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RAPID CABLE LAYING FOR WAR PURPOSES.

By Lieutenant WILLIAM C. CRUTCHLEY, R.N.R.,

AND

C. SCOTT SNELL, Esq.

Wednesday, April 28th, 1897.

Lieut.-Colonel Sir GEORGE S. CLARKE, K.C.M.G., F.R.S.,
in the Chair.

The CHAIRMAN :—I do not think there is any subject which can be brought before the Institution which is more valuable to this country than the question connected with the use of cables in war. In peace we see every day our fleets moved throughout the world by cable messages, and we know that our foreign commerce is practically also all directed by cable. What we do not know yet, and what we want to know is, how far that communication can be carried on in war. Anything, therefore, which will facilitate that communication and enable us to keep up the stream of information which we require, seems to me one of the greatest advantages we can possibly obtain. I am sure, therefore, the lecture we are about to hear will be both valuable and instructive, and I will call upon Lieutenant Crutchley to read his paper.

LECTURE.

SUBMARINE telegraphy in any future naval warfare must inevitably play a very important part.

If the mind can imagine so unusual a state of things, consider what would be the position of Great Britain separated from contact with the world save by steamer alone. Early intelligence in all naval warfare in the past has proved itself invaluable, and there is no reason to believe that it will be of less importance in the future, when the facilities for combination afforded by steam are contrasted with the naval combinations made under sail in the earlier portion of the century.

The object in reading this paper is to elicit an opinion whether in future operations it will be to the advantage of a naval commander-in-chief to have at his disposal the means of establishing communication with either a base, or outlying pickets of ships at a moderate distance, say from 300 to 500 miles. Not only so, but whether the fact of his being able to establish such communication at the fastest speed yet attained by a war-ship may not be of material value in working out a combination of effective force.

It is claimed by the inventor of this apparatus that he can safely lay a submarine cable at any rate of speed within the compass of the fastest cruiser. This would be so far in excess of anything which has hitherto

been accomplished, that some doubt might be expressed as to the possibility of so doing; but that the plan is feasible, is vouched for by so eminent a practical authority, that little doubt can be entertained as to its possibility.

It is needless to say that practical illustration of this would cost more money than it might be convenient to find for such demonstration; but should the verdict given this afternoon be favourable, I have little doubt that such demonstration will be made.

The apparatus is capable of being fitted to a war-ship or a properly equipped telegraph-ship, or as an alternative there is a temporary arrangement which is capable of being adapted to any vessel at very short notice.

Recent discoveries in electricity have given us greater power in communicating than we have hitherto possessed.

I speak now of the possibility of inducing currents in a cable without making actual metallic contact, and that this can now be done is established beyond any doubt (particulars are given in an appendix); it is, therefore, a further reason why such a scheme as is now brought before you should receive your most earnest attention.

With these few introductory remarks I will now pass to a description of the apparatus, and will afterwards sketch out one plan of how this might be of the utmost value in war-time; and the reason I select the instance I do, is that by selecting operations in peace, for example, we offend the susceptibilities of no one.

We may with advantage first take into consideration the type of cable proposed to be used, and in connection with this the following from an eminent maker may be quoted:—"As regards the cost of a submarine cable which would suit your proposed scheme, and which it would be possible to lay and lift more than once, we could supply a small bright cable as under: A conductor of seven tinned copper wires, each No. 22 L.S.G., stranded; insulated with pure and vulcanised india-rubber, sheathed with steel wires, made up in strands of three wires, each No. 20 L.S.G. The price of this cable would be £60 per knot, delivered in tank at our works. The total over all diameter would be 0.45 inch, and the weight 11.4 cwt. dry in air, or 8.75 cwt. when immersed in salt water, the above weights being per knot.

In relation to this matter the mind must be quite disabused of the idea that the cable is to be dragged out of the vessel, as in every-day practice; were this so, the length of the cable, when laid at such a high speed, could not by any means exceed the distance traversed by the ship, it is, however, essential that provision should be made for such a surplus delivery as will admit of inequalities in the sea bottom being provided for, so that no long unsupported spans are likely to exist. At the ordinary speed of cable laying, the cable forms an inclined plane down which, as it were, a percentage of slack can be delivered by loosening the brakes on the retarding gear. At such a speed as 20 knots it is evident that the angle assumed by the cable must be very small, possibly less than five degrees; we therefore find ourselves working under very different conditions.

It will not be denied, however, that it would be possible to lay a thread of cotton from such a vessel as the "Lucania" on an Atlantic voyage, providing, always that the thread was not dragged out of the ship but was thrown away from a wheel at the stern, at a rate in excess of the speed of the vessel. No doubt such a fragile material would be soon destroyed by the action of the waves and currents; but, nevertheless, there is no reason why continuity of delivery into the sea should be imperilled. With the ship at anchor there is, of course, no reason why 21 knots of cotton should not be paid overboard within the hour.

We will now take our electric cable into consideration, and it must be admitted that if this also be similarly handled, we are justified in adopting a similar conclusion; further, although a lengthy term of service is not likely to be required, reliability is a very important factor, and we are, therefore, justified in delivering overboard a goodly margin of slack; dividend paying considerations of course do not obtain.

The mechanical methods to be employed in order to throw overboard cable at the rate proposed require careful consideration. Let us at the outset remember that steel cables for power transmission purposes are in daily use at such speeds as 80 feet per second, *i.e.*, about double the rate of our maximum demand. There is no reason why the appliances used in power transmitting plants should not, with slight modifications, feed a quantity of cable stored in one position, to another some hundreds of feet away, instead of operating an endless cable. This is exactly what we are contriving to do, in delivering from the hold of the vessel into the sea astern. In our sea service, however, we have extra contingencies to provide for, such as the risk of error in making due allowance in the matter of "slack," thus causing a stress to come upon the cable from without the ship.

