true of the class of projections termed orthomorphic. It is so evidently desirable that a map should be the right shape, that one would naturally suppose that a projection of the orthomorphic family must have at any rate some considerable merits as a projection for actual use; yet it is hardly too much to say that the whole family might be thrown into the sea without much loss to the maker of land maps; while if this were done the hydrographer would trouble himself to rescue only one—the invaluable Mercator.

In a School of Military Engineering whose textbook in use contains an excellent though all too brief account of some thirty principal projections, it is almost superfluous to recall to your attention the elementary facts of the subject; but perhaps you will allow me to do so very briefly.

Firstly, a map projection is not necessarily, or even usually, what the mathematician calls a projection: it is not usually a perspective projection such as may be thought of very conveniently as if it were formed by casting on a plane surface the shadow of the meridians and the parallels of latitude from a point source of light. These perspective projections are interesting, and very occasionally useful for special atlas maps, but they are of no great importance, and we shall not consider them further.

The real definition of a map projection is: Any orderly method of constructing the meridians and parallels upon a flat sheet. Among the infinity of such orderly methods we must seek those that have some valuable properties in addition to mere orderliness.

These valuable properties are of several kinds.

1. Accuracy of scale along the meridians or parallels. It is impossible that both can be correct all over the map, for an ellipsoidal surface cannot be transferred to a plane without stretching it in one direction or another. But a map may be, for example, correct in scale

along all the meridians and along one or two parallels; or it may be correct in scale along all the parallels and along one or two meridians selected at pleasure. These are valuable properties, for distances measured on such a map will be more or less correct.

2. Accuracy in the representation of areas. Many projections are truly "equal area": that is to say, areas are represented correctly all over the map. But the shapes and the distances are more or less wrong. Such maps are used for statistical purposes, but for general use we may find that the equal area property has been too dearly bought.

3. Accuracy in the representation of shape. This is not at all the same thing as orthomorphism in its technical sense. Real orthomorphism being impossible, because a plane surface cannot be made to fit an ellipsoidal surface, the mathematician has been content perforce to deal with the very diluted idea of right shape representation implied in the condition that *infinitesimal* areas shall be represented in their correct shapes. How artificial this definition and convention are may be seen at a glance. Compare the shape of Greenland, as represented on Mercator's projection, which is orthomorphic in the mathematical sense, with its shape on a globe, and you will see the wisdom of veiling misrepresentations by a decent use of the Greek language.

4. Accuracy in the representation of direction or bearing, to which we may add, ease of determining the bearing. This latter is a property which usually receives scant notice in the books, yet it is by no means unimportant. It is useful to be able to trace on the map the approximate course between any two points, and this part of the problem, especially the relation between the great circle course to the straight line on the map, usually receives consideration. It is equally useful to be able to take off the map with facility the bearing on which one starts to pursue this course; but the diverse merits in this respect of the various projections have hardly received the attention that they deserve.

5. Facility in construction and drawing. These very important practical considerations are sometimes overlooked in the theoretical treatment of our subject. Yet they may very well be given the preponderating voice in a decision between two nicely balanced claims.

Now in considering the choice of a projection we must bear in mind the great difference between the needs of

(*a*) The sheets of a topographical survey;

(*b*) Atlas or wall maps of a continent or country;

and (*c*) Maps of the whole world.

The dominant factors in these three classes are altogether different, and it is not at all helpful in our consideration of the merits of the polyconic projection, for example, if we contemplate the rather absurd but very frequently seen construction for the whole world on this system. For the whole world it is ridiculous, but for the single sheets of a topographical survey it is almost the best. Since the case of the topographical sheet is the last to be considered in the ordinary book treatment of our subject, and is indeed in spite of its importance sometimes forgotten altogether, we will run no risks in this lecture, but will deal with it first.

In planning the construction of the sheets of a topographical map, we have to decide in the first place, shall all the sheets be made to fit together into a whole? The sheets of the Ordnance Survey will do so, in theory; the sheets of the United States 1/62,500 map will not. In practice the O.S. sheets will not do so either: not because of any theoretical defect, but because of the irregular expansion of the paper. In practice, then, it is sufficient that contiguous sheets shall fit along their margins, and it is now generally considered to be wrong to sacrifice anything to secure a possibility of fit which can never be realized.

Subject to this condition of fit along the margins, each sheet of a topographical series *may be* constructed independently. Shall we aim at orthomorphism, or at equal area representation, or at conservation of true bearing? The answer is easy: Any one of a dozen projections is almost perfect in all these respects so long as we limit our consideration to a single sheet not more than about 4 degrees square. Convenience and ease of construction will then be the dominant consideration. So little difference is there between the different projections that may be used in such a case that it is almost impossible to discover by examining a single topographical sheet on what projection it is constructed. Yet there is one case in which the difference may prove of importance: when it is desired to produce a map on a small scale by direct combination of reductions from the individual sheets on a larger scale. We have possibly an instance of this in the map of Great Britain and Ireland on the scale of 25 miles to the inch. I have often wondered why the meridians and parallels have been taken out of that map? Was it because England is on one projection and Scotland on another? The want of fit along the Border might never be noticed, but the very slight discontinuity in the meridians and parallels might look horrible. So were meridians and parallels taken out, leaving traces of their one-time presence in the curvature of the names of the seas?

The projection originally adopted for the 1-inch map of England—Cassini's—has no special merits, and it is not now employed on any new work, so we will not consider it in detail. The particular use of it in the O.S. maps has one conspicuous demerit, in that while the meridians converge, the sheets remain rectangular, so that as one goes east or west the meridians are more and more inclined to the edges of the sheet. This is an easy source of error in the use of the sheets for such purposes as taking off bearings for night marching, especially since it is stated in many books on military topography that for practical purposes the edges of the sheets may be considered to be N. and S. We may see in such a statement some justification for Disraeli's remark that a practical man is a man who practises the errors of his forefathers.

Modern topographical sheets are most often constructed on some form of the conical or polyconic projection, and we may spend a minute in considering the theory of these. If a cone is made to touch the globe along a parallel of latitude its surface in the neighbourhood of the parallel in question very nearly coincides with the zone of the globe, and we can make a very good projection for the representation of that zone by dividing the parallel of contact as it is divided on the globe, joining these points to the vertex of the cone to make the meridians, and drawing the other parallels, N. and S. of the parallel of contact as circles struck from the same centre, the vertex of the cone, and spaced their true distances apart. This is the simple conical projection. It is perfect in the neighbourhood of the "standard parallel" of contact, and deteriorates N. and S. because while the scale along the meridians remains everywhere correct, the scale along the parallels becomes increasingly too large. It has the considerable advantage that the meridians are straight lines.

Now let us introduce a slight modification. Instead of making all the parallels concentric circles let us construct each parallel as if it were the standard parallel for a cone tangent in that latitude. Then each parallel of our graticule is a circle as before, and the centre of each circle lies on the central meridian, but each at a different point of it. Each of these parallels is then divided truly and the meridians are curves passing through the points of division of the parallels. Such a construction has no merit for a projection of a large part of the globe, and as we have seen the figure by which it is commonly illustrated in the books serves to show this very well, while concealing the real use of the polyconic projection. For a small sheet of one or two degrees each way the meridians are so nearly straight that their curvature can scarcely if at all be detected; the parallels are so nearly concentric circles that the scale along all the meridians is correct within the possibilities of drawing. And moreover, short and convenient tables can be calculated once for all, so that any sheet may be constructed without further calculation. Such tables are those published by the United States Coast and Geodetic Survey, and the tables for sheets on the scales of 1/250,000 and 1/125,000 published by the Geographical Section of the General Staff as Appendix XI. to the *Textbook of Topographical Surveying*. For sheets on these scales nothing more can be desired; the problem is solved once for all; and it does not appear that anything is to be gained by departing from this simple uniform procedure. The Austrian General Staff map of Central Europe is constructed on Albers' conical equal area projection with two standard parallels; this requires that on most of the sheets the scale along the meridians and parallels is wrong, though indeed by small amounts. Theoretically all the sheets fit together, and this will be convenient in preparing reductions. But it is doubtful if this gain is enough to balance the loss in exactness of scale in the individual sheets.

To complete our account of the projections in use for the sheets of a topographical survey we must mention two others:—Bonne's, and the polyhedric.

Bonne's projection is the well-known modification of the simple conic. First constructing the latter with a suitable standard parallel, we then divide *all* the parallels truly, and pass curves through the sets of corresponding points to form the meridians. This is easy to construct, and it has the advantage of being equal area, but the disadvantage of having curved meridians. It has in the past been widely used both for topographical and for atlas maps: more widely perhaps than its merits warrant. In the new French 1/50,000 map they have discarded Bonne and adopted the polyconic.

The polyhedric projection is of little interest. Take on the spheroid the four points that are to be the corners of a sheet, and pass a plane through them. Let fall perpendiculars from each point of the spheroid on to this plane, and we have the projection. In theory it is inferior to the polyconic; in practice it is for a single sheet, or for an aggregate of a few sheets, indistinguishable from it. Adjacent sheets fit along the edges, but it is not possible to combine a large number of sheets into one.

I am indebted to Colonel Close for the following list of projections used in the topographical sheets of European surveys; the list was compiled in the Geographical Section of the General Staff; and Colonel Hedley has very kindly within the last few days given me one or two additions to it.

PROJECTIONS EMPLOYED ON TOPOGRAPHICAL MAPS.

Austria-Hungary ...	1/75,000. Polyhedric. 1/750,000. Old edition. Bonne. New edition. Albers' conical equal area.
Belgium	1/20,000 and reductions. Bonne.
Denmark	1/20,000. Old map. Bonne. 1/40,000. Jutland. A modified conical. All recent Staff maps simple conic with standard parallel 56° N.

Egypt ...	...	Conical orthomorphic.
France ...	...	1/80,000
	and	1/200,000. Bonne.
		1/100,000. Polyhedric.
		1/50,000. New map. Polyconic.
Germany ...	...	1/25,000 and reductions. Polyhedric.
Italy ...	...	1/100,000. * "Polycentric or natural" (? polyhedric).
		1/500,000. Bonne.
Netherlands	...	1/25,000. Bonne.
Norway ...	...	1/100,000. * "Crescent or increasing conic" (? conic with 2 st. parallels).
Russia ...	...	1/126,000. Bonne.
		1/420,000. Conical orthomorphic.
Spain ...	...	1/50,000. Probably polyhedric.
		1/200,000. Bonne.
Sweden ...	...	1/100,000. See Norway.
Switzerland	...	1/25,000
	and	1/50,000. Bonne.
United Kingdom—		
England	...	1/2,500, 1/10,560, 1/63,360, 1/126,720, 1/253,440. Cassini.
		1/633,600. Airy's projection by Balance of Errors.
Scotland and Ireland	...	1/63,360 and smaller. Bonne.

This list is very instructive. The very general use of Bonne's projection is high testimony to the great influence of the Depôt de la Guerre, after which the projection is often called. But it is no great testimony to the originality of thought of all those who have followed in the tradition of plotting a whole country as one sheet, and then cutting it up into a topographical series. Such a procedure has an inevitable defect, which makes it objectionable to modern taste in maps: the meridians are not at right angles to the parallels, so that a sheet bounded by meridians and parallels, as all sheets should be, is skewed and ugly in appearance. This is a grave defect which should long ago have banished Bonne's and Cassini's from the list of projections in actual use; and perhaps would have done so were it not for the immense difficulty of discarding a projection when once it has been adopted. When will the Ordnance Survey be able to issue its maps bounded by meridians and parallels? Never, is the probable answer. The change would be too costly.

We must not forget to mention the new international map on the

* Official descriptions.

scale of 1/1,000,000, with sheets covering four degrees of latitude and six of longitude. In principle the projection is polyconic, but some interesting modifications are introduced.

1. The top and bottom parallels are constructed as standard, and truly divided; the meridians are straight lines joining up these points of division.

2. But the distance between the parallels is slightly modified; the parallels are brought together by a small amount, so that the length of the central meridian is a little small, and the meridians two degrees on each side of the centre are now of the true length. The correction required to do this is very slight, amounting to only 0·01 in. at the most, and the consequent gain is therefore almost too small to be measured on the sheet; but it has an elegance which will commend it to all connoisseurs of the subject.

3. It is not laid down how the meridians are to be divided, but it may be supposed that they are divided equally.

We will now consider atlas maps, in which the range of choice and the difficulties of representation are much greater.

Take first the conical projection that we have already discussed—the so-called simple conic.

One selected parallel of latitude ϕ_0 was represented by an arc of a circle, of such length that the parallel was truly to the chosen scale; the radius of the arc was equal to the length of the tangent drawn from a point on the polar axis of the earth, to touch the earth at the selected parallel, $= R \cot \phi_0$. The other parallels were concentric arcs at their true distances from the standard parallel. The complete standard parallel subtends at the vertex, the common centre, an angle $360^\circ \times \sin \phi_0$, and the angle between any two meridians is, in the same way, the difference of longitude $\times \sin \phi_0$.

We have seen that the defect of this projection is that the scale along the parallels north and south becomes more and more too great. How can this defect be remedied?

Keeping the one parallel as standard we have at our disposal the spacing of the other parallels and the angle at the vertex, or the inclination of the meridians one to another.

If we were to decide to retain the angle at the vertex unchanged, it is evident that by bringing together the parallels we could produce an equal area projection—the criterion for equal representation of areas being that the scale along the parallel shall be inversely proportional to the scale along the meridian. Or, on the other hand, by suitably spacing out the parallels we could render the projection orthomorphic, in the sense that the scale along the parallel should be the same as the scale along the meridian at any point. These would be possible ways of transforming the simple conic into an equal area or an orthomorphic conical projection, but they are not the best ways;

and I have mentioned them only because one might unwittingly get from the books the erroneous impression that the better constructions or solutions of the problem are the only ones.

We do much better if we allow ourselves to modify the angle at the vertex as well as the spacing of the parallels.

It is shown in all the books that we have an equal area conical projection if we construct our concentric parallels by the following law:—

Radius of the parallel of co-latitude χ_0 is $2\mathrm{R} \tan \frac{1}{2} \chi_0$.
Inclination of the meridians $(\cos^2 \frac{1}{2} \chi_0)\, d\mathrm{L}$.

Or we have an orthomorphic conical projection if

Radius of the parallel of co-latitude χ is $m\,(\tan \frac{1}{2}\chi)^n$

Where $m = \dfrac{\mathrm{R} \sin \chi_0}{n\,(\tan \frac{1}{2} \chi_0)}$

Inclination of the meridians is $n \, . \, d\mathrm{L}$, and is at our disposal.

In both these we have preserved the length of the standard parallel, while altering the spacing of the other parallels and the angle at the vertex.

It does not appear that there can be any proof that these particular laws *give* absolutely the best result obtainable, but these solutions have the merit of being concise and elegant. And they are the solutions universally known as *the* simple conical equal area and *the* simple conical orthomorphic respectively.

Our next step will be to make *two* parallels standard, that is to say, represented of their true length. It is quite evident that we can do this in an infinite number of ways. To define the precise method we have one more condition at our disposal. We might, for example, make the cone pass through the two selected parallels in place upon the spheroid; make it in fact a secant conic. But this is a poor solution, because the distance between the parallels is then the chord instead of the arc of meridian. The true secant conic is a projection without merit. What is only too often called the secant conic, even in the best circles, is not in reality a secant conic at all, as we shall see.

With our extra condition at disposal we may make the selected parallels their true distance apart; or we may make the projection equal area; or we may make it orthomorphic. And we have a still larger range of possibilities at our disposal when we consider that we have not yet specified *which* pair of parallels shall be made standard. To enter upon the refinements which should guide our choice in this would take more time than we have at our disposal to-night. Moreover, I am sure that you are already familiar with the most interesting discussion of a projection for the 1/M map of Great Britain which was published by Colonel Close in an Ordnance Survey pamphlet in 1903.

I think that it is scarcely open to doubt that for a single sheet, regardless of its neighbours, the "Minimum error rectified conical projection with two standard parallels" there described, is the most perfect projection that can be employed. But it has just the slight defect of unneighbourliness; and so I suppose that for the international map, where it is of some importance that all the sheets surrounding shall fit along the edges, the Committee were right to prefer the modified polyconic that they adopted.

It is not a little curious that the remarkable merits of the former projection were not recognized long ago. Beside the maps of Norway and Sweden, which as we have seen above are apparently on this projection, we have only, as far as I can discover, the 1/M map of the British Isles now being superseded by the new sheets on the International plan, and I think some of the Indian sheets. I cannot find a single atlas sheet on this projection, which is above all suitable for atlas maps. We can but conclude that the atlas makers are more conservative than anyone would desire.

