Royal United Services Institution. Journal
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rusi19

Submarine Telegraphy

Charles Bright F.R.S.E., M.I.E.
Published online: 11 Sep 2009.

To cite this article: Charles Bright F.R.S.E., M.I.E. (1908) Submarine Telegraphy, Royal United Services Institution. Journal, 52:361, 368-396, DOI: 10.1080/03071840809418803

To link to this article: http://dx.doi.org/10.1080/03071840809418803

SUBMARINE TELEGRAPHY.

By CHARLES BRIGHT, F.R.S.E., M.I.E.E.

On Wednesday, 17th April, 1907.
Commander W. F. CABORNE, C.B., R.N.R., in the Chair.

The following Lecture was delivered in a popular form. It was profusely illustrated by means of Lantern Slides, specimens and working models; but it has only been found possible to reproduce a certain number of the first named.

"The wrecks dissolve above us; their dust drops down from afar—
Down to the dark, to the utter dark, where blind sea-snakes are.
There is no sound, no echo of sound, in the deserts of the deep,
On the great grey level plains of ooze, where the shell-burred cables creep.
Here in the womb of the world—here on the tie-ribs of earth—
Words, and the words of men, flicker and flutter and beat."

—*Rudyard Kipling*

WITHIN the confines of a single lecture I cannot profess to cover anything like the entire ground of my subject. All I can attempt to do is to touch lightly on the main features that are perhaps most likely to interest my audience. Even then, some of you will, no doubt, discover how much I have omitted to deal with.

If, here in Whitehall, you wished to communicate by cable to, say, Bombay, you would only require to go to the nearest Post Office. A good deal has, however, to be done by others to enable your message to be electrically transmitted. It is this that I am here to tell you about, rather than to discuss the abstract question as to whether we are any the better, or happier, for our widespread system of telegraphy.

My subject, in itself, covers considerably more ground than would be supposed at first sight. It might well be thought that the art of telegraphing under the sea was a subject that was confined to the electrical methods adopted for carrying on communication; but before establishing our communication, we must make and lay our cable, to convey the electric current. I, therefore, propose to first present to you a general idea of the theory and practice of transmitting electric signals such as go to form messages.

I shall, thus, be starting with the heaviest part of my subject first, and—if you will allow me—I shall hope to end up with light allusions to lantern slides depicting some of the various historical experiences connected with submarine telegraphy, besides views of telegraph stations in different quarters of the globe, and portraits of the early pioneers to whom we are indebted for our telegraph cable system.

ELECTRIC SIGNALLING.

Before proceeding, however, it may be well to say a few words on early methods of signalling followed by certain references to electricity and electric telegraphy in general; and here I am compelled to strike a mean between concluding that my audience knows nothing about electricity, and concluding that you are all thoroughly conversant with its mysteries. As a matter of fact, we none of us know much about it at present—very little about its nature at any rate—but no doubt many of you know as much as I do.

The desire for communicating with our fellow beings at a distance received considerable encouragement from the early discoveries in electrical phenomena, which—together with the invention of the voltaic cell—gradually led to a practical electric telegraph.

The principle of all telegraph instruments is dependent upon the telegraph alphabet introduced by Professor Morse for the purpose, where different letters are represented by different combinations of short and long periods — whether in the form of sound clicks, as in the "Sounder," or in that of ink marks on paper, as in the Morse Recorder.

The simplicity and economy of the Sounder and such-like for village telegraph offices, and the reliability of the Morse Recorder and such-like for more important "circuits," have been sufficient to maintain the use of the apparatus I have described, except where greater speeds are a special requirement. The objection to this system is, however, the long—in contra-distinction to the short—periods which go to form the alphabet. This is comparatively immaterial for the bare iron wires supported on porcelain insulators which constitute our ordinary overland telegraphs. But where the conditions demand insulated wires—whether overhead, underground, or submarine—it is desirable to achieve a greater speed of working than is possible by this system; and the method adopted is to substitute the long periods by a current in the reverse direction.

The actual apparatus now in use for signalling through submarine cables I shall be describing shortly. Meantime, I would remind you that there are, so to speak, various sorts of electricity. For instance, no doubt some of you are familiar with the sparks and smacks that can be produced from a frictional machine. Others of you will know what a bad time anyone may have if he handles two bare wires which form part of the same circuit conveying a high pressure current, whether for lighting, traction, or power purposes. But in telegraphy—the work to be done being of so delicate an order—we have nothing to do with electricity of the killing kind; and perhaps you will believe me when I tell you that by way of demonstrating the efficiency of one of the earliest Atlantic cables, just after its successful completion, a message was actually sent through, by a battery consisting of a silver thimble containing a morsel of zinc, weighing a grain, and a few drops of sulphuric acid.