The presence of such a strain it is proposed to notify, as well as to make provision against ill effects, by the following arrangement: A pulley at the stern *ejects* the cable overboard, and is driven by a motor capable of exerting only a comparatively small power, and beyond this stern pulley (if we consider the ship from the stern towards the bow), we find a wide drum over which is passing the cable on its way from the hold. In conjunction with this drum, in a manner to be hereafter described, is maintained 2,000 feet of cable under a constant tension; and until this bight of the cable between the stern pulley and the main supply is all paid out, no abnormal stress can be set up on the rest of the cable. As the very lessening of the amount of this bight can be made to increase the supply of steam or other power to the main paying-out engine, if "power" be used for this work, it is only the delay in the responsiveness of such engine and its load that has to be provided for. Now a bight of 2,000 feet would provide an increase of 10 per cent. over the vessel's speed of 20 knots, for about ten minutes, and the question of the sufficiency of the length of the cable held in hand depends upon how we carry our cable.

For instance, let us suppose we take 300 knots of cable as a convenient unit, which will weigh 180 tons and may be conveniently contained

in a compact cylindrical tank, lying longitudinally in the ship. In length and diameter this tank is sufficient to admit of a drum or bobbin rotating within it, of the following dimensions:—

Between flanges	-	-	-	-	-	15½ feet.
Diameter of flanges	-	-	-	-	-	15 „
„ „ core	-	-	-	-	-	6 „

The capacity would be equal to 300 knots of cable; in size the tank is about the same as many double-ended boilers.

The driving power may consist of a set of engines capable of indicating say 150-H.P., thus giving power enough to enable the fully-loaded drum to be given a paying-out speed of 20 knots, from a state of rest, within 100 seconds; or, if already running at that speed, an additional 10 per cent. increase can be effected in ten seconds, whereas we hold in hand ten minutes' supply. With the drum fully loaded the revolutions will be about 45 per minute, and with the drum nearly depleted it must be rotated at about 100 revolutions per minute; the command, however, in the latter case is so perfect, that the power is more than ample.

Obviously if such a drum is arranged in the after hold, a similar one may be adapted to the fore hold, thus admitting of carrying 600 knots.

As this load would be very small for a merchant cruiser or other lightly-armed steamship, she could carry a large stock of coal or other "fleet" requirements.

The idea of a cable running out at 20 knots may be rather startling; therefore particulars of analogous operations are given as an appendix at the end of the paper.

Let us now consider more in detail the means proposed for holding in hand and completely stowing 2,000 cubic feet of cable; this apparatus we will hereafter call the Cable Accumulator.

In principle it consists of a pair of sheaves over which the cable is led (see Figure No. 1), a bight of 2,000 feet being allowed to hang down; to this a constant tension is applied by a weight upon a third sheave. A vertical traverse of a 1,000 feet is obviously impossible on board ship; if, however, the two upper sheaves (see Figure No. 2) are placed side by side, and are of considerable width, *each* sheave constitutes a drum capable of holding 1,000 feet of cable, and we may imagine that by the filling of the drum our third sheave and its weight have been raised until they are in danger of being carried around with the drums. At this point we will dispense with the idea of a weight, and attach our sheave to an arm radiating from the part of the axle between the two drums (see Figure No. 3); the sheave is then free to revolve in a plane tangential to the circumference of the two drums, at the same time it has a clear orbit around them.

Now by controlling the axle where it projects beyond the two drums (these being loose upon it), we are able to put a retarding force upon the tendency to carry the sheave around the drums, thus effecting exactly the same result as attained by the weight previously referred to. Assuming that our system has now become as shown in Figure No. 3, and that the weight *W* there represents the effect of a small hydraulic, steam

or electric motor, it will be seen that if the rate of supply of cable at *A* is say 20 feet per second, whilst the rate of demand at *B* is 21 feet per second, the tangential sheave will be carried around against the torsion of its motor, by which will be maintained a steady retarding stress. In 2,000 seconds of time both drums will be practically empty; for each complete revolution of the arm will take one turn off each drum. This arm and accessories will be rotating at a speed of two revolutions per minute; and meantime the two drums and the sheave are making very rapid revolutions on their separate axes, quite independently of any other motion.

To prevent such a climax as the total clearance of all the turns of cable from off the drums, any movement of the torsion producing motor, typified by weight *W*, will be the signal to the man in charge of the engine operating the main power rotated drum to re-adjust the engine speed, the duty of this particular driver being simply to so regulate his engine as to keep the drums adequately supplied with cable. This might be automatically effected if wished, but might increase risks. It now becomes plain that no strain above a pre-arranged amount, that amount in fact to which the motor controlling the tangent sheave may be adjusted, can occur; even indeed when there is an error of judgment as to the amount of slack required.

In this system the rate of delivery overboard is governed by the speed given to the stern pulley, and in the event of an outside stress occurring, due of course to insufficient speed in paying out, the stern pulley acquires an increased rate of revolution, and the speed indicator attached to it fails to tally with a standard instrument to which this driver is supposed to work. Should he then even cut off his power supply entirely, he will produce no diminution of speed. No injury, however, occurs to the cable on account of the flexibility, as it were, produced by the accumulator coming into play, but the officer in charge must now arrange for an increase in the driving speed.