It is hardly necessary to give here the formulæ for the various conical projections with two standard parallels; they can be found in the books. Let us remark only that they are unique solutions, for we dispose of the greater part of our freedom of choice in choosing our two standard parallels.

All these conical projections have been considered to have their vertices on the polar axis of the earth: not that this is at all necessary, for it would be just as simple theoretically, though more troublesome in calculation, if we took the cone oblique. To do so, however, is almost absurd; there was no particular objection to having a sector cut out of the polar regions, whose geography is at any rate at present very incomplete; but to produce a map of South America like the one now on the screen* is to have a touching belief in the refined intelligence of the user, who must be prepared to find in the more recondite advantages of the projection some compensation for the very obvious ugliness of the abruptly curved meridians and the missing sector of the Pacific. Oblique conical projections are to be classed as freaks, and dismissed from further consideration in a lecture which professes to confine itself to projections in actual use.

Let us now consider for a moment what will happen if we make our cone flatter and flatter until it degenerates into the tangent plane at the point where the vertex has descended, and the constant of the cone becomes unity. If the point of contact is the pole, then

* Not reproduced. See Hammer: Ueber die geographisch wichtigsten Kartenprojektionen. *Plate* IV.

obviously the meridians on the cone are at their true inclinations one to another, and the parallels are complete circles. And now if the cone is oblique? In this case the generating lines of the cone are still lines of equal and true bearing, and the concentric circles are lines of equal distance from the centre; but they no longer correspond to the meridians and parallels of the sphere. These degenerate, or as Colonel Close prefers to call them, these restricted cones, make the whole class of zenithal or azimuthal projections :—zenithal, because the vertex of the cone has come down from the zenith of the map centre; azimuthal, because it is the common property of all the class that they preserve the true azimuths of all points from the centre.

Or to take the opposite manner of degeneration or restriction, let the vertex of the cone, instead of coming down upon the surface of the spheroid, be removed to infinity. We thus derive the whole class of cylindrical projections, which are, it must be confessed, of comparatively little interest or use.

Without going into further details we will make a table of the projections which correspond to one another in the conical and its derived classes.

Conical.	Zenithal.	Cylindrical.
True meridians and one standard parallel	Equidistant ...	"Plate carrée."
True meridians and two standard parallels...	—	"Plate parallélogrammatique."
Equal area, 1 st. par.	Equal area ...	—
Equal area, 2 st. par.	—	Equal area.
Orthomorphic, 2 st. par.	Stereographic ...	Mercator's.

To this list we must add Bonne's projection, the simple modification of the simple conic constructed by dividing all the parallels truly, and joining up the corresponding points by curves to make the meridians. It is equal area, but the strong curvature of the meridians is in many ways objectionable. When the standard parallel is the equator it is a straight line, and the other parallels are parallel straight lines. This, the Sanson-Flamsteed projection, is very easy to draw, and for certain cases that we shall consider presently is useful.

Now let us look at the way in which these various projections are used in atlases. It is not easy to produce statistics that mean very much, because one finds so often that one or two peculiar projections are used for small and unimportant maps, "just for dandy" as Miss Kingsley's West Africans would have said.

But if we confine our attention to the principal maps of the atlases we can see that the following table fairly covers the ground.

Simple conic with true meridians, or else Bonne, is in general use for single countries, such as Germany or the United States.

Conical orthomorphic is frequently used in Debes' Atlas, but not in others.

Zenithal equidistant, or zenithal equal area, is much used for continents, and so, to a smaller extent, is Bonne.

Sanson-Flamsteed is frequent in maps of Africa and of Polynesia, that is, of equatorial regions.

Now the point that strikes one in reading any of the well-known works on the subject, is that it is extraordinarily hard to discover what are the real working errors of these various projections. There is plenty of mathematical investigation of the errors, and formulæ for the maximum alteration of angles round about a point; but such formulæ are misleading in the same way that the general theory of orthomorphism is misleading, in that they deal only with infinitesimal areas; and if one asks, what is the projection for the map of Europe that gives the most correct representation of the true distance and azimuth of the line Gibraltar—Petersburg, for example, it is impossible to answer the question.

It has seemed to me to be worth while to make some calculations in order to discover what are the magnitudes of the errors that one would be liable to commit, if one were to measure distances and bearings upon atlas maps. The results are still quite incomplete, for though I have had the valued assistance of several pupils,* I have not been able to discuss the results as thoroughly as I should have wished; and it is hard to know exactly how to present our results in a systematic and intelligible shape.

Let us begin by calculating the radii of some of the parallels in various conical projections for the map of Europe. The expressions for these radii are very different in form; it will be instructive to see how much they differ numerically.

Conical Projections. Radii of Parallels for Scale $1/10^8$.

On this Scale Rad. of Earth = 63·66 *mm.* 10° = 11·11 *mm.*

Projection.	Standard Parallel.	N.	Radii of Parallels. 30°	Diff.	50°	Diff.	70°
Simple Conic ...	50°	0·766	75·6	22·2	53·4	22·2	31·2
Conic 2 St. Par. ...	65°, 40°	0·787	73·1	22·2	50·9	22·2	28·7
Con. Equal Area ...	50°	0·883	67·8	21·5	46·3	22·8	23·5
Albers'	65°, 40°	0·775	73·9	22·2	51·7	22·4	29·3
Con. Orthomorphic...	65°, 40°	0·800	72·3	22·3	50·0	22·0	28·0

* I am especially indebted to Mr. F. M. Deighton, B.A., Trinity College, and to Mr. T. W. Glare, B.A., Sidney Sussex College, Cambridge.

Next let us consider the errors in distance and in azimuth of a line from the centre to a corner of the map.

I take the centre in 50° N., 20° E., and consider what are the errors in distance and azimuth to extreme corners up in the north of the Kara Sea, and down at the top of the Persian Gulf.

Errors of Projections. Map of Europe. Centre 50° N. 20° E.

Errors of	Corner 70° N. 65° E. Dist. from Centre.	Az. from Centre.	Area.	Corner 30° N. 50° E. Dist. from Centre.	Az. from Centre.	Area.
	%	°	%	%	°	%
Simple Conic ...	+2	+2·6	+10	+1	+8·5	+5
Con. 2 St. Par.* ...	−2	+2·0	+3	0	−1·5	+4
Con. Eq. Area ...	−1	−2·0	0	0	−5·0	0
Albers'*	+1	+1·3	0	0	−1·2	0
Con. Orthomorph. ...	−1	+1·1	+6	+1	−1·5	+10
Zen. Equidist. ...	0	0·0	+4	0	0·0	+5
Zen. Eq. Area ...	−1	0·0	0	−1	0·0	0
Zen. Orthomorph. ...	+2	0·0	−10	+2	0·0	+15
Bonne	−2	+1·2	0	−2	+0·5	0

* Standard parallels. 65° and 40°.

But Europe is a comparatively small place; let us make a similar table for the map of Asia, and take again the extreme corners, up north of Alaska, and down at Port Denison on the coast of Queensland.

Errors of Projections. Map of Asia. Centre 40° N. 90° E.

Errors of	Corner 70° N. 190° E. Dist. from Centre.	Az. from Centre.	Area.	Corner 20° S. 150° E. Dist. from Centre.	Az. from Centre.	Area.
	%	°	%	%	°	%
Simple Conic ...	+11	+9·8	+26	+5	−12·9	+53
Con. 2 St. Par.* ...	+3	+12·4	+14	−3	−3·7	+27
Con. Eq. Area ...	0	−0·6	0	−3	−24·1	0
Albers'*	+6	+13·2	0	−1	−0·6	0
Con. Orthomorph. ...	0	+10·2	+24	−3	−7·2	+76
Zen. Equidist. ...	0	0·0	+18	0	0·0	+45
Zen. Eq. Area ...	−4	0·0	0	−8	0·0	0
Zen. Orthomorph. ...	+11	0·0	+65	−8	0·0	+208
Bonne	−5	+10·0	0	−12	+6·5	0

* Standard parallels. 63° N. and 2° N.

And since in both these cases the region is entirely or largely on one side of the Equator, take for a third example the map of Africa, with an extreme corner somewhere up near the borders of Afghanistan.

Errors of Projections. Map of Africa. Centre 0° 20° E.

Corner 35° N. 75° E.

Errors of	Dist. from Centre.	Az. from. Centre.	Area.
	%	°	%
Simple Cylindrical	+ 5	+8·6	+22
Cyl. Equal Area	+ 3	+9·7	0
Zen. Equidistant	0	0·0	+22
Zen. Equal Area	− 5	0·0	0
Zen. Orthomorphic	+11	0·0	+85
Sanson-Flamsteed	− 8	+2·7	0
Carke's Perspective... ...	+ 2	0·0	+32

Now these tables require more detailed consideration than we can hope to give them in the few minutes at our disposal; but I think that we can see at once some interesting facts.

For the map of Europe the errors are really not very large, and there is little to choose between the conic with two standard parallels, Albers', the zenithal equal area, and Bonne's.

In the map of Asia the errors are naturally much larger; but again we have the same four projections standing out as the best.

In the map of Africa conical projections are clearly out of place, and the cylindrical are not good substitutes; we are left with the zenithal equal area or with Sanson-Flamsteed.

If one had to make a definite choice of the most generally useful projection for all purposes, I should be inclined to choose the zenithal equal area; with that projection one cannot go far wrong anywhere in the world; it is equally useful for Europe, Asia, or Africa. But we must not overlook the fact that the tables above refer to measures from the centre, in which the zenithal projections have naturally an advantage. The conical on the other hand, have the great point in their favour that their properties are the same right along a given parallel, owing to their straight meridians and concentric parallels, and this may more than compensate for the superiority of the zenithal round about the centre. Moreover, the standard parallels in the above tables and calculations have been selected rather roughly, without any refined examination or attempt to make the errors along the mean and the extreme parallels equal to one another. And further, it is probable that we should lay more stress on the preservation of distances and azimuths than of areas; for it is always a difficult business to measure areas with any exactness, and the necessity for so doing will disappear when Colonel Close publishes his tables of the areas of the 10′ trapeziums, which are now, I believe, in process of computation.

If then we may venture on deducing a general rule, I think it should be: You will be safe with the zenithal equidistant; but if your map does not extend to the Equator you may do better to examine the possibilities of a conical with two standard parallels and with true meridians, or Albers', according to the importance attached to the perfect representation of areas, and to the desirability of having straight meridians.

It is doubtful if other projections are worth considering; one may easily go further and fare worse.

We come now to the most difficult part of the subject: the representation of the whole world on one sheet. We cannot hope to preserve any reasonable representation of distances and azimuths, at least directly. If honesty in the representation of areas is our object, for distribution maps, then we may select Mollweide's, especially Mollweide's in two hemispheres; or the very beautiful transverse Mollweide that appeared as the frontispiece to the first edition of the War Office catalogue of maps; and in the second edition is degraded to a mere ornament of the cover. May I venture to express the hope that such a pretty thing will be restored in the future to a worthy position.

But if we regard a map of the world as, in the first place, a guide to getting about the world, then all the usual projections are hopeless. There is not one that will give with any ease the answer to such a question as: What course will a ship take from the Panama Canal to Yokohama? or, In what direction would a flying man start from London to go straight to Sydney?

I would invite your attention to the merits of the gnomonic projection on the enveloping cube. It has been used with great effect recently in astronomy, and I venture to think that it will be found valuable also in geography.

We note first that the cube does not necessarily touch the sphere at the poles, but that its points of contact may be chosen to suit the requirements of the cartographer. In the small example before us the United States receive the most favoured treatment, at the expense of South America and of Africa. It would be interesting to make some experiments to discover just what arrangement gives the most favourable representation of the principal land surfaces of the world; but I have not had time to do so in preparation for this afternoon's lecture.

The fundamental problem in the use of such a map is to draw the great circle joining any two points. We note that a great circle, that is to say a straight line, drawn on any one face of the cube, may be continued on an adjacent face in a very simple way. Let L, M, N, be the middle points of three consecutive parallel edges, and AB a great circle on one face. If BC is its continuation on the adjacent face, we find C from the consideration that C must be as much above N as A is below L. Hence we have the rule for joining two points (*Fig.* 1).

If the points P and Q are on adjacent faces, find by trial a point S on the common edge, such that the lines SP, SQ, make equal intercepts respectively above and below the middle points of the adjacent parallel edges. This is easily done by trial, but I do not know of any direct construction that will give the point S in a simple way (*Fig. 2*).

If the points P and Q are on opposite faces the solution is still more simple. Find the point P′ opposite P, or the point Q′ opposite Q, and join P′Q or Q′P. This gives part of the required great circle, which may be continued round the cube in the way just explained.

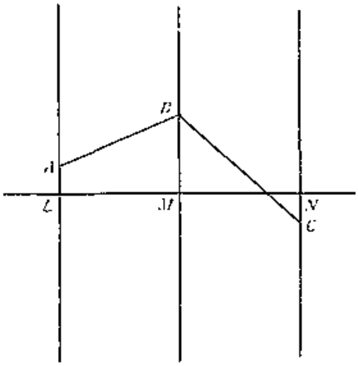


Fig. 1.

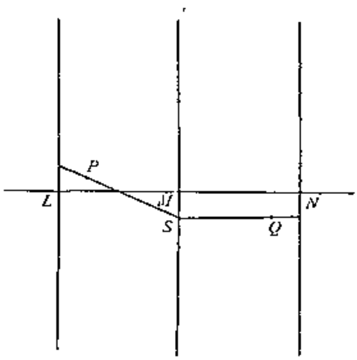


Fig. 2.

The great circle distance may be obtained very easily by means of a scale constructed as follows:—

Let C be the centre of a face of the cube, that is to say, a point of contact with the sphere, and let CM be drawn on the sphere perpendicular to a great circle through a point P. Let c, m, p, be the projections of these points on the cube. Then cm is still perpendicular to pm, and

$$cm = \tan \text{CM}\,; \quad pm = \tan \text{PM} \sec \text{CM}.$$

These are the formulæ from which the projection on the cube is computed.

If then we wish to measure the great circle distance between two points p and q, supposed for simplicity to be on the same face of the cube, we draw the perpendicular cm to pq, and determine the spherical equivalents of pm and mq separately from the above formulæ. Thus, if cm is $\tan\phi$ pm is $\tan\theta\sec\phi$; mq is $\tan\theta'\sec\phi$; and the great circle distance is $\theta+\theta'$.

This gives us the method of making our scale.

Divide OM as a scale of tangents, with the unit equal to half the edge of the cube. Erect perpendiculars on this scale, and divide the perpendiculars as scales of tangents multiplied by secant ($\tan^{-1}$ OM). Draw this on tracing paper, and lay it on the cube with O at the centre of the face, and OM perpendicular to pq. We can then read off at once the equivalents of the two lengths pm, mq. And it would be just as easy to construct the scale so that the distances were given in statute or nautical miles, as to make it read degrees (see *Plate*).

Those who are interested in following further the geometry of this projection of the cube will find a good discussion of it in a paper by Professor Turner, *Monthly Notices of the R.A.S.*, Vol. LXX., p. 204, to which I was indebted for my first knowledge of it.

Of course areas and shapes suffer severely in those parts of the world which come near the corners of the cube; that is inevitable; but the simple geometrical construction just given enables one to draw any desired great circle; and it is not at all difficult by means of the auxiliary diagram to measure distances also. The small example that I am able to show you is traced from an old and out-of-print appendix to a report of the U.S. Coast and Geodetic Survey; its merits can be seen only when we cut up the sheet into the six separate sides of the cube, and begin to play with them.

It is now easy, with this map, to answer the questions just proposed. The great circle course from the Pacific mouth of the Panama Canal runs across the Gulf of Mexico and overland across the States nearly to Vancouver, and thence by Alaska and Kamskatchka down the coast of Asia to Japan—not across the Pacific *viâ* Honolulu as one might at first sight suppose. The consequences of this are very important. San Francisco will be a port of call on the direct sea route, and Vancouver will not be so very far off the route.

Or finally, to take the other problem: the great circle route for aeroplane from London to Sydney. You go by Copenhagen, St. Petersburg, right across Russia and Central Asia, and Southern China to Hong Kong, after which the route is more what one might expect. But I do not think that the start is quite obvious on any of the ordinary maps of the world; and I believe that this form of world-map is worthy of further study. It can be made so that it folds up into the cube and at the same time can be easily opened out flat again for storage. But its most useful form is as six separate squares which can be laid together in different ways to suit the particular part of the world under examination.

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*).

