APPENDIX D.

SUBMARINE TELEGRAPHY.

The following reports, &c., relate to the subject of picking up telegraph cables in war-time, and their utilisation for signalling purposes by men-of-war.

Special attention has also been paid to finding out which is the best form of galvanometer for the purpose of mirror signalling through cables.

The methods employed on submarine cables are: (1) the syphon recorder; (2) the mirror. Syphon recorder.

(1.) The former has been set up by Messrs. Muirhead in "Vernon," and its method of working explained. It has the advantage of being automatic. The messages are stamped out on slips of paper and put into the automatic transmitter, the messages being received on prepared type.

(2.) The mirror. For this purpose a reflecting galvanometer is employed, the signals being read direct from the movements of the spot of light. The Thomson and Sullivan galvanometers are used for this purpose, and, as they are already used for ordinary work in the service it is considered advisable to employ them, although the syphon recorder presents undoubted advantages. Mirror signalling.

The question of the advisability of supplying to foreign depôts, for issue in war time, special grapnels for cutting and picking up telegraph cables has been raised. D.N.O., F. 181. N.S. 6365/98.

The picking up of a cable requires great experience, patience, and care, especially where the depth exceeds 100 fathoms, and it is consequently thought that the cable gear most likely to be of use to a man-of war would comprise :—

2 removable bow cable sheaves.
6 cable grapnels for ordinary bottoms.
2 „ „ „ rocky „
1 dynamometer set with necessary sheaves.

It is further thought that in the depth in which a man-of-war is likely to work, she could use her own wire hawsers as grapnel lines, bringing them to the capstan for heaving in.

The following is a report by Lieutenant Wentworth on his visit to the Telegraph Construction and Maintenance Company's cable ship "Anglian."

The new cable ship "Anglian" carries the latest types of machinery and gear used for cable laying and repairing. "Anglian."

The ship (8,000 tons) contains four cable tanks, each capable of stowing 1,000 miles of deep sea cable. Cable was being passed into all of these tanks direct from the works at the rate of about 85 miles per day, each succeeding layer being whitewashed to prevent the possibility of sticking together in paying out. Cable tanks.

Besides the usual windlasses for anchor work, the ship is fitted with two independent cable windlasses forward, worked by separate engines, the drums of these machines being 8 feet diameter. This large diameter is said to be necessary for working long grapnels. Winding gear.

There is the usual cable sheave over the bows (3 feet diameter). This is considered an absolute necessity for any ship working cables, as an ordinary fairlead chafes the grapnel or wire. Cable sheave.

Engine room telegraphs are fitted close to the bows so that the cable can be watched and the ship worked from there.

The grapnel lines used are compound hemp rope with three or more strands of wire inlaid. This type is preferred on account of its greater flexibility and freedom from kinks, chafing, &c. These are supplied and stowed on board in special bins in 500-fathom lengths. If necessary two such lengths can be shackled together. Grapnel lines, &c.

Two sizes are supplied, one for a 5-ton strain and the other for a 20-ton strain, the strain in lifting a cable under ordinary conditions being about 3 to 6 tons.

The grapnels used are shown in Fig. I. That marked "*a*" is for ordinary bottom, and "*b*" for rocky bottom. Grapnels.

The speed of grapnel over the bottom when grappling for a cable should not exceed one mile per hour in any case. Speed.

Above 500 fathoms the cutting and holding grapnel shown in Plate 28 is used. Fig. C shows grapnel having hooked cable. Fig. D shows grapnel having cut one side of cable and raising the other in its jaws.

Dynamometer.

A dynamometer apparatus is fitted both forward and aft. Without this, picking up cables except in shallow water (below 25 fathoms) would be an impossibility; even then great experience is necessary to know when a cable has been hooked, and to distinguish between a rock and a cable.

Apparatus aft.