The electrical controlling instrument designed for use in conjunction with the work, is shown in the drawings and described in an appendix, but time does not admit of a description at this point. It may, however, be briefly described as an instrument which enables the rate of speed as registered by the log to be indicated to the driver with such a plus or minus reading as shall cause proper allowance to be made for tides, etc. The bearings for a drum of the weight proposed become a matter of very great importance, and the inventor has, therefore, requested the Revolving Bearing Company to submit a special design and model, which are shown. The automatic mechanism inside the main tank, for ensuring regularity in laying each convolution of cable as received, is shown and described in the appendix.

As an alternative plan for carrying the cable, a number of rigid drums of about 40 knots capacity each, are proposed, the height and diameter being such that they may be readily stowed between decks; this system is fully described in the appendix, but in either system there is the minimum of delay in taking in cable, an important item in war operations, so impor-

tant indeed, that the ordinary methods of handling cable, both in taking in a supply or in paying out, would be under serious disadvantage. In the latter case protection by strong convoy would be needed, beside making the operations in hand plain to the enemy's scouts. The one case in point, as an illustration of the value of this invention, is taken from the records at our naval manœuvres of 1888, and here I quote largely from "The Navy and the Nation."

"For the purpose of this experiment it was assumed that war was imminent between two Naval Powers; one, the weaker, represented by Ireland, the other by Great Britain. The enemy was fitting out two fleets in Bantry Bay and Lough Swilly respectively, and two British fleets with their bases at Milford Haven and Lamlash were organised for the purpose of blockading him in his ports."

It is unnecessary before this audience to say more as to similarities of geographical positions.

"Each blockading fleet was superior in strength to the fleet blockaded by it, but the two hostile fleets together were stronger than either of the blockading fleets, *and* they had the advantage of being in immediate telegraphic communication across Ireland, whilst the blockading fleets could only communicate directly by means of cruisers sent from one to the other," or by other indirect method.

It is unnecessary to do more than indicate the facilities afforded by this communication for a blockading squadron to observe an enemy's port from a convenient roadstead; it might materially lessen that strain upon officers and men, which on the occasion we are speaking of was nearly insupportable.

To quote again loosely only:—

Three ships escaped from Berhaven almost unobserved by the blockading squadron and joined two other ships, which escaped from Lough Swilly, at a predetermined rendezvous. The presumption being that this would give the enemy the required superiority over the Northern Squadron, the commander of the Southern Fleet was obliged to raise the blockade of Bantry Bay, at the same time sending his fastest cruiser to warn the commander of the squadron blockading Lough Swilly. The following remarkable words are used:—"It was necessary in the first instance to save the two fleets from destruction in detail, and this could be done if the 'Mersey' joined Rowley in time to redress the balance at Lough Swilly, and to direct Rowley to fall back in the direction of the fast and powerful squadron advancing through St. George's Channel to reinforce him."

With the further second lesson drawn from the manœuvres by the writers of "The Navy and the Nation," I bring these quotations to a close:—"An organised system of coast observation and intelligence is absolutely necessary to a defending fleet, if it is to secure the full advantages of that superiority of force which is England's prerogative on the sea."

No words of mine can add weight to the opinions here expressed, which set forth absolutely the risks which may be incurred by the

unexpected concentration of an enemy's force—risks which would be greatly modified, if not removed, by the adoption of Mr. Snell's invention. Furthermore, there is the great and incalculable boon of being able to lay at full speed a cable where none is shown to exist, and which consequently would not be searched for and destroyed by an enemy.

I have on a previous occasion expressed the opinion that it would be necessary in the event of naval war for the Empire to possess its lines of telegraph communication in positions unknown to the enemy.

The following quotations from a leading article in the *Electrical Review* of April 9th, 1897, are worth attention. Under the title of "The Defence of the Empire," in reference to Lord Carnarvon's letters and speeches, this paper says:—"We think that the warning conveyed in his words to the House of Lords, in a speech made on April 14th, 1885, are worthy of repetition, and might with advantage have appeared amongst the selection. Space will not, however, allow of more than a short extract. In a discussion raised by a question drawing the attention of Her Majesty's Government to the fact that the 'sole method of telegraphic communication with Hong-Kong and some other British settlements in the East was by wires passing through a territory in the possession of a foreign Power, and whether it was the intention of Her Majesty's Government to adopt immediate measures to insure the safety of intercourse by electric telegraph with those parts.' Lord Carnarvon said: 'The matter was a delicate one, but he thought it right to remind the House and the country that in 1878 when there were great alarms as to a Russian war, the Russian Government, who were perhaps more alive to the circumstances of the case than we were, had taken measures for cutting the submarine cables and for equipping ships for that special purpose. It was said at the time, and on good authority, and was generally believed, that there was a carefully elaborated scheme for taking measures against our submarine cables in the Eastern waters. It was quite right to mention these matters now, and he trusted that the Government had not been blind to the danger of leaving them unprovided for; but that while they had had the opportunity and a full warning, they had taken those steps and those measures which might be necessary at any hour.'

"The political outlook to-day is similar in many respects to that existing at the time referred to in the above remarks, and yet we are little, if indeed at all, nearer to a position of safety as regards telegraph communication than we were then. Under such conditions it was, to say the least, disquieting, to know that the only two direct cables between Malta and Alexandria were simultaneously interrupted a fortnight ago, the Eastern Telegraph Company announcing that telegrams for Egypt by their cables suffered delay; and communication was not restored for about a week. In a time of international complications such as the present, it is not at all re-assuring to call to mind that in the event of the two cables between India and Egypt being interrupted, our only reliance for news to or from India, China, and Australia, must be placed on land-lines, one of which passes through Persia and Turkey, etc., and the other

across Siberia and Russia. In reference to one of these routes we may, perhaps, be allowed to quote from a note which appeared some time ago in these columns. 'The Russian Telegraphic Administration has informed the directors of the Indo-European Telegraph Company, Limited, that the latter will not in future be permitted to fill up vacancies which occur in the company's Russian stations with English operators; telegraphists from the Russian service are to be recruited for this purpose.'