Tues[d] 7th. Westerly wind. Cold, Damp, and Uncomfortable. In the Evening there was Some Fire Balls, Other Experiments from the South Bastion, and from the *Enterprise* Frigate. Blows hard at Bed time and all Night. 7th September, 1779.

Wed[y] 8th. Easterly wind. The Same Close Weather. The Enemy very Busy at Fort St Philip, bringing down from their Camp large quaintitys of Stores; some Mortars also, &c. We this Day carried up a twenty four pounder up to the North Lodgment.

Thur[d] 9th. Easterly wind. It rained exceeding hard this forenoon. It must have given the Enemy a good weting. It cleared up in afternoon. Their Tents appear very wet.

Fry[d] 10. Easterly wind. Our People very Busy at the New Battery above the North Bastion. It seems now to gain Credit that our Gov[r] intends to Fire upon the Enemy Soon. The Gov[r] is at our House this and every other Day for this last Month, but no one can tell the Result of these Meetings, as there is never any one Present, except himself and Colonel Green. I am now following the example of a good Many of the Inhabitants &c, sending some of my most Valuable Furniture and other Matters out to the South. Many of the Jews and others have obtained leave to erect small Houses, or rather Hutts, at the Southward. I have also Divided our Stores and Live Stock between this House and the Mount, as it may be very likely I and the Female part of our Family, will be Under the Necessity of being out there, in case the Enemy should Fire upon the North part of the Garrison.

Sat[urd] 11. Easterly wind. Hear there is to be a Council of War at the Governor's this forenoon, Consisting of the three Colonels and the Admiral, as follows—The Governor, General Eliott—Lt Gov[r] Lt Gen[l] Boyd—Lt Gen La Motte, Hanoverians—Colonel Ross, 39th Regt—Colonel Green, Chief Engineer—Colonel Godwin, Royal Artillery—Admiral Duff—Captain Sir Thomas Birch.

Various now were people's opinions. However it was all silent. In the Evening Gen[l] Boyd was here for two hours with the Colonel.

11th September, 1779. The Evening passed as Usual, and the Col ordered his Horses at Gun Fire the next Morning, as indeed He does almost every Morning. Every Body in the Garrison has given up all Sort of Entertaining, as Early hours at Night as well as Morning was now become Necessary, nor were the Days passed without great hurry of business. I am now coming to a very Interesting part, and will Endeavour to be as particular as I can, in order to make it Understood in a Small degree how we were all Circumstanced at this Time. Several officers were under the Necessity of keeping Journals. The Engineers all do for the Chief Engineer's Inspection, and *He* keeps a very Separate one, which I believe is not intended to be shown to any one in this Garrison. My few remarks are as I said only for my Family.

Sun^d 12. This Morning at half past Six the Garrison began to Fire upon the Enemy. The first shot was from the New Battery call'd the *Superior*,* above the North Lodgment, 900 feet high. It was fired by Captn Loyd, Royal Artillery. We kept up a very heavy Cannonading for an hour. Most of the Garrison got upon the Hill. I never heard such a Noise in my Life. It is impossible to express the Bustle of the place. I mean amongst the Inhabitants. As to the Troops all was quiet, or as other Days. No Soldiers were allowed to go up the Mountain but those on Duty. The Gov^r was up as high as Williss. There was most of the officers, particularly The Artillery. There had not any Orders been given on that Head, as that would have made the business too publick; Indeed I believe it was not known to Ten persons including the Council. I can safely say I had not the least Idea of it, any further than it was Universally believed We should begin in a Day or two as We all thought it was to Commence as Soon as Ever the Chief Engineer had Reported the New Batterys being ready, and He had thrown out hints of that being about the following Tuesday or Wednesday. To return now to our Morning's business. The Colonel returned to Breakfast at 9. From that time the firing keep up all the Day from the North parts of the Rock, more or less, as our People discover'd the least appearance of any of the Enemy's Troops. In the afternoon there were Six Mortars fired, 2 of the Shells fell into Fort Barbara. We keep it up till 11 at Night. An easterly wind all the Day.

It is not easy to describe the hurry that this Days business Involved every body in, as it was Supposed the Enemy would Soon Answer our *Salutes*. I have already mentioned that many of the Shop keepers were removing their Goods &c. Great quaintitys were already gone; and this Day made them truly Anxious to remove what was still left. For this business every Person had full Imployment—Porters running here and there—old and young Jews frightened to Death almost as their *Dreads* greatly exceed all other Degrees of People. By the Night near all the North End of the Town was

* Afterwards named *Green's Lodge*. See 13th inst.

totaly abandon'd, The officers were likewise trying to change Quarters, particularly such as had families. I did not move any of my family, only as I mentioned before, sent off every chief part of my most Valuable Goods. Our plate was put into a Boomb Proof, my Household Linen, Books, and Cloathes, to Store houses at the South End of the Town, and our Stock as I before said, at the Mount, leaving only real and Useful Necessaries in the Town Quarter (which is quite in the Line of Fire). During this whole Day we could easily distinguish the hurry the Enemies Camp was In, When the First Shott was Fired they were relieving the Guards at the Lines, and at the same time Large Parties were employ'd bringing down quaintitys of Stores, as Usual, in large Waggons and Carts, drawn by Horses and Mules. I saw Several myself, whose drivers had left the poor Horses &c standing, whilst They made off, We know that Several Mules and Horses were killd. The Colonel has order'd a Boombproof to be made in the lower part of our Gardens at Mount Pleasant. It was a Reservoir for Water and is about 15 Feet long, 10 Feet broad. It will be a very good and Comfortable Consideration in Case of an attack by Sea, and if that does not happen it will keep the Water always cool in case we wish to Turn into the original Intention. It appears as if it would be a very Good Place.* 12th September, 1779.

Mondy 13. Easterly wind. The Enemy had been heard at Work all the last Night and the Garrison had fired 6 shott in the course of the Night, and again early in the Morning. At 10 oclock I went out to the Mount to see how the things were disposed of there. A very fine day. I staid till Eveng' heard Various reports of what We had done by our yesterdays Work, The Govr has given the Name of Green's Lodge to the highest Battery newly Erected which had taken the Name of Superior. It is a Work now found to be of a very Essential consequence, and was at first proposed to the Govr before the least Idea of the Communication being stopt, even as March last, by Colonel Green. The Govr submitted it to him, and it was begun about † weeks agoe.

Tuesd 14. Easterly wind. The Enemy not at all advanc'd. Very few shott sent last Night. The Colonel all over the Mountain to Day. The Garrison in good Spirits, Towards the Evening the wind seem'd Westerly. One thirteen Inch Mortar fired this afternoon. Uncertain of the Effect. We are sending to the Mount more things to Day.

Wedy 15. Easterly wind. The Enemy much the Same, and our firing rather less. Several flying reports of our having kill'd Men as well as Horses the other Day.

* It is still used as a reservoir, but the original roof was removed about 1907 to allow the lawn tennis court to be extended.

† The figure here has been corrected and is very doubtful, but appears to be a 3 or a 5. It was actually commenced on August 20, 1779.

16th September, 1779. *Thurs*^d 16. Easterly wind. The Garrison keeping up a smart firing all the forenoon, on account of Working parties. In the afternoon We fired three Shells from a thirteen Inch Sea Mortar, pointed from our upper heights, towards the Laboratory Tents. The two first Burst as Soon as fir'd and fell into the Sea. The third went into the Camp, within 400 yards of the Tent in Front. It has afforded Us Satisfaction in General as we now are getting the Range of our Shott &c. It is to be tried again. N.B. The Mortars are found good but not the Shells.

Fry^d 17. Easterly wind. Very Close and Hot. I find myself growing much indisposed. So much hurry has affected me. More Tents are pitched in the Enemy's Camp. There are 13 Battalions now come, and it is said there are to be 16 in all. There has been only one Working party seen to Day. It is Supposed they are a little Alarm'd at what passed on the 12th and yesterday, and as it is conjectured have sent off an express to Madrid. I have omitted to mention in Due place that the Streets in the Garrison were begun to be plowed up on Tuesday the 14th inst. They began in Irish Town, and plowed up the Main Street to the Grand Parade. This Day They are in our Street and have come up within a 100 yards of Us.

Satur^d 18. Easterly wind. The Enemy the Same; We also keep up a Smart firing as of late. At Noon it began to Blow Westerly, and a Venetian Ship got In, bound for Holland. I grew much indisposed, which gives me great Concern at this time.

Sun^d 19. Easterly wind. I had been in great pain all Night in one Foot particularly, and proposed Staying in bed all Day. However upon hearing that the above Mentioned Vessel was going to Sea this Day, I used every endeavour to write home and would not on any account mention the painful Situation I was then In. I wrote to My Sister and inform'd her that We had been very *Noisy* and Busy ever since this Day Week. We had Several Gentlemen to Dine this Day, and in the afternoon the Colonel was obliged to go out at Landport to make *Observations*. He went as far as the Gardens! with only an *Orderly* Sergeant, as it was not proper to take any Number! I was uneasy till He came back. A Shell was Fired this afternoon with good success at Fort St Philip. In the Course of last week—about Friday—the Cupola of the White Convent* was taken down also the Arch and upper part of the Governor's Church.† All the Inhabitants and Shop keepers in the Main Street from Bedlam Barracks down to Waterport have left their houses. At 8 this evening a great Number of Shells and Shot were fired. It surprised most people, what could occasion so Much Firing. Captn Johnson upon the Batterys.

* Probably the Whitefriars Monastery which was at this time the Admiral's residence. The site is now occupied by Bland's Stores.

† The King's Chapel.

Mond 20th. Easterly wind. The captain of the Batterys began to Fire as soon as Day appeard and fired an amazing Number of Shells, so much that it is allowed He could not have kept up a heavier fire had the Enemy been at the Gates. This conduct is disapproved of. Major Lewis* relieved him this morning. N.B. This is the first Day that the Major has fallen In to do the Duty of Captain since He had the Brevet Rank of Major. The Enemy has made some few advances, and have taken down some Stone Centry Boxes, likewise the Roofs of some Guard Rooms. In the Evening we threw some Shells, with good Success it is said, into Fort St Philip. Hear that Poca Roca cave is fitting up in high order for the Reception of the Governor.† The Venetian did not go last Night. Find myself a little Easier to-day. Every kind of Provision now is exceedingly dear and scarce. 20th September, 1779.

Tuesd 21st. Easterly wind. A great Number of Shot and Shells fir'd this morning. Nothing to be had at the Market except one Hog which is Sold at 3 Rials‡ per pound, equal to fifteen pence Sterling. Captn Eyre upon Batterys. Very Moderate in firing all Day and Evening. The Weather exceedingly Hott now. My foot better.

Wedy 22. Easterly wind. At half past 12 last Night we had a Number of shot fir'd. It continued for near a quarter of an hour, and again a few more Early in Morning. Capt Grove went upon Batterys this Morning. The Enemy have made some additional alterations in their camp, and Several Rows of Tents are pitch'd towards the Eastern Shore, in a line from the first Tents. Our firing very Moderate all Day; a few Shells at 10 at Night. We have taken no Notice of this day, viz., the Coronation Day.

Thur 23. Easterly Wind, fine Day. One other Tent, a Laboratory one it seems, Under the Queen of Spain's Chair, and likewise an Additional Number to the Left Line. Capt. Loyd upon the Battery to Day. Very Moderate in firing all Day. More Tents in evening. Find that most of the Regts are come to the Camp except one Battalion of the Catalonians.

Frydy 24. Westerly wind. Little Firing this Morning. Hear the Enemy has made More advancement in their Lines, and also that 2 Mortars are at the Lines. This piece of News is doubted by some. Capt Paterson upon the Batterys to Day.

Saturd 25. Westerly wind. No Firing all Night. Capt Sowerby upon the Batterys to Day. In the afternoon we fired 6 Shells from Green's Lodge; five and half Inch Shells, out of a twenty four pounder.

* This officer was in command of the Artillery at the end of the siege, having succeeded Lieut.-Colonel Tovey who died on 27th November, 1781, and who had himself succeeded Colonel Godwin.

† It was never taken into use by him.

‡ Capt. Spilsbury in his diary gives the following monetary table:— 1 Dollar is 8 Reals; 1 Real 16 Quarts; 1 Pistol, 5 D. 5 R.; 1 Cob 12 Reals; 1 Doubloon 22½ D. The Dollar at 42 pence sterling makes the Real worth 5¼ pence.

25th September, 1779. 4 went into Fort Barbara, one into the Sea, the other Burst. Two Bullocks, belonging to the King's Works, are to be killed for to Morrow; which are by the Chief Engineer's orders to be Sold at a Rial and half. All the beef that has been of late were sold at 3 Rials pr lb.

Sun^d 26. Westerly wind. Very little Firing last Night. Capt. Johnson upon Batterys this Day. The Enemy preparing for Enlarging their Camp. This Day at Noon a Soldier of the 72nd, employed as a Carpenter out at Landport, went off the Works and got to one of the Hutts; was fired at from Williss with Grape Shott and also Some Shells; and Some Shott went into the very Hutt. The Man was not seen at all. It is therefore Uncertain whether this man is killed or remains there, to get off in the Night. This afternoon a Dutch Vessel was coming In. The Enemy's Row Galleys and Boats took Her when she was very near our Admiral and carried her over to Algezira. This whole Day the Spainish Admiral has had a Red Flag Hoisted upon his Main Top. They examined the Dutch Vessel and then let her go. A Top Sail Vessel appear'd from the East this Even.

Mond^y 27. Westerly wind. The Spainish Admiral has the Same Red Flag hoisted this day. This Morning a Swedish Vessel taken. Supposed to be the one that was in Sight last Night. She was also Carried over to Algezira. She Saluted the Spainish Admiral with 7 guns who returned 3. Major Lewis upon Batterys.

Tues^d 28. Westerly wind. No material alteration in the Camp. The Spainish Admiral has the same Red Flagg for the third Day.

Wed 29. Westerly wind. The Enemy are getting Mortars upon the Point, Fort Negro. Capt Martin upon the Batterys. The Spainish Admiral has not the Red Flagg this Day. It is conjectured it has been owing to a Court Martial held on board. Very little Firing this Morning. Mr Holloway came down at Noon from the Midshipman's lookout and reports that He has very clearly seen 4 Mortars Mounted at Fort Negro. He Saw Some of them as they were bringing from the Orange Grove, drawn by 20 Mules each Mortar. There has orders been given this day for the Steeple of the Spainish Church to come down, and the Clock and The Bells likewise. This Evening was cold and damp. Great Complaints for want of Fresh Provision.

Thur^d 30th. Westerly wind. Colonel went up to Williss. Capt Grove upon the Batterys. The Mortars are removed from Fort Negro and taken to the Lines. This is a cool Morning, and at Noon it appeared like Rain. There was some Veal in the Market which was Sold at 5 Rials, 2 Shillings of English money, pr pound. This Even at Sun Set, when the Enemy fired their Evening Gun as Usual at Point Negro there was a Ball in the Cannon. It was Seen by Many as it fell into the Sea. It is supposed to have been owing to their having Neglected to take out the Ball in the Day time, as they always Used to do. We have been very Moderate in the Firing this Day. 30th September, 1779.

October 1st. Fry^d. Westerly wind. This Day the Guards mounted at 8 oclock. Capt Loyd at the Batterys. We have keep up a Smartt firing this Morning. Writing a letter to my Son to go by the Venetian Ship which was to have gone upon the 20th of last month.

Satur^d 2. Westerly wind. Colonel went up to Rock Guard. Capt Sowerby upon the Batterys. Very little firing this Morning. The Enemy are Unroofing a Guard Room at the Lines. N.B. It is to be remarked that We have been very attentive in one point, which is that of never having fired any one Shott at the officers Guard Rooms. It has in general been directed to the Working parties, &c. It rained a little this Day and Blows fresh in Evening which gives Us hopes of Boats coming over from Barbary.

Sun^d 3. Westerly wind. In the Night it began to Rain pretty hard attended with Thunder. At Guard Mounting it came on very hard. Capt Johnson upon the Batterys. The Gov^r has order'd that there should not be any 13 Inch Mortars fired to Day. At Noon it Cleared up and the Wind came to the East. Several Shott in afternoon. The Enemy have brought down a Mortar to the Artillery Park. The Venetian sailed this aftrnoon. It rained all the Evening very hard.

Mon^d 4th. Easterly wind. A man of the 58th Deserted last Night from Middle Hill Guard. This makes 5 that have deserted since the Investment, three Hanoverians, one of the 72nd and this of the 58th. The Enemy have lighted up Fires in their Camp to air Themselves after the Rains. Major Lewis upon the Batterys to Day. The Enemy have added 2 more Laboratory Tents in the Artillery Park, one in the Front, the other in the Rear.