The apparatus aft consists of the paying-out gear, a large drum, dynamometer, and stern sheave. An automatic apparatus records at any instant the number of knots of cable paid out, and the speed of the ship is regulated by the dynamometer strain on the cable. The position is plotted every two hours and signalled.

Under-running.

Under-running is now never resorted to, as it is a very difficult operation, and hard to avoid bringing the weight of the ship on the cable.

Conclusions.

In the opinion of Mr. Lucas (whose experience of cable laying extends over nearly 40 years) it would appear that the sphere of action of a man-of-war (as regards cable work) would probably be limited to comparatively shallow water for two reasons :—

1st. There is no space available on board for the necessary winding gear, dynamometer, &c.

2nd. Given these, the necessary experience which is essential in grappling cables, and vital in deep sea grappling, would probably be absent.

It would therefore seem, then, that for the present the ordinary form of cable grapnels only would be necessary, and the smaller the ship working the better the chance of success. The ship's wires and capstan could be improvised to do the necessary work, the strain being felt and watched carefully in the absence of a dynamometer.

Mirror speaking.

With regard to the conditions under which signalling to the shore is carried out through the cable, after the end is picked up and the method employed, it is interesting to note that the Telegraph Construction Co. are, and have been, working under precisely similar conditions in this respect to those in which it is presumed a man-of-war would be at the end of a cable. Their ships are frequently asked to repair strange cables leading into stations using instruments the nature of which they are ignorant of.

It is also a significant fact that no operators are carried on board, the necessary signalling being done by the electricians, who are capable of working at a slow speed only.

The instruments used exclusively are as follows :—

Instruments used.

Thomson's marine galvanometer (improved type), fitted with damping arrangement.

Universal adjustable shunt.

Double pedal key.

Dry cells, battery power ranging from 20 volts on long lines down to 5 volts on short lines.

Condensers are not used on board, these being invariably put on the shore end.

Under these conditions the rate of signalling can be as slow as two or three words a minute, and the deflections remain quite clear. This was actually seen and tried in the test-room.

Remarks on the Thomson' galvanometer.

The following information was elicited from the chief electrician of the company as to the relative merits of the Thomson's improved galvanometer and one of the moving coil Sullivan type :—

For rapid balancing work, especially when the ship is in motion or subject to heavy vibration, the moving coil instrument is at its best.

It is also satisfactory for mirror speaking when the rate of signalling is very rapid (not less than 15 or 20 words a minute).

It was pointed out that the usual rate of working with unskilled operators is considerably below the above (about five words a minute).

For this purpose the Thomson galvanometer is found by experience to be, not only more suitable but absolutely essential, on account of the greater stability of its deflections as compared with the Sullivan type of instrument. Indeed, the Sullivan, on its first introduction, was tried on mirror speaking work, and was rejected for the above reasons.

The Thomson instruments used have a resistance of from 6,000 to 30,000 ohms, three of these being fitted in the cable test-room.

Thomson's galvanometer fitted with damper.

The damped slide for Thomson's galvanometer has its mirror placed in the centre of an oblong strip of aluminium, which is suspended in the usual way, the suspending threads being, however, considerably stouter than before.

The whole slide, top included, is enclosed in a brass case, there being a glazed hole in the case opposite the mirror. This air-tight case assists the aluminium strip in increasing the damping effect, and limits the deflection to about 200 divisions on the scale.

It is necessary to enlarge the slot in the galvanometer to take this new pattern slide.

In all other respects the galvanometers are identical with the present Service pattern.

The following is a detailed description of the cutting and holding grapnel referred to in Lieut. Wentworth's report and shown on Plate (28), Fig. (C and D). The grapnel has a prong P, on either side for catching the cable. The arms A, A are prevented from closing by two bolts B. These bolts are thinned away in the centre, and when a heavy strain comes on the grapnel line and so on the wires at T, which are merely the ends of the wire ropes showing at the bottom of the grapnel, the bolts snap, and the arms A, A close on the cable. These arms hold the cable firmly and one arm will at the same time cut it. The knives K, K and S, S are put, one on the far, and the other on the near side of the grapnel. In the picture the cable would be cut on the side K, K, while, if the grapnel had been towed with the other side down, and the cable caught by the other prong, it would have been cut on the side S, S. This grapnel is not nearly so efficient for grappling a cable as the ordinary type previously referred to, but must be used in deep water.