"With such knowledge available, it is astonishing that no effective means have as yet been taken to place beyond danger our means of assured telegraph communication between England and her Eastern and Australasian possessions."

The plan which is here adopted, not by any means perfect in detail, yet gives a workable scheme which should render this object a matter of comparatively easy accomplishment. The main object at which the inventor of this plan and myself wish to arrive at this afternoon is to ascertain, as was previously stated, whether there is sufficient advantage to be got from it, to compensate for the outlay of money it would cost.

I ought, perhaps, to state that although I have modified details of the apparatus, the invention is that of Mr. Snell, to whom I shall refer you for any explanation of mechanical details.

APPENDIX A.

SMALL UNIT SYSTEM OF CARRYING CABLE.

This consists in placing the cable on board in drums of 40 knots capacity, and arranging them in columns. The cable is drawn alternatively from each column, the wire throughout being already suitably joined up.

Two sets of special paying-out gear are arranged at the head of the columns, and as a drum gets depleted the continuation of the cable leads to the adjacent drum. The paying-out gear of the depleted drum is afterwards lifted off, and the next full drum brought into position under the gear, which is again lowered into place, and the tail wire then properly arranged on the pulleys. This operation would be required once every two hours with the vessel going 20 knots, and thus ample time exists for making the exchange of drums.

Examination of the drawings will show that an outer horizontal guide wheel, carried on a rotating arm, receives the cable as it is drawn over the rounded nosing on the drum. It is then passed to a second guide wheel in a different plane, which is mounted in such a manner as to admit of travel vertically under the tension produced on the cable, and this movement, acting upon two bell crank levers, loosens a band brake which otherwise tends to retard the rotation of the arm. This brake is put on by a spring.

By this system the cable is drawn off always under a certain amount of tension, and a lessening demand causes the brake to be applied until the speed of rotation of the arm is suitably reduced. The overhead guide wheel is mounted to swivel automatically when the last turn of cable is

run off a drum, as the cable, of course, leaves the rotating system immediately below and begins to feed from the adjacent drum.

The tail wire from one drum leads over the overheard guide wheel of the next drum, then under the vertical wheel beneath and so on, thus forming the commencement of the next drum of cable.

The counterweight on the rotating arm it is proposed to place, at first, near the centre of rotation, allowing it to run out under centrifugal force. This will admit of quicker starting from a state of rest. In the drawings this is not shown, but the modifications necessary would be very simple.

In case of a change in supply from one drum to another, impending, the brake would be applied to the "receiving drum" of the accumulator or deck, so as to momentarily lessen the speed of *drawing off*, without of course affecting the *paying-out* speed into the sea, the reserve of cable on the accumulator allowing of this operation.

Space does not admit of a fuller description of the system; it will be seen, however, that it has the merit of allowing very rapid loading of a vessel, and a large amount of cable may be carried. The cable would be wound on the drums with a "twist" so as to come off "straight."

Each drum may have a water tank surrounding it, readily detachable when empty drums are returned. This is necessary to enable the cable to be kept wet if the vessel is in port for a long period.

The means of making the drums fast and changing the empty ones for full ones at the heads of the columns is not shown in the drawings; indeed, to reduce the paper within reasonable limits and maintain discussion mainly upon strategic questions, necessitates much cutting down. Should opinion, however, be favourable as to the value of the power to so rapidly lay a cable, attention may afterwards be more fully focussed on the means proposed to effect it.

APPENDIX B.

AUTOMATIC TRAVELLER.

The Automatic Traveller, which receives the cable as it leaves the drum, traverses a special alley way, constructed on the side of the tank, as will be seen with reference to the illustrations. A rack runs throughout this alley, in which a worm is caused to gear; this worm being attached to the frame carrying the pulley. On the axle of the pulley is an eccentric or crank which oscillates, by a connecting rod (see *A* in the illustration), a pair of pawls which in turn drive a ratchet wheel in connection with the worm, the connection being made by a pair of bevel wheels. This oscillation produces a similar oscillation in the worm, unproductive of any real traversing action unless one of the pawls is kept out of gear by a special tripping lever (see *B* in the illustration); then as a result an intermittent forward traverse is given to the whole apparatus.

As to which pawl shall be thrown out of action, it is dependent upon the angularity of the cable, which will cause pressure upon one of a pair of wheels at the end of a vertical lever. This lever being connected with

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once a second when making 20 knots speed. The disc is provided with projecting pins in electrical connection with the spindle and supporting standard, and by the contact spring shown; as the disc rotates the circuit is completed with the standard engine-room indicator.

If now the travel of the armature carrying the driving pawl be adjusted to a certain amount, each time the magnet is energised it may be made to move the disc so that a corresponding impulse will be transmitted to the engine-room indicator by the contact arrangement before explained. At this point let it be assumed that cable delivery at a rate of 10 per cent. over the vessel's speed is needed; the adjustment screw is slacked back to give the armature a longer stroke, sufficient to produce in one minute, during which the electro-magnet has been energised sixty times, such a rotation to the disc that 66 contacts have passed under the contact spring, and the engine-room standard is therefore showing 66 steps per minute; so that the driver must adjust his engine speed until the second indicator, which is worked by the ejecting drum astern, synchronises with the standard. By putting duplicates of these two indicators into the chart-room, the driver's actions are under supervision; and if he (the driver) finds an outside pull act upon his engine, which is soon evident by its failure to respond to his attempts to synchronise it with the standard indicator, it must arise from a taut cable due to an error in reckoning by the officer in the chart-room. The driver must, therefore, inform that officer by voice tube or electric bell, and he can see at once by the duplicate instruments he possesses that the engine speed is unavoidably running above the officially instructed rate. He then slacks back his adjustment screw to produce increased register in future, and by turning the disc by hand he can cause the standard index to read level with the second or stern drum one; things can then be allowed to run along once more. Great accuracy of adjustment is made possible by the long pointer.