Tues^d 5th. Westerly wind. Raining very fast. Captn Eyre upon Batterys to Day, Very little Firing. The man who Deserted Yesterday was found this forenoon, quite Dead and most of his Limbs Broke to pieces.

Wed^y 6th. Westerly wind. Captain Martin upon Batterys to Day. The Enemy has brought down 2 More Mortars to the Artillery Park. A few shott fired to Day. In the Evening We had a Signal up for a fleet.

Thur^d 7. Westerly wind. Fine Morning. Col. went to the South and to New Mole. Capt Patterson upon the Batterys.

Fry^d 8. Easterly wind. Capt Loyd upon Batterys. A French Privatter took a Swedish Vessel as she was coming In and carried her over to Algezira. Our Artillery People are very Busy this Day Taking a twenty four pounder up to the Rock Guard which is an amazing height! and of course a very difficult Business. The bomb proof at Mount Pleasant is now Completed, only wants Airing. It is a very Comfortable looking place.

Satur^d 9th. Westerly wind. Fine Morning. The Colonel at the

9th October, 1779. Castle before Breakfast. About 10 this Morning a firing began in the Bay, between some Spainish Row Boats and some Xebeques, and the *Childers* Sloop of War, who was going out to protect some of our Men of Wars Boats who had taken a Prize and was bringing it In. They were fired upon; a chace ensued and it obliged the Sloop to return to her Station after having been out about an hour in which time she had got up nearly as far as the Orange Grove and had been fired at from Fort Negro. Admiral Barcelo, &c, and all the Camp had Turn'd out Under Arms. Captain Paterson upon the Batterys. This forenoon a Circumstance happened in the Bay, besides what I have just mentioned, that gave great displeasure to the Garrison, viz., a Boat from Barbary loaded with Bullocks was going over to Algezira about the time of the Sloop being out in the Bay. It is Supposed that We might have brought Her Into the Mole with Ease, had our Frigate gone out. All this adds to the discontent of every Body, and many very Disagreable things were said on the Occasion, and some of the officers of the Navy and Army behaved in a Slighting Manner to Admiral Duff Who carried it with an Air of Indifference!

Sund^y 10. Easterly wind. A very fine Morning. Colonel upon the Rock. Breakfasted with Captain Sowerby who had the Batterys to Day. Very moderate in the Firing all day.

Mond 11*th*. Easterly wind. A Dull Day. Major Lewis upon the Batterys. The Enemy Seem busy upon the Common about 100 yards from the Strand, between the two Guard Rooms. They are employ'd throwing up Some kind of Work. They have about 150 Men at Work.

Tues^d 12. Easterly wind. At the Castle before Breakfast. Captain Eyres upon Battery. Two Town Boats for Cattle sailed last night, one of which was pressed by a Spainish Vessel, which obliged the Towns People to quit Her, and take to a Smaller Boat. They took our Vessel and Carried Her over to Algezira. The other got safe to Tangier. Very little firing all Day.

Wed^y 13. Easterly Wind. Capt Martin upon Batterys. The Colonel went up the Hill at 10 oclock to see the Gun Fired from the Rock Guard, attended by Capt Loyd who Laid the Gun. They Fired at the Western Fort. Most of the Shott took place and greatly alarmed a Party of Dragoons who at first took it to be the Blasting of the Rock, till such times as they found the Shott amongst them! They then made into a Ditch.

Thurs^d 14. Westerly wind. Captain Patterson upon Batterys. The Colonel at the Castle before Breakfast. Last Night a Hanoverian Captn Belonging to La Motte's Died Suddenly. A man of the 58th trying to Escape from Middle Hill was Dash'd to pieces. At this time I was Taken exceedingly ill and continued so till the End of the year. I shall not therefore be able to put down any Daily occurrence. However the most Essential I shall Endeavour to set down Here, as I was just Enabled to put a few Interesting Circumstances into my pocket Book; which makes me able to carry on a Sort of Journal; at least of what was Most Material. 14th October, 1779.

On the *27th* of this month I wrote to my Sister by a Venetian ship which did not sail (till) the 2d of Novbr. I was not able to keep up any Journal. Nor did any very Interesting or Essential change or Difference in our Situation occur. Every Article of Provision had long been too Dear and too Difficult to get. This had made it a very Uncomfortable Circumstance to every one in the place. However upon the whole the Troops keep up a very great degree of Spirits. Nor ought I to omit Saying that the Governor took every Necessary Means to take care of them and their Families, Endeavouring by every method to oblige them to Lay In as much fresh Dry Stock as it was possible for them to get; and therefore every officer help'd their men and at least to answere for them. However the poor Inhabitants began to look in a very Uncomfortable Way; the Jews in Particular.

*November 1st.**

11th. Thursdy. The two first Deserters came In, of the Wolona Guards.†

Sundy 14. This morning a fine Cutter was chased into the Bay by the Spainish Men of War. She got to Windward of the Enemy and drove the Spainish Admiral &c behind the Hill. She proved to be a Folkestone Privatter called the *Buck*, Captain Fagg. He Brought Her In with the Utmost Conduct as a Sea Man and with Spirit. From this time the Enemy's Fleet was dispersed and left *US* Sole Masters of the Bay; it was therefore expected that *We* should have availed ourselves of it. However it did not turn out So! As our Men of War made no attempt to move. All this Seeming Neglect hurt Every Individual in the Garrison; and Several very Severe Papers were put up on the Different Parades Reflecting upon the Admiral's Conduct. A Windmill was now Erected up the Hill, near the Garrison Hospital, in order to Grind the Wheat that was taken from a Dutchman. Many of the Inhabitants in much want. The Chief Distress is the Want of Flour and of Firing—two very great Wants indeed.

about *the 20th.* The Enemy took Two Neutral Ships in the Face of the Garrison and very near to the English Admiral, and one of them was a Swedish Vessel Loaded for this place belonging to some Jew Merchants, who inform'd the Admiral it was the Vessel they expected as she made the proper Signals, but He did not chuse to send out any assistance! by which We had the Mortification to see her taken over to Algezira, and We Were deprived of Many Articles this Garrison stood in great need of, particularly Coals as the owners

* No entry follows this date.
† The Walloon Guards.

20th November, 1779. were certain there was a Large quaintity on board. About this time Mr Holliday, the principal Baker in this Garrison, refused to Bake, owing to the want of Wood. He had at this time 51 Sacks of Flour left. The Gov^{r} took them all away except two which He allowed him to keep for his Family. In the beginning of this Month the Small Pox first Broke out in the Garrison. It began in an Inhabitant's House, a poor Jew's. One child was nearly Recovered before it was found out, and an other taken ill. Every Method is taken to prevent the disorder spreading, as it would have been a very bad thing at this time. The Means were used as follows—an examination was made amongst the Different Reg^{ts} of those Men who had not had the Small Pox, and they were directly orderd out to the Southward, and the same Number Sent In to do the Duty; the Jew's family was removed to a House in Irish Town; a Large airy place. They were ordered to be keep close and to admit of none to those who went In with them. As other children were taken ill, they also were sent to that House; by which means it avoided Spreading. There was 7 Children in all that had it, but it never took amongst the Troops. I shall observe when the Troops were brought back to their Respective Reg^{ts}.

Upon the 27th of Dec^{br} the Small Pox being all over the Troops were all properly fix'd—the children still kept in Irish Town—and no communication whatever with the rest of their Relations. It is not certain how this Disorder got into the Garrison. Some think it was brought In by some Privatters' Men who were taken out of an English Ship which run on shore near Fort Barbara, which ship was Burnt.

December 1st. In the beginning of this Month the Weather was very Mild and pleasant. I went to the Mount for a week.

10th. I wrote to my Sister, sent it by a Packet Boat to Barbary. I was taken ill about the Middle of this Month and came to Town. It began to be very bad Weather; and also the Garrison had all the appearance of having a very bad Season in all Respects coming on. The Troops were Well and as yet in good spirits, but the great Want of Flour and of Firing began to oppress. The Boat which had gone over upon the 10th to Barbary came back a few Days before Christmass and brought a very few Goats and fowls which sold at an amazing Price. There was some very bad Beef, old Cows, to be kill'd against this Holiday time—(as it used to be call'd)—but so bad and so very Dear that it could not be thought of (but) by very few indeed. It now Rained every Day.

Christmass. This Day was tolerably fine as to the Weather, and every Body tryd to appear Easy and Contented. We had a few Friends to dine with Us, and upon the whole we did the Best We could.

Sund 26. Raining and Unpleasant Weather. The Enemy quiet just now; many of their Tents are unpitching, and it is rather at this time an *Hutment* than an Encampment of Tents. We Seem to Understand by Several More Deserters that They are in nearly as Much Want as ourselves. 26th December, 1779.

Mondy 27. The Enemy this forenoon Fired 4 shott, supposed to be at our Fisher Men who had indeed gone too near the Spainish Coast. One of the shott, a twenty four pounder, went into the Head of the Princes Lines, but did no harm. It Blowed very hard all this Day and the next Night; but to let us See how Unexpectedly the Goodness of Providence is at Such times as We poor shortsighted Mortals think ourselves in the utmost Danger, behold in the course of this last 24 hours We had a Blessed supply of Wood which had been brought down to the shore near to the Ruins*, intended for the Use of the Camp. It was chiefly Brush Wood. The wind Drove directly into the Bay. The same fortunate wind Drove it towards the New Mole; and it was going round towards Europa. Our Men of War sent out their Boats. They got a Large Quaintity,—and what Ever We could stop, that was done near the Old Mole and outside Landport. It was a great Supply for this Garrison, as it is at the least calculated to amount to 500 Quintals and will be enough to Supply the poor Inhabitants and Soldiers Families for Six Weeks. The Govr gave those men leave to get into the Garrison who had families. It was Truly a God Send and highly Worthy to be Remembered, and it was likewise a Loss to the Enemy. Just before Christmass Day the Bakers left off Baking. We then began to Use our own Stock of Flour. We first began by taking 10 lbs of Flour and making into three Loaves, Sending Wood to the ovens (the Bakers having none). Our Flour was exceeding White and Good; there was now remaining some of the Kings flour in the Victualling office which We the second time try'd and mix'd with some of our own; it made tolerable Bread. N.B. This was flour from the wheat Ship that was taken from on board a Dutch Man some Months agoe. Several Deserters had come In from the time the two first came, which was upon the 11th Novbr and they all report that the Camp was very Sickly and ill provided, and that the Enemy frequently come out from the Lines and go to the Gardens of Landport and Rob. I have as yet omitted to mention that upon the 14th of this Month a Spainish Deserter of the Wolona Guards trying to Escape to Us was fired upon from Fort St Philip, and a Party of Horse came out from their Lines to take him. He was hurt by their shott and likewise received a Wound from one of the Horse Men, was taken back into the Camp and the Next Day was hanged upon a very high Gallows Erected upon a high Hill, and left hanging all Day. By the Boat from Barbary we find all Communication between that Part and Portugal is totally

* The ruins of Carteia appear to be meant. Drinkwater says the wood was washed down from the banks of the Palmones and Guadaranque. Spilsbury says about 5 tons were collected.

27th December, 1779. Stop'd. The last Venetian was took. The Boat which went over to Barbary upon the 10th Inst return'd as I have before said a few Days before Christmass and brought a very Small Supply. I shall now proceed to mention the astonishing Price of Family Articles upon the Close of this Year, but first I am to observe that whenever any of the Oxen belonging, and employ'd by the Chief Engineer, in the King's Works, was ordered to be Kill'd for the Supply of the Troops and of the Garrison—(which was done as the Grain and Straw was drawing near an End)—this Beef tho' exceeding Fatt and Good was by the Chief Engineer's orders sold at 2 Rials per lb. All other beef tho' not fitt for eating hardly for 4 Rials. The Boat brought a few Goats which sold at 18 Dollars a piece, equal to £2: 15: 0. At other times 6 or 7 Dollars was looked upon (as) rather Dear. They are cheap in Barbary. The Fowls, very bad, sold at one Dollr 4 Rials. We had not any Mutton in the Market for a long time past; till the Day before Christmass when one very bad poor sheep was Kill'd!—which was Sold by the Quarter at Eleven Dollars two Rials pr Quarter, equal to Six and thirty Shillings Sterling. I can not avoid Mentioning a Circumstance which happened to our family During the Blockade; One Day I had a Leg of Pork brought home from the Market; it was very good Meat, but it absolutely cost nine Dollars, equal to one pound 10 shillings! what a Sum for one Joint of Meat! and at that time if I had not bought it no other kind of Fresh Meat presented itself—only think of the Poor.

The Prices of Meat & Poultry at the Close of the Year 1779.

	D.	R.	Q.		£	s.	d.
Beef per lb	0.	4.	0.	...	0.	1.	9.
Veal per lb	1.	0.	0.	...	0.	3.	6.
Pork ,, ...	0.	6.	0.	...	0.	2.	6.
Goat ,, ...	0.	6.	0.	...	0.	2.	6.
Flour ,, ...	0.	2.	0.	...	0.	0.	10½.
Pease ,, ...	0.	1.	0.	...	0.	0.	5.

The above shows the high rais'd price in English as well as in Spainish. As to Poultry it was not very Easy to fix a price, as any one which had to dispose of any strove to get the most for them. However it was in General as follows. N.B. I had no occasion to buy, having most exceeding plentyfull Fowl Yards, at a very great expense indeed, but still I had enough.

	D.	R.	Q.		£	s.	d.
Turkey, a piece ...	18.	0.	0.	...	3.	0.	0.
Geese ,, ...	9.	0.	0.	...	1.	10.	0.
Fowls ,, ...	2.	0.	0.	...	0.	7.	0.
Ducks ,, ...	3.	0.	0.	...	0.	10.	6.
Pigeons, a pair ...	1.	4.	0.	...	0.	5.	0.

and when ever we got Fish it was beyond all Price.

(*To be continued*).

TRANSCRIPTS.

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.

EARLY SUBMARINE TELEPHONE CABLES.

THE first submarine cable of any length specially designed and provided for telephonic purposes by the British Post Office was that between St. Margaret's Bay and Sangatte, laid in 1891; at that time the intention was to limit the use of this cable to the provision of telephonic facilities between London and Paris. Since then, many other cables have been laid (*vide* Appendix I.), and these have all been practically of the same type. The weight of copper and gutta percha in the cores was so proportioned as to make them specially suitable for use in connection with considerable lengths of land wires. The Port Mora-Donaghadee cable, for example, connecting the English and Irish telephone systems forms a link between 400 or 500 miles of land line on each side. The data available in 1890, when the first Anglo-French cable (referred to above) was designed by Mr. H. R. Kempe, now Electrician to the British Post Office, were naturally somewhat incomplete, but the results obtained with the first telephonic circuit between London and Paris have proved eminently satisfactory from the date of its first use. This has been testified to by the demand of the public, not only for additional facilities between England and France, but also for the establishment of telephonic communication between England and Belgium. In the latter case facilities were provided in the year 1902.

I was serving as a subaltern in the 2nd Division Telegraph Battalion, Royal Engineers (now "K" Company, R.E.), in 1890, and became in this way associated with the work of establishing the first international telephone circuit affecting this country, for I was charged with the duty of making all the necessary arrangements for the selection of a suitable route for the lines from London to the coast, the preparation of the estimates and the superintendence of the construction of the works necessary on this side of the water. I can still recall the anxiety that existed 20 years ago in relation to the elements of the problems concerning which so little practical knowledge existed, and which it was felt might have such an important influence on the success or failure of the scheme in hand. Very strict instructions were issued to ensure, not only that the wires of the aerial section should be fastened to the insulators in such manner that the centres of the four wires of a twisted group would form the corners of a true square at these points, but also that the poles themselves should, as far as possible, be the same distance apart. Great care was at the same time taken to reduce the use of gutta-percha-covered wires to a minimum, and for this purpose the usual practice of leading wires into the more important post offices on the route for facilitating the localization of faults was abandoned. The first precaution is still observed, but the same attention is not demanded to-day in respect of the uniform spacing of the poles, and the introduction of paper-insulated cables has permitted a return to the normal practice of looping the conductors into the important post offices for testing purposes.