Cutting and holding grapnel.

On June 18th experiments were carried out at the Western Telegraph Company's station at Penzance in the presence of Mr. Sullivan.

Report on Sullivan's Galvanometer without condenser on long lines.

The trials were attended by Commander Evan Thomas (Officer in charge of the Signalling School), a Chief Yeoman of Signals from Devonport (Higher Standard), Lieutenant Wentworth (T) of "Vernon," and a Torpedo Instructor Telegraphist.

The total length of the cable in use was 2,600 knots, the resistance 8,200 ohms, and capacity 900 microfarads.

The galvanometer, fitted with the new form of suspension and coil frame, was joined up direct to the cable without condensers, these being cut out for the purpose of the experiment.

The spot of light was, at first, thrown upon a scale, but this was subsequently removed, as the readings were found to be too large, and, for convenience, the spot was left on the wall of the room.

No shunt was employed, Mr. Sullivan preferring to reduce the deflections by mechanical means.

The method adopted was to get the distant end to send for one minute and then to make any alteration necessary, then send again, and so on.

A suspension, recently supplied by Mr. Sullivan to "Vernon," was first tried, the battery power being 40 volts.

The readings being too large, battery was reduced to 20 volts, and subsequently to 10 volts.

The test messages now, although quite readable to the cable operators, were quite unintelligible to the T. I. telegraphist and the highly trained Chief Yeoman of Signals.

Up to this point the speed had been from 18 words down to about 10 words a minute.

Mr. Sullivan now substituted a stiffer suspension for the one previously in use, in order to sharpen up the deflection, and sending was resumed at the rate of about five words a minute.

Letters here and there now became distinguishable to our men, and, after a few minutes, whole words were taken in by them.

As 1½ hours had now been occupied in reaching this stage of the experiments, it was not thought advisable to delay the traffic any longer, but, in order to try the new pattern test and signalling key recently approved for naval service, it was joined up in place of the Company's signalling key, and several messages were sent with it satisfactorily.

It is a noteworthy fact that Mr. Sullivan (although he was well acquainted with the electrical conditions of the cable, and had brought all his experience to bear upon the manufacture of a slide specially for the experiment) had some difficulty in getting signals intelligible to our two telegraphists, and a great deal of manipulation with the galvanometer was required in order to obtain this desired end.

From a signalling point of view, and whatever be the type of galvanometer employed, it is evident that special practice or instruction in this particular class of work is absolutely necessary (even to the Higher Standard men), if they are to be capable of receiving cable messages on the mirror, with any degree of certainty, even at a comparatively slow speed of five words a minute.

The chief difficulty at present is to construct an artificial line for instructional purposes which would resemble electrically the various types of submarine cables likely to be used in war-time.

There is no doubt this visit has proved beneficial. The line used was one of exceptional length, and not in good condition. The trial was an exceedingly interesting one, and gave a good idea of the difficulties which, it is thought, can eventually be overcome.

It is thought that much further experience will be gained by the proposed trip in the cable steamer, sanctioned by A.L.G. 3736/3551 of 6th June 1899. It has been ascertained that the Telegraph Construction and Maintenance Company will have much pleasure when the opportunity occurs of acceding to their Lordship's wishes, which are that a torpedo officer and two men should be allowed to make a short trip in a cable ship in order to witness the actual conditions and method of signalling, and the processes of grappling and raising a submarine cable.

This trip will afford an opportunity for experience with the Thomson instrument as a mirror speaker, and enable a comparison with the Sullivan to be directly obtained as to their relative suitability for cable work.