In considering the controlling arrangement, another point which would contribute towards the successful handling must not be lost sight of. That is, all orders telegraphed by the bridge to the main or propelling engines would be made to also ring up the chart-room and cable delivery engine-room, and there show the nature of the orders, thus putting the people in a state of readiness, which would be very handy in case of a change of speed impending. It should be also possible for the cable machinery driver to signal the main engine-room in case of any emergency arising from trouble with his own mechanism.

APPENDIX D.

The cutting of a cable which is being paid out at so rapid a rate as 30 feet per second presents certain difficulties and risks, unless it is done quite astern of all gear on deck, and also in a manner which does not entail either a sudden stoppage or a sudden release, to mechanism working under stress.

This severance it is proposed to effect by the following means:—

The cable takes, say, two or more turns around the ejecting, motor-driven drum astern, and it is pressed upon just before leaving the drum by a wheel the same diameter as the drum; chain or other gearing joining them ensures synchronism in the movements of the two. In the periphery of one wheel is fitted a chisel, in that of the other an anvil. This is preferable to two chisels, as a small amount of back-lash in the gearing will not matter where a fairly broad anvil is used, whereas it would upset the meeting of two chisel points.

To these two accessories are fitted tail levers, which, being in different planes, do not meet as the wheels revolve, but if a blade (shown in the drawings and marked as a "parting lever") be dropped between these, each lever is forced inwards, the chisel and anvil protrude as the wheels turn, and the cable is severed.

It will be seen that short lengths would be continually cut off, like a string of sausages, unless the parting lever was at once removed. However, the cut being beyond the position where the cable is gripped, it does not affect the hold, or the load on the machinery generally. The paying-out mechanism may now be stopped as soon as expedient with safety; and here it must be noticed, that if the cable accumulator has been pretty well depleted prior to cutting the cable, it is possible to stop the stern ejecting drum very rapidly, and leave the accumulator to gather in the slack that obtains on account of the momentum of the main drum. With the small unit system the stoppage throughout may be much quicker.

The buoyming arrangements shown in the drawings may be used, so that buoyming may be also effected at full speed; or it is easy to let the cable-ship pass between two other ships or buoys, connecting which a steel hawser is laid, with plenty of slack. It is thus easy to get hold of the cable without delaying the cable-ship.

The cable, it is assumed, would have a sinking rate of about 2 feet per second, and therefore a following ship in fleet evolutions would not foul it. See the diagram, which also shows that a cable-ship with a turning circle of 840 yards diameter would not cause inconvenience to the cable-laying.

If provision had to be made for harbour manœuvring it would be well to pass the cable over a pulley at the end of a long spanker-boom on the cable-ship, so that it could be swung athwartship to clear the screws if the vessel had to go astern.

APPENDIX E.

Inductive telegraphy is a special subject, about which much has been written, and which is still engaging a large amount of attention. With a view to ascertaining the views of two of the leading experimenters in this direction, the following problems have been submitted to them:—The diagram given below shows a land station *A*, which is in communication with the cable vessel *B* 100 miles away, and which has still 200 miles of cable in her tank. A vedette *C*, 50 miles out, wishes to communicate with either ship or shore; will there be any difficulty?

To this Mr. Charles A. Stevenson, of the Northern Lighthouse Board, replied :—"There is no difficulty in another cruiser or vedette communicating ashore, or to another cruiser that has laid down a submarine cable

Diagram 1

from ashore, at any part of the cable. All that is wanted is that the vedette have a bow connection with the water, and in addition a long tail wire reaching down into the water, working by electrostatic induction. I do not recommend telephonic communication for such a purpose. It is possible that a more effective arrangement would be attained by the electro-magnetic system, by looping the wire thus (see Diagram 2), and

Diagram 2

this I am absolutely certain would work well, as I have tried it; but it is less simple of application in a nautical sense."

In *Engineering*, October 23rd, 1896, appears a letter from Mr. Stevenson, in which he says :—"Induction from a submarine cable, with currents of but a fraction of an ampere flowing in it, laid in 30 or 40 fathoms of water. . . . is sufficient to make itself audible in a telephone aboard ship, in connection with a proper apparatus costing but a few pounds." Mr. Stevenson's experience in inductive methods of communication is too well known to need lengthy description. It is worth remembering in connection with this problem, however, that he succeeded in bridging a gap without wires, as shown below. Current sent through *A*, caused induced currents in *B*, thus maintaining communication.

The following problem was submitted to Professor L. I. Blake :—
A, *B*, *C*, *D*, are enemy's ports, and cable is laid as dotted. Assume a vessel escapes from *C* heading towards *B*. The vessels at *C* are not swift enough to catch her, but if they can advise *B* she may be intercepted by more powerful vessels. Total length of cable from *A* to *D* is 250 miles, and we wish at each position to be

able to communicate with the others. Professor Blake replied :—"While the problem which you propose in regard to communicating between ports while under blockade, contains conditions not yet tried in full, still

the experience which the Light-House Department of our Government here [U.S.A.] has had in the application of the method proposed by me, makes me feel confidence in accomplishing what you desire. I speak hesitatingly thus because I do not like to exceed my experience, but I am assured of the correctness of the principles involved.¹

"The most difficult question in my mind would be the transmitting of sufficient energy in the form of an alternating current, through a cable of so much self-induction, if iron armoured, as a cable of this length would probably be.