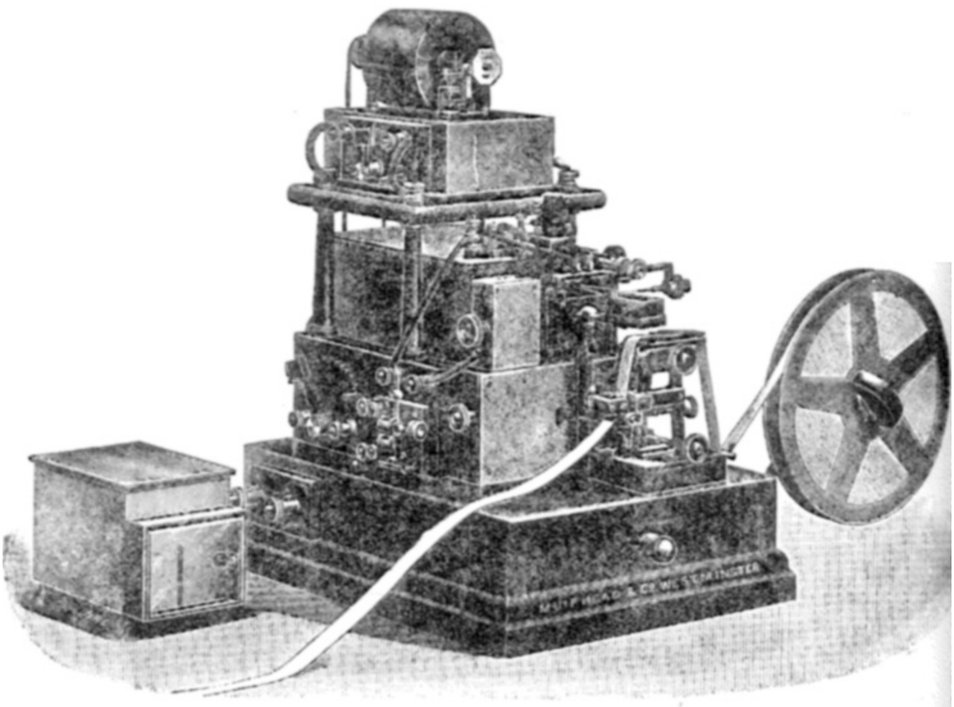
In ordinary practice we very generally employ a few Leclanché or other voltaic cells, the number varying from 5 to 100, according to the length, type, and condition of the line. Accumulators are also much used, and so are dry cells.

When a current of electricity is passed through a cable by connection with a battery of the description I have named, the insulated conductor, having a certain electrical resistance (the inverse of conductivity) and a certain electro-static capacity—that function of any Leyden jar system which determines its capacity for electric charge in a given time—what is known as electric retardation takes place. This tends to check the complete charging or discharging of a cable spontaneously.

Having endeavoured to present to you an idea of the general principles of electric signalling through cables, I will now turn to a consideration of the apparatus employed in practice.

In the year 1867, the then Sir William Thomson (afterwards Lord Kelvin) introduced what is known as the Siphon Recorder for receiving signals through more or less long lengths of cable, and this is now in general use, one of its main advantages over previous apparatus being that it supplies a record of the signals as received.

A recent pattern of this instrument—due to Dr. Alexander Muirhead—you have before you here.



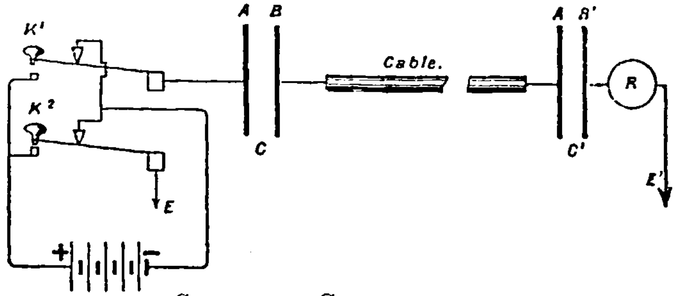
THE SIPHON RECORDER.

It consists of a light coil of wire vertically suspended in the field of a permanent steel magnet.

Attached to the coil is a light glass siphon, one end of which dips into an ink vessel, the other hanging over a continuous strip of paper drawn along by an electric motor. Thus, every deflection of the suspended coil, actuated by a current passing through it, is recorded by a horizontal ink line of certain direction and length across the slip.

Some of you may naturally wonder why the coil should deflect when a current passes through it. To this I can only reply that it

does so, as surely as the magnetic needle of a compass—or of a needle telegraph instrument—does, when under the influence of an electric current. There is no really complete explanation of such electrical phenomena, and it is impossible to go into the matter in further detail this afternoon.