It is furthur thought that all we can do in the meantime will be to endeavour to reproduce, in a line artificially for practice, conditions somewhat analagous to signalling through long cables, and this matter is being looked carefully into.

From the present experience it will not be desirable to go to the expense of extra suspensions of the new pattern for Sullivan's galvanometer, as it is thought that, in its present state, too much skilled manipulation is required.

Report on galvanometers by captain of "Vernon," 17 April 1899.

It is thought that sufficient experience has now been gained to be able to form an opinion as to the relative merits of :—

(1.) The Sullivan galvanometer.

(2.) The Thomson galvanometer (with improved slide).

The slide was fitted, at a cost of 6*l.* 6*s.*, to a service Thomson galvanometer, and the suspension so adjusted as to give a sensibility practically equal to that of the Sullivan.

Under these conditions, over short lines, both with and without condensers, as regards "dead beatness," neither has the advantage, although the Sullivan is, perhaps, slightly quicker in reaching its final position on the scale.

Both keep their zero equally well.

In forming an opinion as to the relative merits of the two instruments for Service purposes, it must be borne in mind that there are two distinct uses to which they would be put, and that these demand qualities which are, to a great extent, opposed to one another in actual practice.

(1.) Balancing, testing, and measuring.

(2.) Mirror signalling in war-time.

The Sullivan instrument is, doubtless, the most suitable for the first of these, and it is on this class of work that it is thought a mirror galvanometer would receive most use on board.

(1.) Altogether, taking into consideration :—

(*a.*) The use to which a reflecting galvanometer would, in the vast majority of instances be put on board; and

(*b.*) The rough handling, want of skill in setting up, and possible want of practice in the operator himself,

there is no doubt that the Sullivan galvanometer is the most suitable instrument of the two for all-round use in the Service, and this especially so when it is considered that the instrument would almost exclusively be used on the above-mentioned class of work, *i.e.*, balancing and testing.

With regard to (2) :—

Report on galvanometers.

In short lines, up to a few hundred miles, the two instruments are equally good; but when working through long lines of high resistance and electrostatic capacity the Thomson instrument, owing to its high resistance (5,000 to 30,000 ohms), would be the most suitable of the two, since there would be no "creeping" of the deflections, and messages could be sent at a low rate, three to five words a minute if necessary.

It may be mentioned that the majority of cable-repairing ships use a Thomson form of galvanometer, fitted with a damped speaking slide for signalling purposes; and it is also well to note that a great many of these ships carry no trained telegraphist, the ship's electricians dealing with the necessary signalling at a slow speed.

It is the probable necessity of having to work at a slow speed which would render a high resistance instrument, with a mechanically damped mirror, more suitable for service work, particularly taking into consideration the possibility of having to signal to strange stations.

If trained operators and a quick rate of working could always be ensured, then the Sullivan Galvanometer would probably fulfil all requirements.

In this connection it is well to note that the two largest cable-laying and repairing firms, viz. :—(1) Telegraph Construction Company, and (2) Messrs. Siemens Bros., use high resistance Thomson type of galvanometers with mechanically damped slides for speaking purposes in their cable ships.

It is also an interesting fact that these companies (who between them have laid the majority of submarine cables in the world) are working under precisely similar conditions, in this respect, to those in which it is presumed a man-of-war would be when at the end of a cable, since the Companies' ships are frequently called upon to repair strange cables, leading into stations using instruments the nature of which they are ignorant of.

If it is thought of sufficient importance to equip fleets with the apparatus necessary for signalling through long cables I would suggest supplying each flagship, torpedo depôt ships and foreign depôts with Thomson's Galvanometer (improved) for speaking purposes, together with one submarine cable-signalling key.

It may be pointed out that this could be done at comparatively trifling expense, as there are now a large number of Thomson galvanometers in the service which could be converted and brought up to date at a cost of 6*l.* 6*s.* each, the best of these instruments being selected for the purpose.