"I found in practice that one terminal plate is sufficient on the ship, as the hull of a steel vessel or the metallic sheathing of a wooden vessel would serve well as the other plate."

INTERESTING DETAILS OF SANDY HOOK LIGHTSHIP.

Prof. Blake adds :—"It is perhaps proper for me to state the experience which we have had in the application of the system off Sandy Hook, N.Y. We communicated telephonically there with a lightship lying six miles from the shore station, and our test plant was in operation some six months. The area of diffusion was about 16 acres, out of which the lightship could not swing. The energy delivered into the grid was exceedingly small, because it was necessarily limited by the power of the telephonic transmitter, and this power did not exceed 4 watts with the best transmitters that I could obtain anywhere or knew of. Had we attempted to telegraph by means of makes and breaks in the alternating current, receiving through a telephone, we could have delivered many fold the energy employed. Our purpose, however, was to allow *telephonic* communication by ordinary men handling the ship. While this is the limit of our practical experience, still, by means of an artificial cable, we seemed able to extend the length of the cable portion very many miles.

"I might add that within this area of diffusion we communicated constantly between moving vessels properly equipped, and could easily overhear conversation between the lightship and the shore station, while we were upon a neighbouring vessel. Of course, any such diffusion area could be secretly known and communication thus protected."

¹The technical details of the method of carrying out such an installation are also supplied by Professor Blake; but as permission to make them public has not been obtained, they are reserved for the present.

Notes on Prof. Blake's System of Communication.—A shore station with *B* battery, *C* telephonic transmitter, *D* receiver, *E* earth plate. On the

lightship *S* are similar appliances, similarly lettered, also *G* grid below. At Sandy Hook the depth of water is $10\frac{1}{2}$ fathoms.

The equipment on the tender "Gardinia," which steamed about and communicated, cost only a few pounds. In practice, the inventor has found that with a bare copper wire of low resistance (in place of the grid), he could develop the region of communication for about a mile or more along the direction of the wire, and for several hundred feet all around it. See *Electrical Review*, September 6th, 1895.

Other experimenters, amongst whom Messrs. Willoughby Smith and Granville must be mentioned, have also investigated the subject, and sufficient experience seems to have been gained and *data* made available to justify the assertion that simple strategic lines, from point to point, can be laid; that communication, along the length, by any vessel provided with a simple equipment costing but a few pounds, is a possibility; and, moreover, communicating vessels need not drop anchor or make any continuous metallic connection with the cable.

Such possibilities are interesting in peace-time, but in war-time may render invaluable aid and economise the labours of the vessels used for despatch services; above all, the convenience of instant and continuous communication is too apparent to need emphasising.

As an illustration of a method of communication so simple, it may be assumed that *A* is a port under blockade. *D*—*E* is a cable, and *C* is a blockading force always in touch with it, such as by a vedette-boat or larger vessel cruising within its radius of induction. It is therefore plain that scouts, say at *D*, upon sighting any hostile or relieving force attempting to raise the blockade, can fall back upon the immediate neighbourhood of the cable and inform the main body *C* without loss of time. By the cable, outlying scouts *E*, can be recalled to strengthen the main body.

One or more cables may be used, or any different telegraphic arrangement made. In event of fog the time saved and service rendered by the cable might be all-important.

The question of the efficiency and reliability of the systems above described does not materially affect the value of the power to lay a cable at 20 knots, as there is always the direct metallic connection system to fall back upon, and the possibility of a blockading force being able to establish an ordinary station upon an enemy's coast, where effectually covered by the guns of the squadron, or upon an outlying rock.

APPENDIX F.

WIRE ROPE INSTALLATIONS—TO SHOW SPEED OF DELIVERY.

On the Schaffhausen system the pulleys are placed from 330 feet to 450 feet apart, whilst the speed of the ropes is 61·8 feet per second. This is $36\frac{1}{2}$ knots per hour.

The speeds at which wire ropes are commonly driven range between 30 feet and 80 feet per second, and 80 feet per second is 63 knots per hour.

As regards vertical winding in collieries:—In the case of Walsall Wood Pit, No. 1. the maximum speed is reached in 18 seconds, the time occupied in taking the run of 550 yards is 44 seconds, which gives an average speed throughout the run of $37\frac{1}{2}$ feet per second, the maximum speed being 60 feet per second or over 40 miles per hour. Dead load at moment of starting 142 cwt.

There is little question that the rapid manipulation of the load and accurate stopping required in colliery operations involves careful attention, yet it is successfully effected year in and year out. When therefore we consider that the problem of high-speed cable laying requires no such sudden or extreme variations in speed, but consists essentially of throwing away the cable at a steady speed, a little in excess of that of the vessel, we surely need not despair of success. Further, we have our 2,000 feet of cable in hand as a stand-by for emergencies.