The laying of the first cable (constructed by Messrs. Siemens Bros. & Co.) was carried out by H.M.T.S. *Monarch*, under the command of the late Mr. D. Lumsden. This operation was commenced on the French coast on March 9th, 1891, on which date the French shore end was landed, the weather being favourable and fine. The late Mr. E. Graves, then Engineer-in-Chief, Mr. (now Sir) William Preece, then Electrician, and other officials from the General Post Office, had proceeded to St. Margaret's Bay to await the arrival of the *Monarch*. Shortly after the cable ship had come within sight of the English coast, it was overtaken by a sudden and violent snowstorm; the sea became very rough, and Mr. Lumsden found it necessary to cut the cable and run for shelter. For a time doubt existed as to the safety of the *Monarch*, which had completely disappeared from our view. It was not until the 12th of March that operations were again commenced and the laying of the cable completed. Within a few days after the end of the cable had been landed at St. Margaret's Bay, good commercial speech was proved possible between London and Paris.

Descriptions of the first British International telephone cable have already been published.* The essential particulars have been extracted, and are given in Appendix II.

EXPERIMENTAL PROVISION OF AIR-SPACE SUBMARINE CABLE.

From time to time, the several Administrations charged with providing international telephonic services have been called upon to extend the range of communication. The problems connected with the transmission of speech have in consequence been kept constantly before their engineers, and have received close study. A slight departure from the original type of cable employed was considered in 1897, when the question of providing telephonic facilities to the Isle of Wight was first raised. It was well known some 50 years ago that the high electrostatic capacity of gutta-percha-covered conductors greatly affected the transmission of electric impulses, but it was not until 1887 that a satisfactory theory of telephonic

* *Electrical Review*, Vol. 27, p. 309, 1890, and Vol. 29, p. 247, 1891.

transmission was formulated. In that year, Oliver Heaviside* gave the essential parts of the theory of telephonic transmission, pointing out the importance and beneficial effects of self-induction and stating the relation which must exist between the constants of a circuit in order that electrical waves of all frequencies may be transmitted without distortion. His investigations show great power of mathematical analysis and a wonderful insight into complex electrical phenomena. To him most certainly belongs the credit of being the earliest investigator in the field of telephony to predict the measures necessary for progress in the art of speech transmission. Unfortunately, however, it was many years before any attempt was made by engineers to apply the mathematical deductions which Oliver Heaviside had placed within their reach, to the solution of practical problems in connection with long-distance telephony.

The difficulties which manufacturers may experience in realizing the specifications of the practical engineer have always to be considered whenever a wide departure from existing types of cable is proposed. So far back as 1891 Silvanus P. Thompson obtained a patent for "Improvements in means for use in or in connection with the conveyance of varying electric impulses, applicable to electric signalling for telegraphic, telephonic, or other purposes" (Patent Specification No. 22304, of 1891). The improvements suggested were the employment of distributed inductances, leaks, etc., and this patent specification may be considered to have afforded independent testimony to Heaviside's views. Engineers, however, were not convinced as to the practicability of effecting improvements in telephonic transmission by this means, and therefore a solution to the problem was sought by devising a method for materially reducing the electrostatic capacity of submarine cables. A proposal which contemplated a solution of the problem in this manner was placed before the British Post Office and was readily accepted. The air-space type of cable designed by Messrs, Willoughby S. Smith and W. P. Granville (Patent Specification No. 8573, of 1895) was, in 1897, brought to the notice of Sir William Preece, then Engineer-in-Chief to the British Post Office. The extension of the telephone trunk service to the Isle of Wight had just been sanctioned, and it was felt that a suitable opportunity existed for the employment of the air-space type of cable for the projected service. Further, it was hoped that data of a practical kind likely to prove useful in connection with future developments would be obtained by a trial of this type of cable, and in consequence, communication between the mainland and the Isle of Wight was provided by an air-space cable laid between Stone Point and Gurnard Bay, a distance of about two knots, on June 30th, 1897.

The electrical tests carried out when the cable was laid proved it to be in every way satisfactory. Speech tests were also made and disclosed no feature in the design likely to cause difficulty in practice. It was discovered later, however, that this apparent freedom from defects was due to the fact that the cable under test was of too short a length for a complete investigation of its telephonic efficiency to be made. The

* *Electrician*, Vol. 19, p. 79, 1887; Electrical Papers, Vol. 2, p. 119.

practicability of manufacturing long lengths of this type of cable, with conductors symmetrically arranged throughout their whole length, had not in fact been proved; but, at the time, the results of the tests were considered sufficiently encouraging to justify the adoption of this type of cable in connection with problems of greater magnitude, so that when an increase in the number of telephone circuits between England and Ireland was suggested in 1898, this type of cable was adopted for the purpose.

The Gutta Percha Company has most courteously supplied a short description of the method used in the manufacture of the 4-core gutta-percha insulated air-space cable laid between Nevin, Wales, and Newcastle, Ireland (Appendix III.). When this Anglo-Irish cable was tested under practical conditions, a very serious defect was discovered, namely, that when two telephonic circuits were formed on the four wires, it was not possible to carry on conversation simultaneously without overhearing; in fact, serious inductive disturbances existed between one pair of conductors in the cable and the other pair.

Great disappointment was experienced when this fact came to light, and to clear up the situation a series of experiments was arranged in May and August, 1900, by Mr. (now Sir) John Gavey on the three cables (two telegraph and one telephone) which at that time connected Nevin, in Wales, and Newcastle, co. Wicklow (Appendix IV.). These experiments were intended to determine—

(*a*). The relative volumes of sound in each cable, the terminal conditions being maintained the same in the three cases.

(*b*). Whether overhearing existed between diagonal pairs of wires in any of the cables, and, if so, to what extent.

(*c*). Whether speech was practicable through two cables of standard telegraph type (107 lbs. copper, 150 lbs. gutta percha) when joined in series—*i.e.*, over 120 knots of this type of cable.

(*d*). Whether the four wires of the telegraph cables joined in multiple would improve speech as compared with that of a metallic circuit in the same cables; that is, to ascertain what effect a decrease of resistance and a corresponding increase of capacity would have on telephonic transmission and—

(*e*). Whether the superimposing of a telegraph circuit on a telephone loop materially lessens the efficiency of the telephone circuit.

The results were as follows:—

(*a*). *No.* 1 *Telegraph Cable.*—Volume of sound sufficient for commercial purposes, but no margin for extension; articulation well defined.

No. 2 *Telegraph Cable.*—Volume slightly in excess of No. 1; articulation very well defined.

Telephone Cable.—Volume excellent on each pair of diagonal wires; conversation could be carried on with receiver some inches away from ear.

(*b*). *No.* 1 *Telegraph Cable.*—There was a very faint trace of overhearing between diagonal pairs, probably due to the "twist" having been removed at the point where the cable was led into a hut at one of the landing-places.

No. 2 *Telegraph Cable.*—There was no overhearing between diagonal pairs of wires.

Telephone Cable.—The overhearing between diagonal pairs of wires was so loud and distinct as to result in the conversation on one pair of wires being easily heard on the other pair by induction.

(*c*). Speaking was just practicable between experts.

(*d*). Speaking was less practicable than in the preceding experiment.

(*e*). The volume was reduced by about one-fourth, and the articulation somewhat blurred.

The following conclusions were definitely drawn from the foregoing experiments:—

1. Commercial telephonic communication between terminal points connected by a 60-knot length of the ordinary submarine telegraph cable of the standard type is possible, but there is no margin available under such conditions for extending the range of communication beyond that distance.

2. The air-space type of cable of a similar length—60 knots—does afford a sufficient margin for extending the range of telephonic communication very appreciably if combined with suitable aerial conductors, but the existence of overhearing between the two pairs of conductors, and the disturbances introduced by utilizing one pair of wires for telephonic purposes and the other two wires simultaneously for high-speed telegraphic purposes, precludes the employment of this type of cable for telephonic purposes wholly, or for joint telephonic and telegraphic purposes, unless the telegraph circuits are impeded and worked at a low speed.

Within the last two or three years, a further series of experiments have been carried out on the Anglo-Irish air-space cable with a view to eliminating if possible the disturbances referred to. The experiments were designed with great care and were carried out for a prolonged period, but the results showed that the proposal, which had been revived, to utilize this particular cable for the purpose for which it was originally intended, would have to be again abandoned, at least for the present. There appears to be little doubt that the cause of the failure of this type of cable is due wholly to the difficulty in manufacturing it in such a manner as to ensure that the conductors shall retain the positions they are intended to occupy, *i.e.*, so that their centres shall form at every cross-section a true square.

Proposals involving the Provision of Additional Telephone Facilities between England and France.

When the question of laying an Anglo-Belgian cable in order to establish direct telephonic communication between London and Brussels came up for consideration, it was decided, in view of the failure of the air-space cable, to use the same type as the original Anglo-French cable. The length of cable required was about 50 knots, and as it had been proved by experiments on circuits formed by looping the conductors of the cross-channel telephone cables that good speaking was possible through 80 knots of this type, it was therefore quite safe to lay 50 knots, and it was probably a wise decision to use a proved rather than an unproved cable.

In 1908 the French and British Administrations found that the public demand for telephone facilities between the two countries had increased, and as a result of the negotiations between the Postmaster-General and the French Government it was decided to provide four additional circuits (*i.e.*, two new cables) between England and France, each country providing and laying one.

In considering the best means for providing the additional circuits it was recognized that it was not a matter in which the problem consisted merely of increasing the existing number of channels of communication, but one which afforded an opportunity, whilst providing the additional facilities required, to extend the range of intercommunication so as to embrace centres not hitherto included in the international zones owing to the great distances separating them. The consideration of the problem from this point of view naturally involved the utilization of all the information on the subject of telephone transmission which had been accumulated in the Engineering Department during the past few years, in order that the design of the cable should admit of the realization of the greatest practical increase in its efficiency at a moderate cost.

Three methods of increasing the range of telephonic transmission, so far as submarine cables are concerned, have been prominently before the Engineer-in-Chief's staff, viz. :—

(*a*). By the use of heavier copper conductors, and by an increase, at the same time, of the separation between them.

(*b*). By the provision of one or more closely arranged layers of suitable iron wire over the whole length of the copper conductors in the cable—the so-called "continuous" loading system.

(*c*). By the introduction at regular intervals of suitably arranged inductance or loading coils—the so-called "non-continuous" or "coil" loading system.

Two varieties of cable in which it was proposed to obtain increased efficiency in transmission by the employment of a larger quantity of copper per unit of length have been submitted to the Engineering Department, and, needless to say, these have been very carefully considered. In both of these designs, provision has been made for the introduction of layers of paper between the copper and the gutta percha. Some particulars regarding these cables will be found in Appendix V., and it will be seen that each of them contains only a single circuit.

According to our present experience, paper appears to be a somewhat unsuitable material to employ in the manner proposed on account of its hygroscopic qualities which cause it to absorb moisture from the gutta percha, quite apart from the question of the probable high cost of maintenance that a cable in which paper is used may involve. However, an effort is being made to discover some effective means of overcoming the practical difficulties which have been encountered, owing to the moisture exuding from the gutta percha.

A diagram of sections of various types of telephone cables that have been adopted or proposed is given in Appendix VI.

The problem is naturally one in which commercial considerations are paramount. Even a Government Department cannot really afford to provide public utility services at a very great loss, and it has been the desire of the British Post Office so to lay out its plant, especially in connection with telephonic development, that the annual revenue shall at least be equal to the annual expenditure. The natural desire of the telephone engineer is to have ready at all times schemes for extending the range of communication, in order to anticipate the demands of the public in this direction.

The question of providing cables of higher efficiency comes under consideration only as the distances of the points between which they are required become relatively great; in such cases the magnitude of the capital cost involved in providing the cables rises in a nearly geometrical ratio if the problem is solved by the simple expedient of increasing the weight of the copper conductors, and for this reason proposals for heavier copper conductor types of cable have in recent times been in abeyance.

The two practical methods—that of "continuous" loading and of "non-continuous" loading—have been the only ones considered, therefore, in connection with the proposal to increase the number of cross-channel communications. Needless to say, the advantages and disadvantages of these two types of cable have been very thoroughly studied. All available literature bearing on the subject has been scrutinized, and such information relating to those types of cable which have already been laid by Foreign Administrations have been obtained. For convenience a schedule is given in Appendix VII. of some foreign loaded submarine telephone cables which have been provided in the past,* together with a short description of what is involved in connection with the design of the "continuously" loaded type of cable. The latter type of cable certainly appears to offer an advantage, as being mechanically simpler than the "coil" loaded cable, but our investigations have shown that the increase in efficiency which it was desired to obtain could only be realized at an incommensurate cost. Moreover, it has been found that it is not possible to predict with sufficient accuracy, by mathematical calculation, the results likely to be obtained by the "continuous" loading, owing to the difficulty in attaching correct values to the electrical constants involved. In theory, the designing of a cable of this type seems to require merely the solution of the apparently simple problem of ascertaining the increase of inductance which can be obtained by providing layers of iron wire or

* *Elektrotechnische Zeitschrift*, Vol. 29, p. 586, 1908; and also *Journal Télégraphique*, Vol. 29, p. 187, 1905.

tape of known permeability over copper conductors of known diameter, assuming that the nature of the dielectric to be employed has been determined and that the overall diameter of the finished cable shall remain a fixed dimension.

An expression for the inductance of a loop, each of whose conductors is wrapped with a continuous layer of iron, is given in Appendix VIII. Although such a method of applying the iron would give the greatest possible inductance, either for a given outer diameter of the iron covering or for a given weight, yet it cannot be adopted owing to the excessively large increase of effective resistance which will accompany the increase of inductance, for at high frequences the eddy-current loss in such an iron sheath would be impracticably large. Hence the iron covering must be electrically divided, not continuous. In the cables of Appendix VII. the iron was served in the form of one or more layers of wire; and for a loop so loaded, the inductance and increase of effective resistance due to the eddies in the iron may be calculated from the further formula of Appendix VIII.

(*To be continued*).

THE SEARCH FOR SECRECY IN RADIO-TELEGRAPHIC COMMUNICATIONS.

(From a pamphlet of the Congresso Internazionale della applicazioni electriche. No. 26).

SECRET communication by wireless telegraphy from a station A is that which enables the message to be received by stations B, C ° ° ° ° to which it is desired to send it, whereas other stations either are not affected, or at any rate receive the message in an unreadable form.

The importance of secrecy varies with the nature of the transmitting stations, thus whereas it is best for messages sent by ships, whether signals of distress or others, to be received by all other ships or land stations within range, it is on the other hand highly undesirable for messages from military or postal stations to be read by any but the station for which they are intended. Postal stations will generally be long range ones, and they are not liable to intentional interference as would undoubtedly be the case with wireless stations with an army in the field.

Several methods have been adopted to ensure the secrecy of messages, viz. (1). The tuning method:—(*a*), Electrical tuning; (*b*), mechanical tuning. (2). Application of directed waves. (3). The use of a series of wave trains. (Bull's system). (4). The use of figures or of cryptography. (5). The use of mechanical apparatus inserted in the transmitter, which automatically transcribes the telegram into secret characters from which they are re-translated by a similar apparatus in the receiver. (Hovland's system). (6). The use of high speed telegraphy.

The first method is based on the known fact, that in feebly damped circuits strong oscillations are only produced under the influence of waves of frequency equal to, or nearly equal to that for which the circuit is tuned. It can be applied in two ways. With a receiver tuned to a certain frequency it is possible to adopt either of the following methods:—(1). To send waves of the same frequency, but only during the duration of the telegraphic signals. (2). To send waves of a frequency equal to that of the receiver during the transmission of signals and waves of a slightly different frequency during the rest of the time. The disadvantage of the first method is that any station which can easily tune its receiver can in a short time get the right tune and consequently intercept the message. The second method is by far the better—the difference in tuning need in the case of continuous waves only be very small (about ½ per cent.). The receiving station must be very sensitive. It is moreover possible to occasionally vary the tunings, on a prearranged system which further increases the difficulty of intercepting the messages. The advantage of the tuning method is that communication cannot be easily interfered with except by very powerful waves, or those of the same wave-length; in fact whilst making interference difficult it does not absolutely prevent overhearing. It is generally combined with the methods which will be subsequently described; it does not involve the use of any special detector, but admits of the employment of detectors of the most varied descriptions. (*b*). A mechanical tuning is produced, when one or more instruments in the receiving circuit, such as relays, telephone diaphragms, etc., are syntonized with the frequency of the spark, so that they become especially sensitive to impulses which possess its frequency. This method is of no particular use for the insurance of secrecy, except inasmuch as it increases the sensitiveness of the receiver and thus admits of the use of less energy in the transmitter, which makes interference on the part of strange stations more difficult.