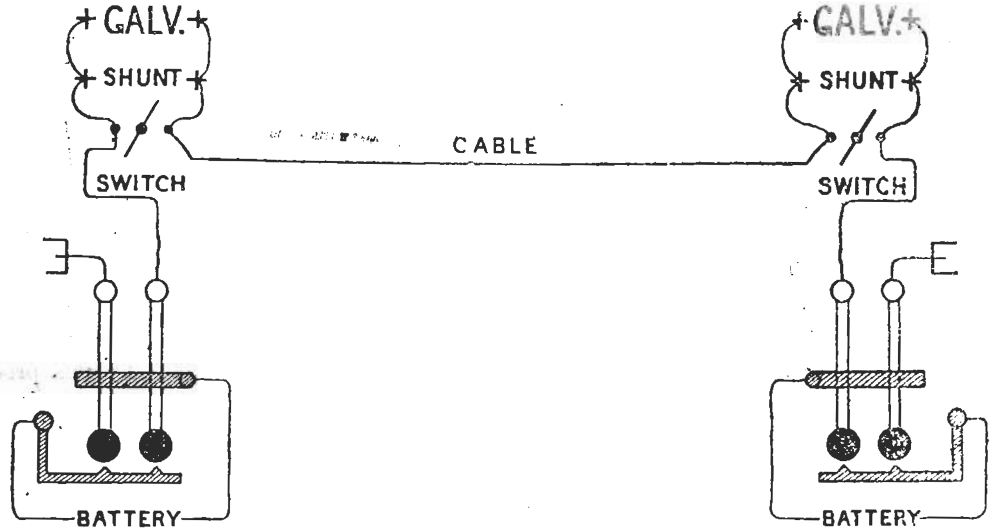
By this plan we should have the Sullivan galvanometer for general work in the fleet, &c., and sufficient Thomsons for mirror signalling available for war.

As regards condensers, these are never used at the ship end of a cable, and cable ships do not now carry them.

Connections.

The appended sketch shows the method of joining up two stations for mirror signalling in its simplest form. The galvanometers should be short circuited by the switches whilst sending, except for an occasional test.

The voltage employed for short lines is usually about 10, and, should faults in the cable necessitate increased voltage in sending, it should not exceed 20 unless condensers are available to protect the cable.



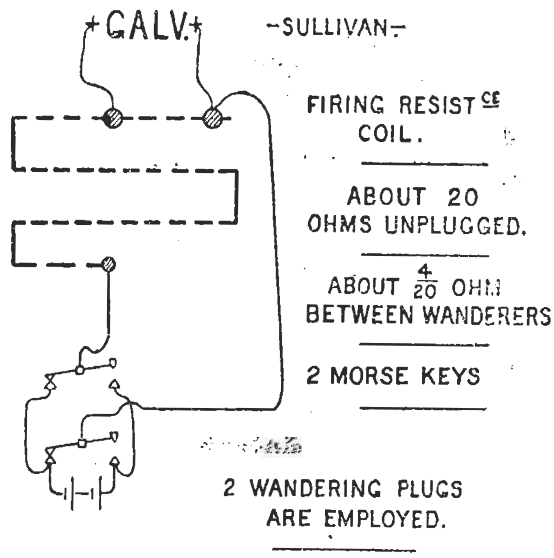
A reversing switch for the galvanometer is often useful.

Practice.

Ships carrying Sullivan galvanometers can obtain a rough idea of this form of signalling by joining up the galvanometer to a F.R. coil and two keys, as shown, and sending at the rate of about 10 or 12 words per minute, using a battery of two or three cells, according to the length of scale available for reflecting the spot of light.

Artificial line.

The type of signalling on sound lines has been more clearly reproduced in "Vernon," but the system of connections requires considerable simplification.



No artificial line at present constructed ever reproduces the "wandering" of the spot of light **due to faults** in cables, earth currents, &c., and it is the irregular moving of the position of the **zero point** which necessitates constant practice.

CABLE GRAPNELS.