Admiral Sir N. BOWDEN-SMITH, K.C.B.:—Sir George Clarke and Gentlemen, I am very sorry that the lecturer has such a poor audience here to-day, but I can assure him that it is not from indifference on the part of my brother officers to this important subject which he has brought before us, but because the great mass of naval officers are serving afloat. I feel sure, however, that many not present to-day will read this lecture in the JOURNAL with interest. I came here myself more to hear what experts might say as to the feasibility of laying a cable in this proposed rapid manner, and also to know, if possible, what the cost per mile would be for laying such a cable, on the understanding that the cable costs, as the lecturer states, £60 a knot in the first instance. If the proposal were ever adopted, and carried out from a sailor's point of view, I should advocate specially-fitted ships being used for it, instead of utilising any of our vessels-of-war, and I am rather inclined to think that the ordinary cable-ships would do the work for us if required. I know that they have comparatively slow speed; but with such a light cable they might be able to lay it sufficiently fast to suit most requirements. With regard to the proposal to establish communication with an outlying picket of ships unless off a blockaded port, I do not see very much advantage in it, because if you had a group of ships stationed some distance

from the land they would probably, by preconcerted arrangements, be required to change their position pretty frequently; and, therefore, anything in the way of a cable going to a certain latitude and longitude might hamper their movements. As regards laying a cable in war-time between two fixed points,—I think it might be of the greatest use, because as the lecturer points out, the enemy at first would not know of its existence, and possibly, therefore, it would not be so liable to be interfered with as those previously in use. With regards to existing cables, I do not think we pay sufficient attention in landing them at some place which would be necessarily patrolled by our ships-of-war or be under our observation. I know many parts of the world where our cables are laid for a considerable distance in very shallow water, where they would be very easily searched for and destroyed. And then they are brought to land hundreds of miles from any military or naval station, where the cable-house, and the instruments, and the shore-end of the cable are all liable to be destroyed by the smallest hostile cruiser.

The CHAIRMAN (Sir G. Clarke):—As Lieutenant Crutchley has nothing to reply to, I will make a few remarks. I am sorry the discussion has not been so well maintained as I had hoped. There are, generally speaking, two policies which have been advocated in regard to the laying of cables with a view to war. One is to lay your cables always in deep water, and bring them to shore as seldom as possible; the other is to lay them in shallow water, and bring them to the shore many times. I believe that the general idea now is that the last course is best for us, and I quite agree with that course myself, provided that the landing-places are on British territory, or on the territory of some neutral Power, which would permit us to control the telegraph stations there established. The risks of a cable must necessarily be very great in war. I do not think that we can calculate upon keeping cables going as they are in peace; it cannot be expected. But we have immense resources for restoring cables; and I think it is to the policy of restoring cables, bridging gaps, and laying new lines that our efforts should point. For us a policy of cutting cables would, as a rule, not be advantageous. There are certain cables—I should not like to specify them—which we must be prepared to cut under certain conditions; but, broadly speaking, our policy is to keep cables going, and it will be the policy of an enemy to cut them as far as possible. Cables can be grappled in water up to 2,700 fathoms, brought to the surface, and cut; but the process is a long one, and always requires specially-fitted ships. As Lord Carnarvon has stated, it is the case that when hostilities were threatened with Russia, arrangements were made for the cutting of certain cables; but the Russians did not appear to have had the appliances or the science required for carrying out the operation, and were obliged to approach a citizen of another nation. The advantages that we have for the repair of cables, and for the laying of new cables, are quite unrivalled. Altogether, I believe, there are about thirty-eight cable-ships in the world with trained crews and appliances thoroughly capable of doing the work, and of these thirty-eight I do not think more than four or five are under a foreign flag, so that we have almost a monopoly of trained men and of fitting appliances for carrying out these special operations. Of course, that applies equally well to cutting operations. If it were our policy we could cut cables with greater certainty and more quickly than any other Power. At the same time, we can produce in England something like 2,000 knots of cable a month, and that rate could be maintained if the supply of gutta-percha would hold out. There is a certain amount of experience of cutting cables in the Peruvian-Chilian War. The Chilians cut a cable which they very easily found, because it was only three miles from the shore; they towed the ends many miles apart; but when it was necessary to repair this cable the trick was found out, and the restoration was very quickly made. But that restoration had to be made by a British vessel—there was neither knowledge nor were there appliances in Chili or Peru sufficient for the operation. During the Zulu war a cable intended for Australia was temporarily laid from

Durban to provide communication. During our occupation of Port Hamilton we also laid a cable with connection to China. Port Hamilton is a place which, in my opinion, we ought never to have given up. I believe that the cable still lies at the bottom of the sea, but it is probably now worthless. When the British fleet went to Constantinople in 1878, arrangements were made for keeping communication with it by cable. Events turned out differently; but the cable would have been of extreme importance in the operations which we might have undertaken. I do not think the importance of rapid communication in war can be possibly be overrated. At a period nearly 100 years ago, just before a certain memorable 1st of August, about two words sent to Nelson would have changed the history of Europe, and very possibly have relieved us from the Egyptian question of the present day. Fleets, I think, will undoubtedly have to take with them in certain cases cable-ships having appliances for laying new cables, putting down branches, and for repairing breaks as they occur; and in the resources which we possess for that purpose I think we have a very great advantage over all other Powers. It seems to me, therefore, that any arrangements, such as the lecturer has proposed, for quickening the operation of laying new cables must necessarily be a great gain. As far as I can see, there is no mechanical objection to the plan which is proposed. I think that the proposal is on the right tack, namely, the employment of power for paying out the cable and making use of a long compensating bight. The arrangement of the paying-out drums seems most ingenious. What I do not feel quite so sure about is the chance of a kink occurring. When you are paying out at a speed of 20 knots if a kink does occur—and I think, looking at the arrangement of the small horizontal drums in the figure a kink might occur—there would be a considerable risk of the cable parting. As regards other questions, and especially the problem which is given under Diagram I, I think it is almost too soon to express an opinion. Science is quite in its infancy as regards what may be done with induced currents. It does seem to me, looking at that diagram, that it would be a little difficult to place your ship right over a cable and to align exactly with it. I do not think as matters now stand, unless the alignment was very true and the ship was very fairly over the cable, that communication could be effected. As regards Diagram IV. in which two blockaded ports are connected with cable, I rather think that it would be better for the blockading ships, if they could maintain themselves off these ports, to cut the cables, and pick up the seaward ends, thus making their communications. I am quite sure we are on the eve of a great discovery in induced telegraphy, and that before long we shall be able to do a great many things which now appear impossible. In conclusion, I think anything which can be done to facilitate cable-communication in war, to make it more certain and more reliable, to bridge over the gaps which are certain to arise, and to lay the new lines which are certain to be wanted, must be of great advantage. With regard to what Admiral Bowden-Smith said, I think he is perfectly right. We have too many exposed cable-landing places, where a cruiser sending a boat ashore, might destroy the instruments. There are too many such cases; but arrangements have been made, to my knowledge, in some places, for giving telegraph stations some measure of protection, and I hope that further preparations of the kind will be made. The destruction of exposed telegraph stations is certain to be attempted in war. I think we ought to be prepared, if such a raid takes place and a telegraph station is destroyed, to at once replace the instruments and restore the communication. I am sure that I speak in the names of all present in expressing our thanks to Lieutenant Crutchley for this most interesting and instructive paper, and in assuring him that we all think that the object which he has brought before us is one of extreme importance to the British Empire.