(2). By employing directed waves, it is possible to restrict geometrically the area over which the interception of waves is possible, but stations on a direct line between those in communication cannot be prevented from reading messages. The efficiency of this method will increase when it is possible to direct waves better than at present; the fine results already achieved by Bellini-Tosi and others make it likely that this will take place.

(3). This method consists in using a set of definite series of wave-groups—a series is necessary to discharge the receiver—each series is composed of several wave-groups, emitted at varying intervals of time. The disadvantage of this ingenious system is the time it takes, for a complete series is required each time to discharge the receiver and thus the speed of sending is low. It is moreover comparatively easy for a third station to discover the nature of the series and thus intercept the message.

(4). Cryptography being by no means a system restricted to wireless telegraphy it is not necessary to describe it here in detail. Its disadvantage from the wireless point of view, is that any stray waves easily increase the difficulty of receiving, and thus special precautions must be adopted to ensure the correct receipt of the message.

(5). To Captain Hovland, Norwegian Navy, is due an ingenious system which consists in the insertion of apparatus in both transmitter and receiver, which automatically cipher and decipher messages. This is open to the following disadvantages:—(i.). The two special apparatus must be properly set. (ii.). The speed of transmission is small. (iii.). Special coherers or detectors, easily influenced by stray waves, are required.

(6). High speed telegraphy tends to make a message hard to intercept as there is but little time in which a strange station can get into tune with the two stations at work. The speeds hitherto recorded with the Poulsen system are 300 words per minute for a distance of 300 kilometres and with an initial energy of 2·3 kilowatts and 170 words per minute for a distance of 1,500 kilometres (partly over water) with a primary energy of 32 kilowatts. In the first case both masts were 65 metres high, in the second the transmitting mast was 100 metres and the receiving 65 metres. A very sensitive suspended coil galvo. was used at the receiving end.

The author concludes by stating that to ensure secrecy the best methods are; for a definite wave-length:—(1). Use of cryptography. (2). Use of the Hovland system for short distances. (3). If the stations are situated far away from one another and much trouble is expected high speed telegraphy, with or without ciphers, should be employed.

A. H. SCOTT.

THE TRANSYRIAN RAILWAY.

(From the *Revue Militaire des Armées Étrangères*, October, 1911).

ENGLAND is at present connected to India by means of two telegraph lines:—

(1). *Viâ* Constantinople, Scutari, Siwas, Diarbekir, Bagdhad and Bassorah, after which point the line is continued by the cable of the Persian Gulf Co.

(2). *Viâ* Berlin, Warsaw, Odessa, Kertch, Tiflis, Djulfa, Tavriz, Kazvin, Teheran, Ispahan, and Karachi, at which point the line joins the Indian network.

This second line is maintained and worked in Persia by an English company. Both lines follow the caravan tracks which have been in use for centuries. One of these lines, that *viâ* Bagdhad is about to be, so to speak, supported by a railway; this gives it advantages over the Persian and not improbably will result in a loss of trade for the second line. What more natural then than the construction of another railway line to support the line thus weakened.

For many years the entire export and import trade of Persia has been almost entirely in the hands of Russian or English houses, and the treaty of the 31st August, 1907, fixed the spheres of influence of these two countries. Thus Great Britain promised not to endeavour to get for her own subjects, or those of any other nation, contracts of any description or commercial advantages north of a line going from:—Kars-i-Shirim, Ispahan, Yezd, and Khakh to the junction of the Persian, Russian and Afghan frontiers, and moreover undertook not to oppose any concessions asked for or obtained by the Russian Government in the region north of the above line.

Russia makes similar promises for the country south of a line from the Afghan frontier to Gazik, Kerman and Bender-Abbas.

Finally both Russia and Great Britain agree not to oppose without previous discussion the granting of privileges to subjects of one or the other power in the district between these two lines.

The only really efficient military body at the disposal of the Shah is the Cossack brigade (eight squadrons, a battalion and two batteries) which force in view of its small numbers is incapable of keeping order in the interior of the country. For this reason Russia garrisoned the chief towns in her sphere of influence with Russian troops. The Persian Government however has begun to concern itself with the security of the regions and has asked for the repeal of the Russian garrisons. Swedish officers have been asked for to reorganize the Persian gendarmerie.

In the British sphere of influence, brigandage was in full swing in 1910, and the Foreign Office proposed the creation of a police force of

Persian soldiers and British officers on the same lines as the Cossack brigade, but measures were taken by the Persian Government and thus this scheme fell through.

There have been since 1907 repeated disputes between Persia and Turkey as to the possession of a strip of territory 30 k.m. broad and 250 k.m. long on the common frontier of these two States.

Finally Germany is seeking by means of the Bagdhad railway to open a market for its produce in Persia, and has already got one bank in the capital, Teheran.

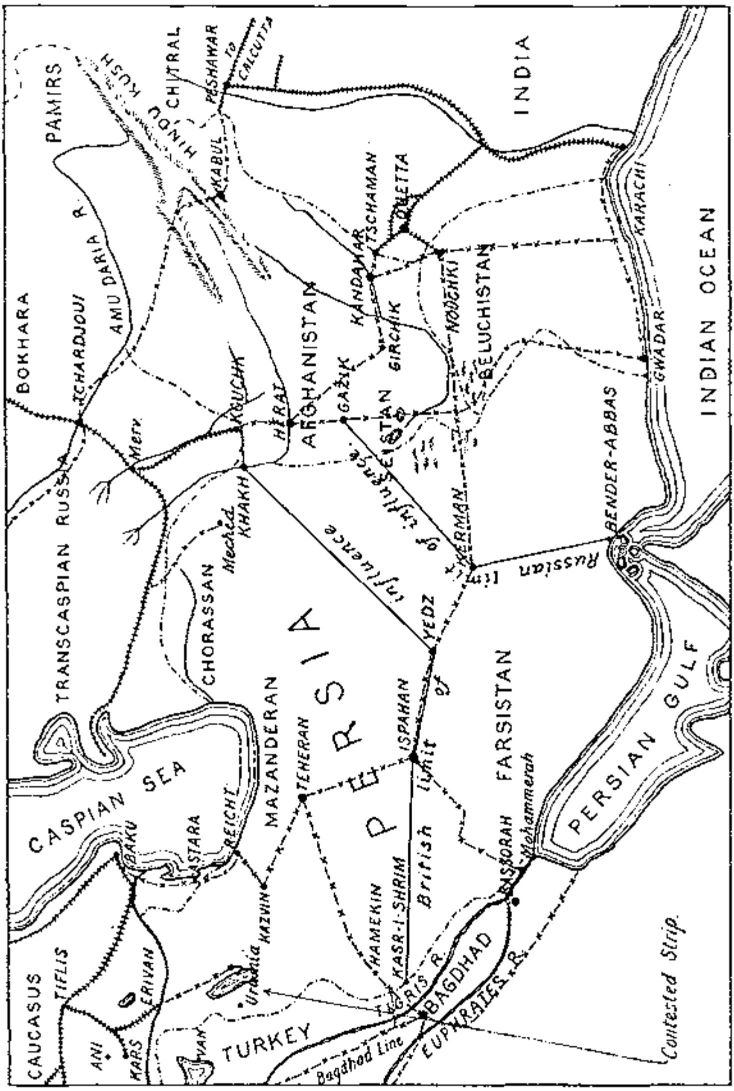
Russia has declared herself prepared to allow the construction of the Bagdhad railway and agrees to construct a line from Teheran to Hamekin so as to join the Bagdhad line at the latter point; and in return Germany promises not to traffic north of the line Kasr-i-Shirim, Ispahan, Yezd and Khakh, and the Afghan frontier, *i.e.* the line of demarcation of the British sphere of influence. Thus the situation at present is that Russia's interests in Northern Persia remain untouched, so do Great Britain's in the south-east, and Germany awaits the opening of the Hamekin line in the west.

When the Persian capital is joined by rail to the Bagdhad line, the situation will alter, for then Teheran will be about equally near to the German railhead and to the Russian frontier, and German and Russian commercial interests will oppose each other. It is in fact not improbable that in certain respects the Germans will have advantages over their rivals; hence the necessity of opening up by rail some other part of the country, so as to provide a fresh market for Russian goods, and hence again the origin of the Transyrian.

The Russian idea is to combine this advance of her railway system with a through line to India, thereby getting the trade from England to India which at present seems likely to be absorbed by the Bagdhad line.

Between the Russian and British possessions in Central Asia there lies Afghanistan, a country of about the same size as France, which separates these possessions by a strip 550 to 600 k.m. wide in the south and 25 to 30 k.m. wide in the north. The country in the north is of so hilly a nature as to render the idea of crossing it by a line of rail well-nigh impossible. The conquest of this country is fraught with such difficulties as to make it a very hazardous enterprise, and more is to be gained by letting it gradually civilize itself under the influence of its own Amir. The idea of a Transyrian railway has led both countries to study Afghanistan during the last 20 years, studies which have been misinterpreted as sources of dispute, and which far from aiding the construction of the line only impeded it. It is really only since 1907, that having come to a definite understanding England and Russia are able to study together this important question which has numerous partisans in both lands. Various routes have been proposed for the line:—

(1). Of late years in England it has been suggested that the Indian railway system should be prolonged to Gwadar on the Persian Gulf, and that from there the line should go to Herat, *viâ* the Seistan, and along the Beluchi-Afghan frontier, to end at Kouchk, the present terminus of the Russian lines. The advantage of this line from the military point of view



–x–x–x– *Various lines proposed to open up new districts to trade.*

Existing railway lines.

-·-·-·- *Frontiers.*

——— *Limits of spheres of influence.*

is that it can be protected by the fleet for a distance of 400 k.m., all along the Persian Gulf.

(2). After 1907 it was suggested to start the line not from Karachi, but from Nouchki and then let it follow more or less the same route through the Seistan to Kouchk.

(3). In autumn, 1910, M. Khomiakov, former president of the Duma, and president of the Russian bank of commerce with foreign lands opened negociations in London for the construction of the Transyrian by one of the following routes :—(1). Baku, Astara, Riecht, Kazvin, Teheran, and then through the Seistan to Nouchki, (2), Djoulfa, Tabriz, Kazvin, Teheran and the same route as before. Both these lines would place Teheran 8,400 or less kilometres from Calais, the shortest distance from Calais by the Bagdhad line will be 8,660 k.m.

In Russia the extension of the Caucasus system into Northern Persia is urgently asked for.

On the whole neither country has any very great interest in constructing a line uniting the provinces of Persia to the capital, whereas on the other hand both lands wish to keep to themselves the markets of the countries round Persia, hence it seems probable that some line will be built on the route suggested in (1) or (2) (rather from Teheran southward) as a rival to the Bagdhad railway, and so tap those markets which the latter cannot touch.

A. H. SCOTT.

NOTICE OF MAGAZINE.

RIVISTA DI ARTIGLIERIA E GENIO.

September, 1911.

AERONAUTICS; ITS PRESENT CONDITION IN RELATION TO MILITARY SCIENCE.—By Capt. Ottolenghi, General Staff.—The author examines with lucidity and carefulness the practical military application of aeronautics and asks what are the practical limits? and the means of adopting an airship for offensive purposes:—(*a*), By bombarding the masses of the enemy at the time of assembly, and by dropping mines on the loading and unloading stations at the moment of confusion; (*b*), during the operations by damaging the advanced magazines and depôts of the enemy, by throwing into disorder the organizations of his retirement, troops in camp, columns on the march, while crossing a bridge, or defiles, or destroying an obstacle which delays their advance? (*c*), in fortress warfare for the defenders to ruin their adversaries' parks, and even more so for the attackers to bombard from a height the keep of the place, or by ascertaining at the right moment the opposed resistance of the garrison, and hastening the assaulting operations.

Again, an airship may be effectively employed for scouting and exploring:—(*a*), During the assembly of the troops by gaining information which could not otherwise be collected during the time that the normal means of communication between the belligerents were interrupted; (*b*), it may also be a means of exercising control over information otherwise collected, not only with regard to the army but to the whole of the enemy's country which may be preparing for the strife; it may be to ascertain the enemy's dispositions for assembling his troops in principal centres, and for their location in larger or smaller numbers, at one or the other extremity of the probable front of his initial alignment; what forces would be collected in the second line; so that the Commander-in-Chief from the beginning would be able to form a sufficiently concrete idea of the enemy's intentions; (*c*), during the operations, the aeronauts will hover and observe the exact front of the enemy's position, the initial movements of his great units, his completed works, the positions occupied by his reserves; in retreat the directions taken by the columns *en route*, their strength, and the places chosen for their halts and reorganization.

The aeronauts will more especially be able to furnish valuable information on the posts occupied by the troops who had concealed themselves in folds of the ground with the object of threatening the flanks and rear, also regarding the position of the enemy's batteries, and the effect of their fire. In mountain warfare they will render useful service by observing the action of the enemy in the valleys, and preventing surprises; and in siege warfare they will be able to discover the ideas whether of attackers or defenders, and the relative places of attack or defence, the positions selected for the batteries, the batteries under construction, the system of commands, etc.

As a means of communication they will be infinitely more rapid than any other means that could be employed. Being independent of topographical conditions and the network of roads, the aeronauts will be able to assist in the field of strategy by co-ordinating the action of the larger units, between themselves, and with the cavalry pushed forwards in advance, as well as in the field of tactics. The immediate consequence of this new state of things is the necessity of concealment.

The action of the infantry will in the future have the characteristic of great mobility; it will have to be prepared to be ready at all costs to overcome the critical period which may now be of very serious importance, and which would become unbearable, if the soldier were not able to find any period of rest under cover of the ground or temporary entrenchments, owing to the effect of the airships.

Freed in a measure from some of the duties which absorb a great part of its activity,—scouting, etc.,—the cavalry will probably return to its essential function as a combating arm, and will always assume its proper character *as an element of force rapidly placed in position.*

The artillery arm would seem to have its conditions improved owing to the possibility of discovering the concealed targets which it may have in front, and by having its fire controlled and corrected without as at present having to await the advance of the infantry. The artillery also will derive much advantage from the great distances of its ranges, without change of position which is always dangerous and is to be avoided as much as possible.

It may be said of the engineers that it is certainly destined to re-solve some of the important problems connected with military aviation and to place at the disposal of the aeronauts the latest methods of communication derived from scientific studies; especially those connected with telegraphy and wireless telegraphy.

It will probably be characteristic of the battle of the future, that the commander by the aid of the airships will have clear information of what is happening on the field; the action will be more intense and more rapid; the fronts of the alignments will be less extended than those of the last wars.

In the last and preceding wars of the latter half of the XIXth century, the battles consisted of a certain number of distinct episodes, each of which with its own character devolved from itself was quite independent of what was happening around.

In battles so conducted, the commander although he may have had at his disposal rapid means of communication and transmission of orders, was seldom able to see with his own eyes; others saw for him and hastened to report their impressions and notions. These reports were collated and the commander with their help was obliged to form a picture that was often not in accordance with the actual facts.

Matters will certainly be changed after aeronautical science is employed as a subsidiary to military operations. The commander by means of the information given by the airship will be able to form an exact idea of the situation.

The battles of the future will be characterized by greater rapidity in the evolution of manœuvres. And the reason is obvious. That state of nervous tension caused by the continuous preoccupation of an unknown danger will be increased by a new peril threatening from above. And since the trenches and folds of the ground cannot prevent this new danger, and concealment may be a useless precaution, a feverish movement of action and of overcoming the crisis may be engendered among the troops with a view to obviating the impending danger. Hence the necessary consequence will be the rapid evolution of manœuvres.

And another characteristic of future battles perhaps will be a smaller extension of front.

Considering all these new characteristics of the battles of the future it perhaps may not be too premature to foresee a return to the Napoleonic conduct of operations, when battles were conducted in three distinc phases,—the *preparation*, the *development*, and the *crisis* and these were determined by the will of the Emperor.

So we may be induced to ask if the day may not be very far off which was prophesied in the enlightened mind of Von Goltz* in which in the face of large masses wanting in valour like the armies of Xerxes and Darius a new Alexander may arise at the head of a reduced body of soldiers, perfectly armed and exercised, solidly constituted, who would easily overcome troops innumerable but enervated and inoffensive.

Offensive and Defensive.—Authors of all times have pronounced in favour of one or the other methods of combat, Clausewitz decisively in favour of the defensive, while Blume considered the offensive as the most efficacious. No one can be surprised that the question again arises after the conquest of the air, the greatest victory over nature of any time, but we can reliably affirm that the defensive will derive greater profit from the new science than the offensive.

Instruction of Officers.—Breadth of view has always been required from officers, with a ready and safe judgment and ability to discern the truth from the false. Above all they should in all cases enquire—What is to be done in analogous circumstances? How to solve this or that tactical problem? How to exercise the command of this or that detachment?