SECTION
N°1 EJECTING & CUTTING
GEAR

Fig. 1

Fig. 5

SECTION
N°2 HOLDING IN HAND 2000 FT. OF CABLE
UNDER CONSTANT TENSION
WITH FREE GIVE & TAKE
ACTION

Fig. 2

SECTION
N°3 CARRYING
BULK
OF
CABLE
BY LARGE ROTATING DRUM
-300-KNOTS CAPACITY- OR A SERIES OF
40 KT. UNITS

Fig. 3

Fig. 6

Fig. 7

Note by C. SCOTT SNELL, Esq.:—

Admiral Bowden-Smith remarked: "I am rather inclined to think that the ordinary cable-ships would do the work for us if required. I know that they have comparatively slow speed; but with such a light cable they might be able to lay it sufficiently fast to suit most requirements." Perhaps the following extract from an editorial in the *Electrical Review*, of June 4th (in a review of this paper), will give "expert's opinion" sufficient for the purpose. It runs thus:—"To assist in forming a comparison of methods, we may mention that 8 knots an hour is considered rather a high speed to pay out even 'deep sea' cable, though there have been occasions when, under favourable conditions, 10 knots have been accomplished. So high a speed, however, as 10 knots is considered dangerous, even with very large tanks, and the ship would be slowed down while the cable near to the cone is running out. Were it not for this fact, cable could be laid much faster . . . but, as before mentioned, the risk of turns fouling in the tank prevents this." I would add that the maximum rate of hand-coiling in ordinary tanks being about 5 knots per hour, it would occupy 60 continuous hours to take in 300 knots of cable; this, by the "small unit" system, could be dealt with in four hours; and, further, what is of equal importance, by adapting the size of the unit to the requirements of railroad transport, it would be possible to load a ship—say at Falmouth, instead of sending her to the Thames—thus effecting a great saving in time, and lessening the war risks. The best protection for a cable from enemy's attack must lay in secrecy as to its existence; or, failing this, secrecy as to its exact course. It is evident that an ordinary cable-ship, by its very appearance, or by its slow speed and necessary escort, introduces grave risks of drawing upon the cable the very attention it is most desirable to avoid. Compared with the rapid passage of an ocean greyhound or other mercantile cruiser (temporarily adapted to the small unit system), which could cover a considerable distance even in the night hours, the disadvantages are very obvious. It will be noticed that the ejecting gear—on the merchant cruiser shown—is purposely carried out by horizontal wheels, so as to be kept out of sight; and if every merchant cruiser trailed a short length of $\frac{1}{2}$ -inch diameter rope astern, or the cable was coloured grey, there would be little chance of the enemy detecting that any vessel was actually at work; better still, the delivery might be made below the water-line. With reference to the remark of Sir George Clarke that a kink might occur "looking at the arrangement of the small horizontal drums in the figure," I believe I am correct in saying that Sir George was, at the time, under the impression that the drums revolved; probably subsequent study of the figures, with due reference to the description, will, therefore, clear up the misconception. For those interested, it may be stated that further details and descriptions, relating to buoys at full speed, etc., are given in the *Electrical Review* under dates June 4th, 11th, and 25th; and that, during the winter session of the Institution of Electrical Engineers, in all probability the whole technical details of an equipment for a merchant cruiser will be dealt with by a paper thereon. With regard to inductive telegraphy, I think I may justly claim, that whilst its successful introduction would add to the advantages accruing from the use of submarine cables in war, it might still be eliminated, without taking from the great strategic value which would accompany facilities for laying a cable by an ordinary ocean greyhound, at her highest speed. As an illustration, suppose Brest blockaded, in the darkness of night such a vessel might start away, and with her great speed safely run the gauntlet of hostile cruisers loose in the Channel, and land the cable end at Falmouth before daylight. Thus time would be saved in requests for stores, reinforcements, or new gear or repairs—the latter important items in a steam navy; also instant information would be conveyed of coalition changes in Europe, or re-arrangements of hostile fleets, and telegraphic communication with colleagues watching other ports, etc., would be possible. Shall we neglect such advantages?