It seems to us that in such considerations, with the new science of aerial navigation there should be created a new special instruction for officers, especially for those called upon to direct the operations of war. The picture taken from above that will be presented to the eyes of these officers will not be very different (except in its proportions) to that represented on a topographical map on a large scale, and should represent

* Barone Colmar von der Goltz—La nazione armata. Prefazione.

with proper markings, the troops on both sides. This shows the importance of instruction for officers in the study of these pictures and completing their professional culture by applying such study to the direction of manœuvres by means of the map.

E. T. THACKERAY.

BOOKS RECEIVED.

HANDBOOK OF THE SWISS ARMY. Prepared by the General Staff. H.M. Stationery Office. 1911. (*For Official use only*).

SCHEME AND ORDERS FOR THE MILITARY ARRANGEMENTS AT DELHI IN CONNECTION WITH THE CORONATION DURBAR. Superintendent Government Printing, Calcutta. 1911.

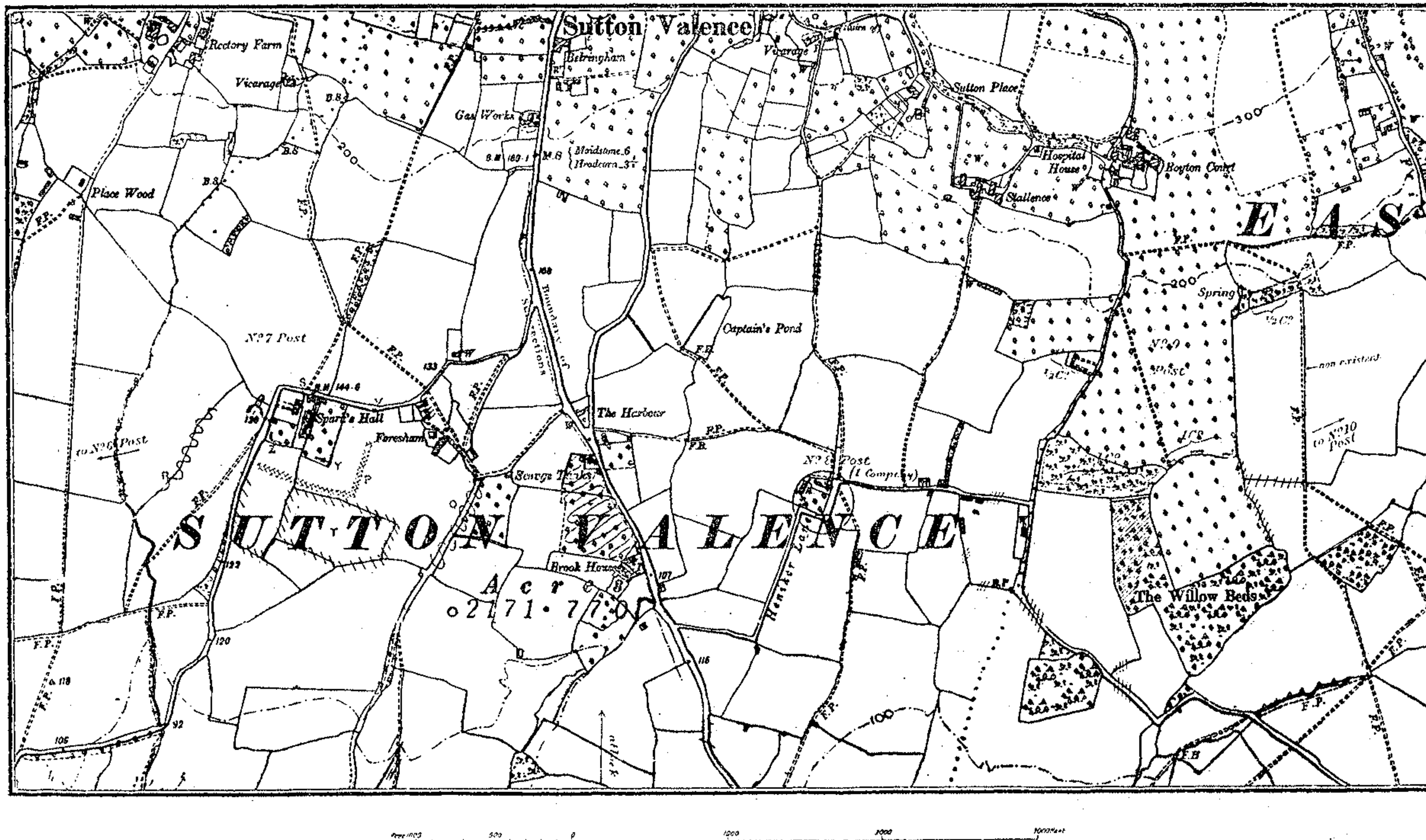
THE HIGHWAY OF THE AIR AND THE MILITARY ENGINEER. A Lecture by Lieut. Geo. A. Taylor, Australian Intelligence Corps, at the United Service Institution of New South Wales. July, 1911.

BUILDERS' QUANTITIES. By Horace M. Lewis. 1s. 6d. net, 1s. 9d. post free. E. & F. Spon, Ltd., 57, Haymarket, London.

THE RADIO-TELEGRAPHIST'S GUIDE AND LOG-BOOK. A Manual of Wireless Telegraphy for the use of Operators. With 90 illustrations. By W. H. Marchant. Price 4s. 6d. net. Whittaker & Co., 2, White Hart Street, Paternoster Square, E.C. 1912.

Fig. 1.

DETAIL OF WORK DONE AT N°. 7 AND 9 POSTS.



SOME NOTES ON FIELDWORKS.

Fig: 2.

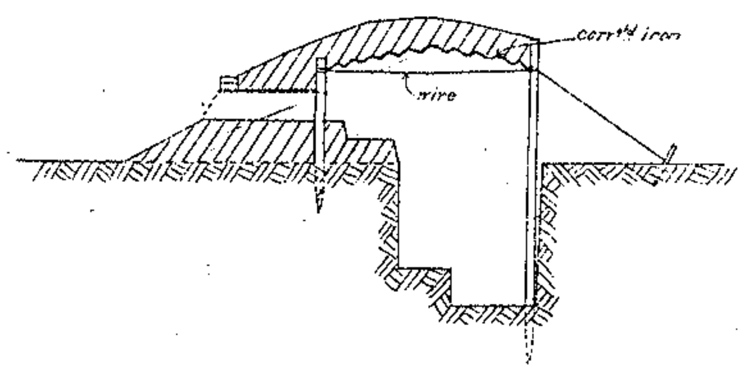
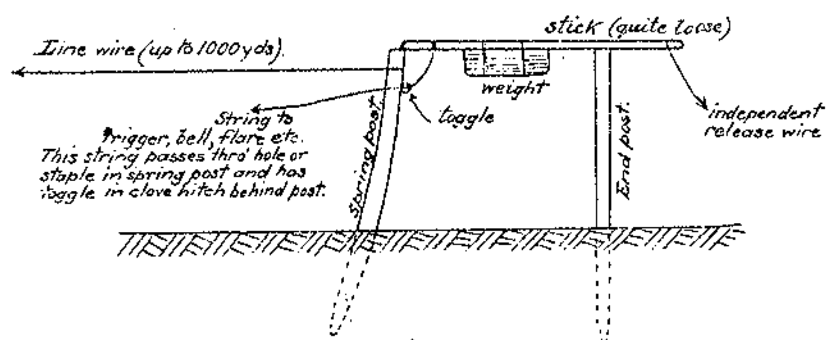


Fig 3.



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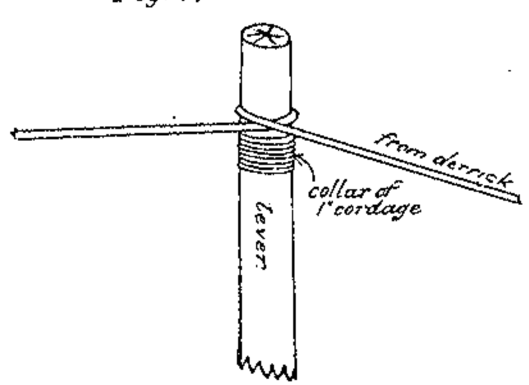
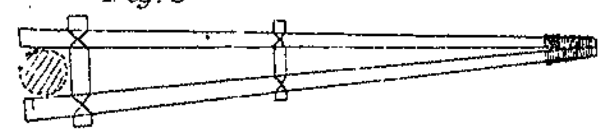


Fig: 5



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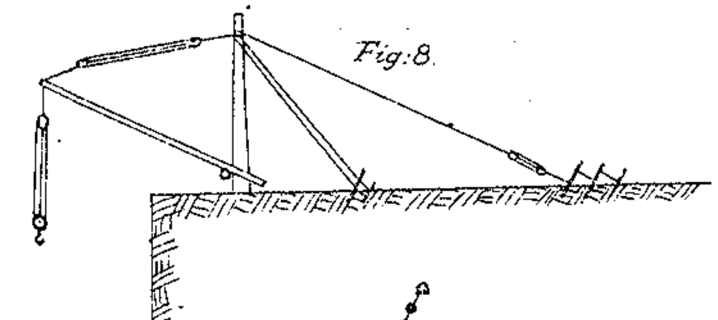

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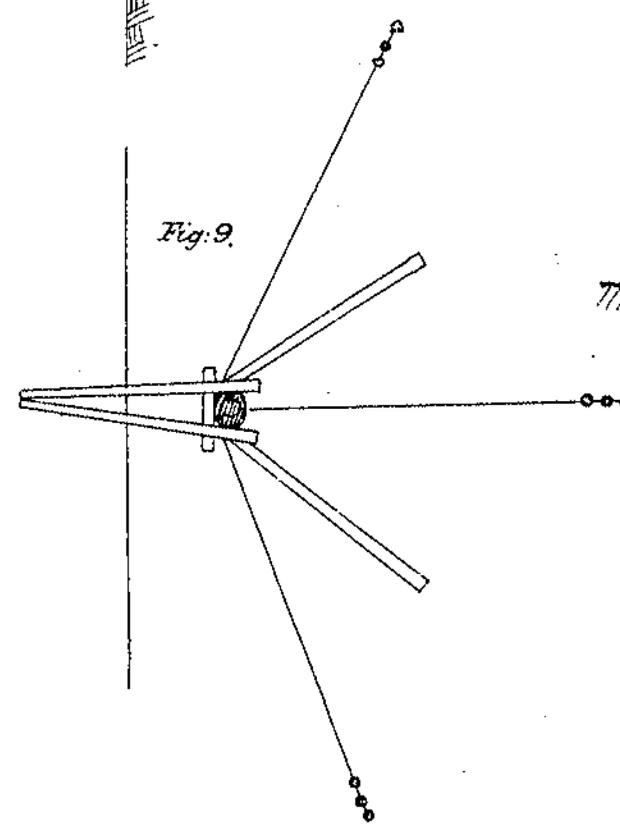

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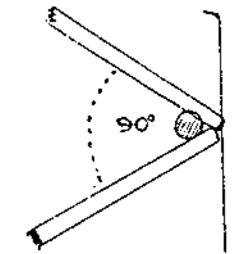

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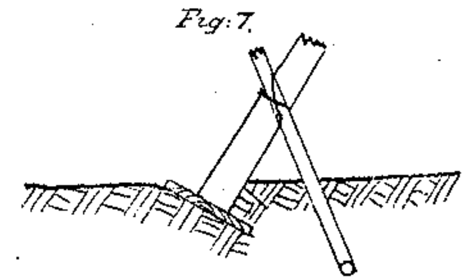

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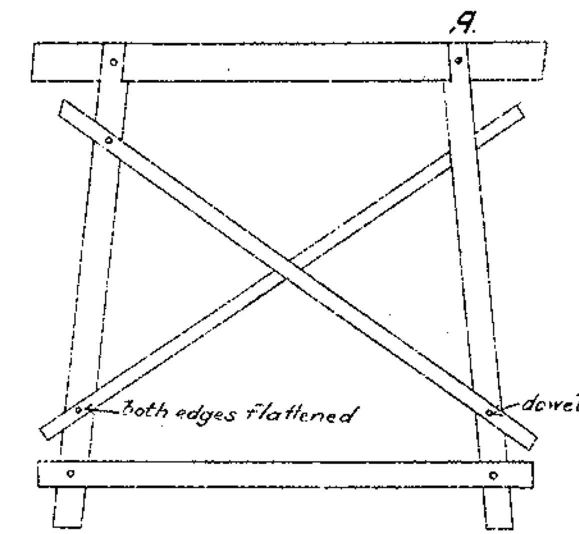

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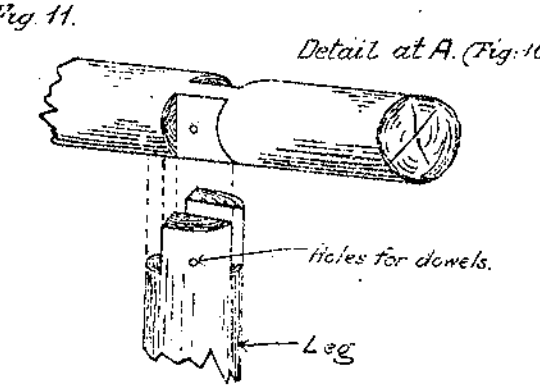

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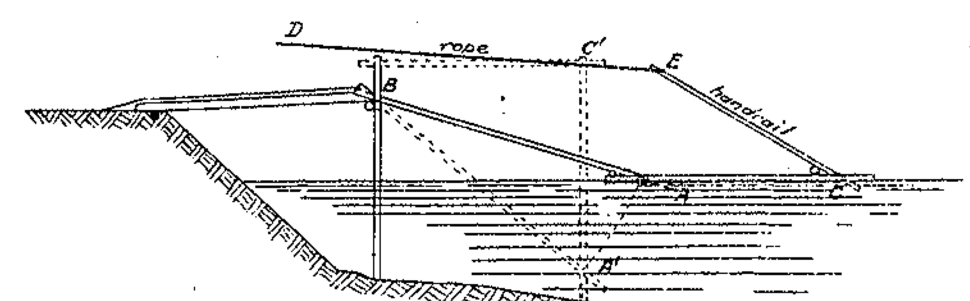


Trestle is floated to AC. A light frame AB of two spars diagonally braced is then fixed at A and B. Rope DE is then hauled on and trestle comes into vertical position at A'C'. The frame AB remains as longitudinal bracing A'B. The distance A'B must be obtained from the section.

SOME NOTES ON FIELDWORKS.

Fig: 13.

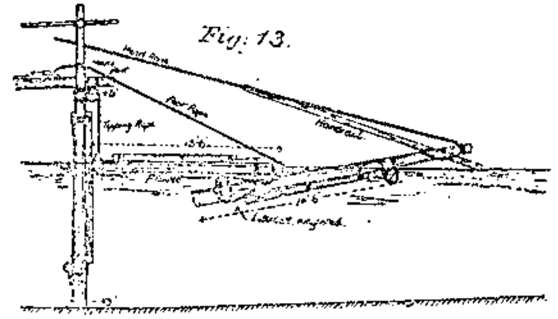
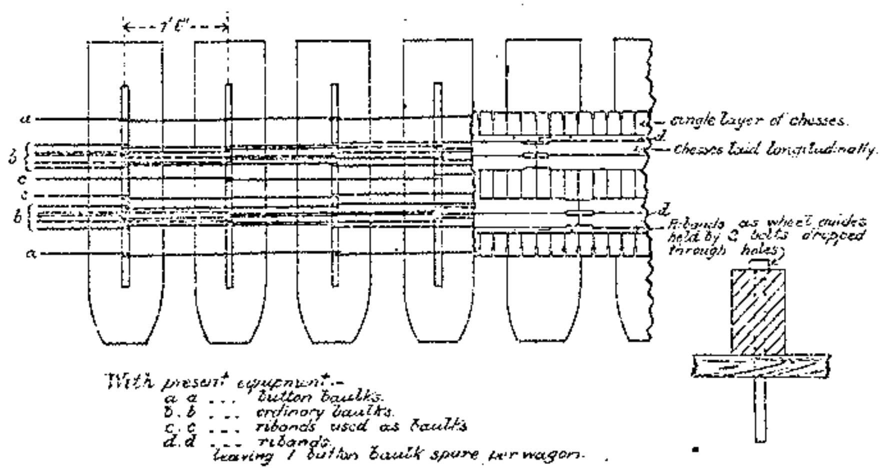


Fig. 14



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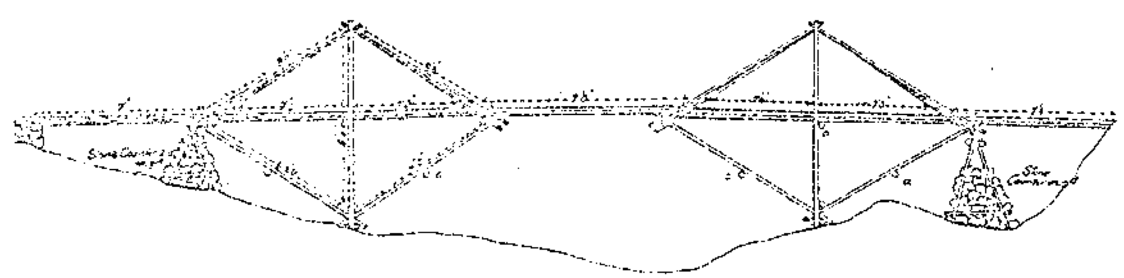


Fig: 16.

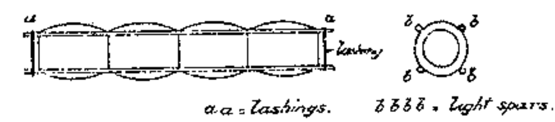
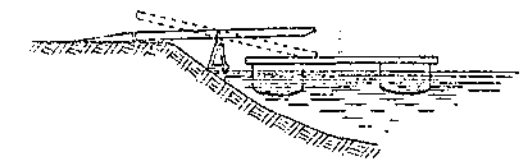


Fig 17.



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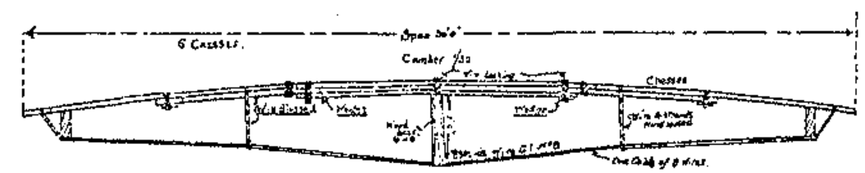


Fig. 19.

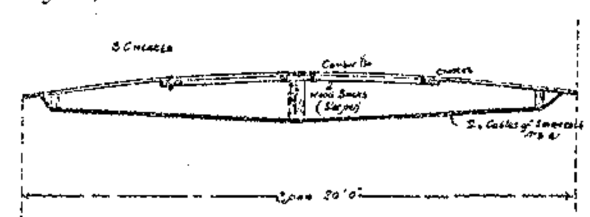


Fig. 20.

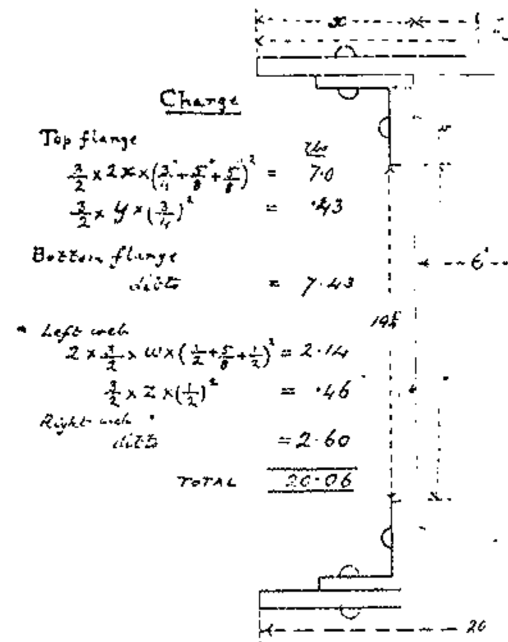
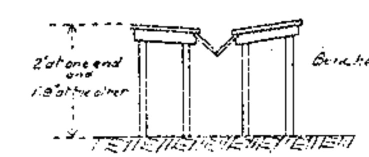


Fig. 23.



A PONTOON BRIDGE FOR STEAM TRANSPORT.

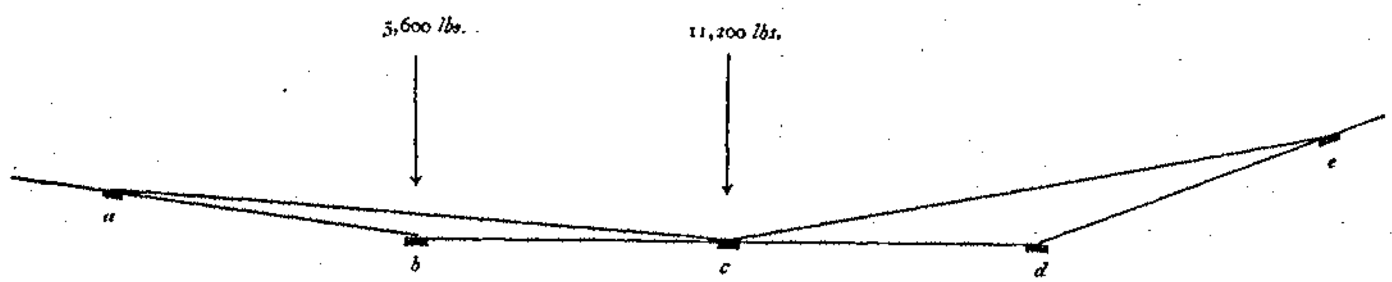
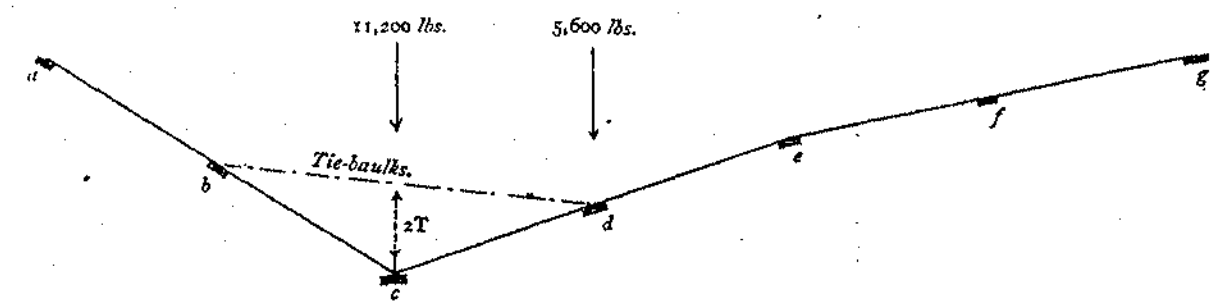


FIG. 1.



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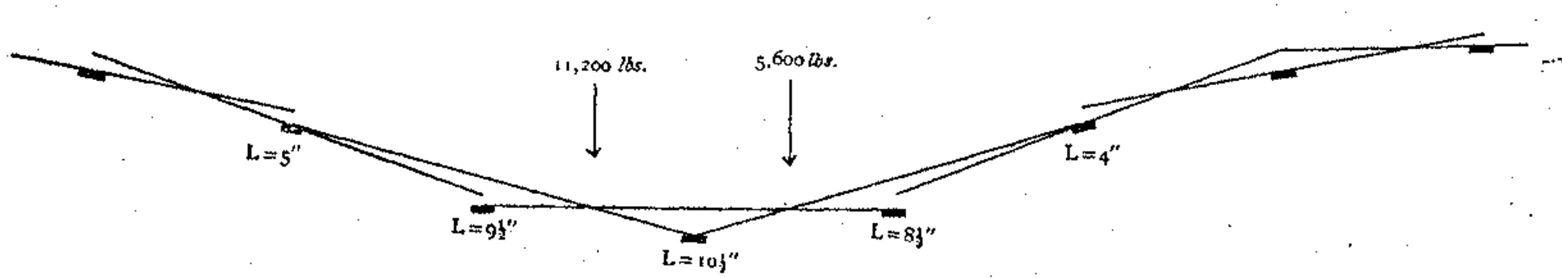


FIG. 2.

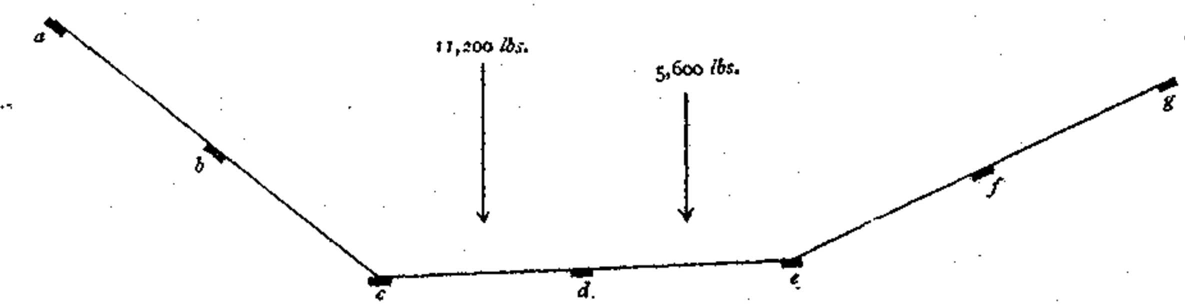
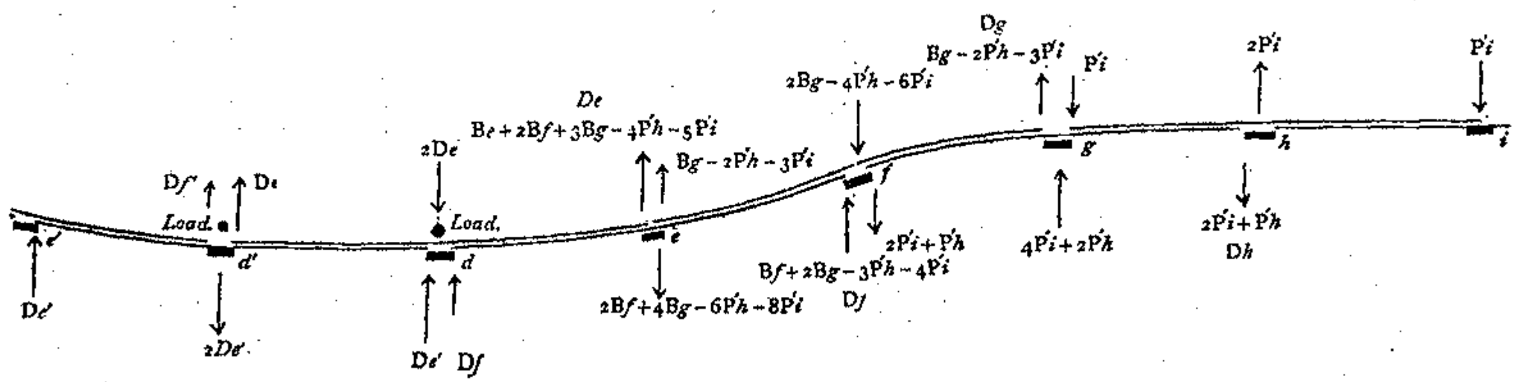


FIG. 5.



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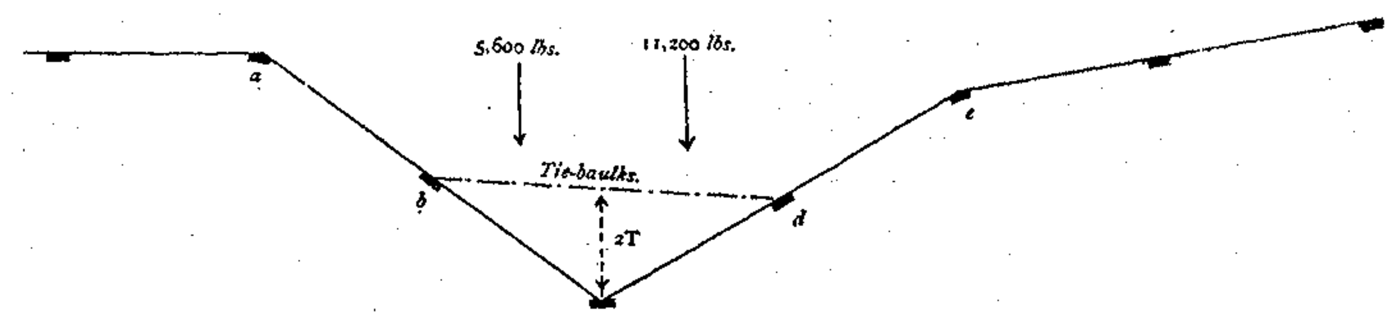
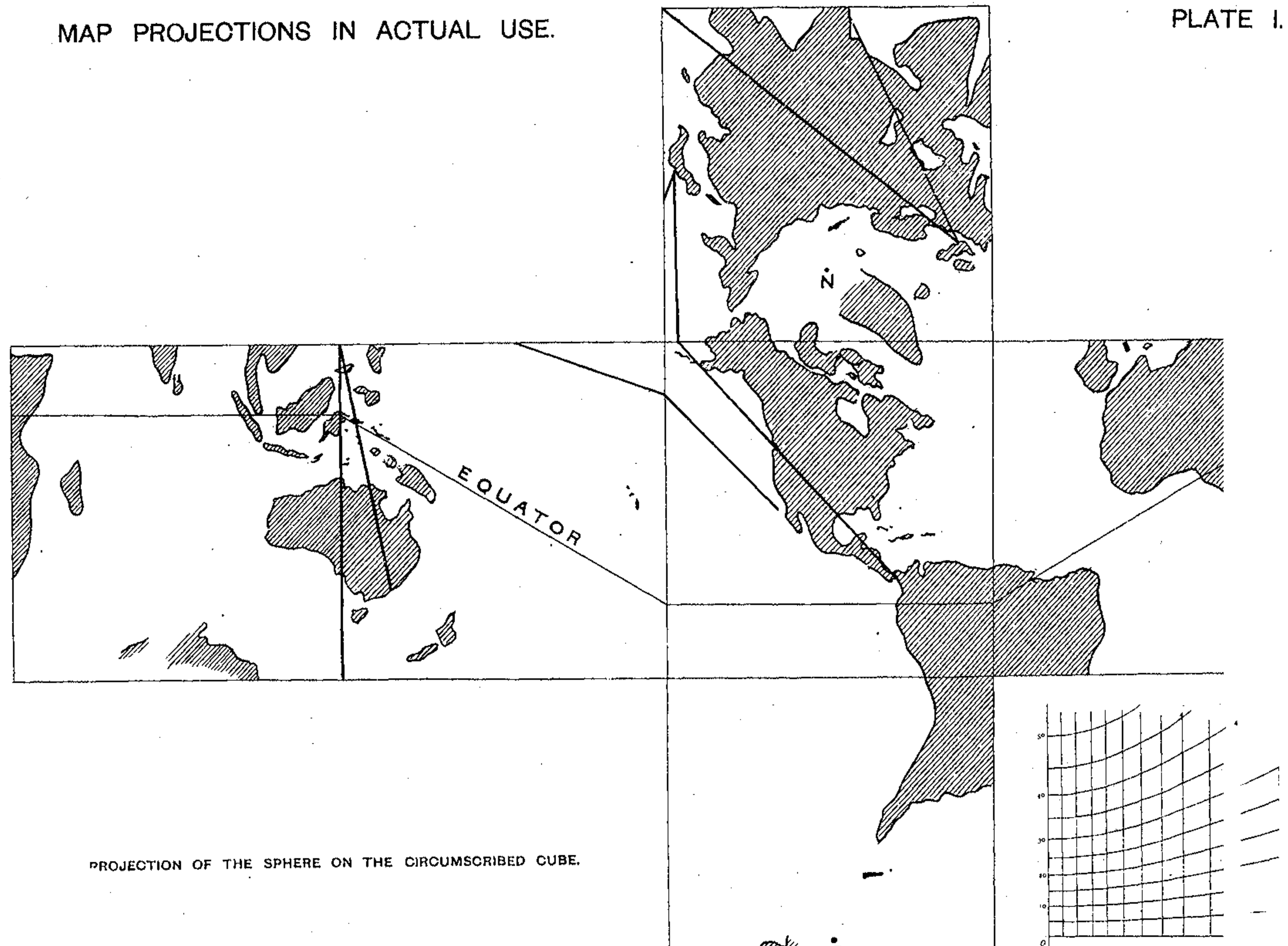


FIG. 6.

MAP PROJECTIONS IN ACTUAL USE.

PLATE I.



Scale for reading Great Circle Distan

(Place O at centre of face of cube: OM perpen
Great Circle).

PROJECTION OF THE SPHERE ON THE CIRCUMSCRIBED CUBE.