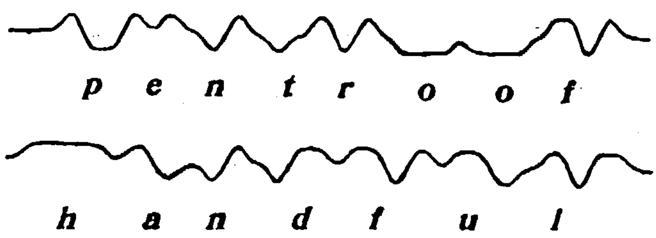


SIGNALLING CONNECTIONS.

At the transmitting end, the current is conveyed into the cable by manipulating a key of the type shown here, which, by the depression of one or other of the tapping-levers, connects one or other pole of the battery with the end of the cable, thereby sending a current in one direction or the other—or, to put it in another way, sending either a positive or negative current as the case may be—the result being a deflection of the suspended coil at the other end in one direction or the other.

I should, perhaps, mention that the same result could be achieved in a primitive manner by touching the bare end of the conductor with one pole of the battery or the other, the only use for the key being to effect this object more readily and speedily.

The rapid manipulation of these keys has become such a fine art that a speed of some 35 words a minute can be attained successfully by experienced operators.



SIPHON RECORDER SIGNALS.

With this system, the Morse alphabet is turned to account, as shown here. It might naturally be supposed that great difficulty would be experienced in deciphering such a language. Skilled clerks, however, can make out almost anything in these snake-like movements.

Increased accuracy and speed are further secured nowadays by automatic machine transmission apparatus on the same principle as is in vogue for the despatch of Press news on land telegraphy—the tape at the receiving end of the line being distributed amongst various clerks.

Here before you is the automatic transmitter, but I do not propose to deal with this further to-day, though you can see it working afterwards. It suffices to say that the message is first mechanically punched out on tape, which is then run through a clock-worked automatic transmitting apparatus.

Duplex telegraphy, first applied to cables in 1870, is a system in which the output is nearly doubled, by sending and receiving messages from both ends at one and the same time. This system is adopted on all lines with a sufficiently large traffic to warrant application, thereby tending to save the cost of an additional cable. This, again, is a little too complicated for dealing with in detail here. The general principle is, however, that—by means of resistances and capacities corresponding to that of the cable itself—artificial establishment of an exact electrical balance at each end of the line is secured under normal conditions. This balance is, then, only upset in accordance with the transmission of signals, thus permitting these to be despatched and received from either end at the same moment. The application of condensers at each end of the line, as well as other methods for curbing the current, also tend towards increased speed and greater clearness of signals. Thus, an Atlantic cable of to-day designed to give a speed of 50 words per minute, will practically work at a speed of 100 words a minute on the duplex system in conjunction with automatic machine transmission.

Even the most proficient clerk can scarcely manipulate the transmitting key at a higher rate than 35 words to the minute; but the automatic transmitter is capable of any speed practically; and the receiving apparatus is nowadays almost limitless in its capacity. So much so, that it is really only the line itself which governs the speed on an important ocean cable; and the electrical proportions of this can—within certain limits—be made practically anything in accordance with what the traffic warrants. Thus, it will be seen that wireless telegraphy has something to compete with in the way of output. It should here be added that the working speed of a cable is dependent on its length. It is, in fact, inversely proportional to the square of that length; and it is for this reason that we have to provide a very much larger conductor and insulator for long than for short cables, if we want to get the same high speed.

With a view to effecting automatic, instead of manual, translation between lengths of submarine line, the cable relay may be said to have been the dream of the cable manager for years, and one that has seriously occupied the minds of many an electrician. Only comparatively recently, however, has complete success in this direction been achieved; but, though a subject of the moment in cable circles, anything more than this passing allusion would be unsuitable here.

The practical effect of submarine telegraphy is further achieved by the code and cypher system, whereby a number of words are represented, in secrecy, by a single word or a combination of figures. To take an example, the word "Elgin" in a certain mercantile code stands for as much as "Every article is of good quality that we have shipped to you."

CONSTRUCTION OF THE CABLE.

Having given you some idea of the principle of electro-telegraphy as applied to submarine cables, I will now pass on to the cable itself and its various constituent parts as manufactured.

The Conductor.

Let us first deal with the all-important conductor. On account of its marked superiority, electrically to all metals except silver, which is too expensive, the wire used here has always been composed of the purest possible copper. The first Atlantic cable had a conductivity only about half what a similar cable of the present day boasts; this is due to the greater purity of manufactured copper, which now, indeed, exceeds that of the old standard for pure copper.

A solid wire being unsuitable mechanically, the conductor takes the form of several—usually six—wires laid up, or stranded, together round a central wire. The size of these wires varies with the electrical requirements, being mainly dependent on the length of the line required; and in very long cables—such as those spanning the Atlantic and Pacific Oceans—the central wire is usually of a larger gauge in order to more effectively meet prevailing conditions. In the actual specimens of cable on the table you will be able to gain the best idea of the ordinary sizes of conductors for the various lines.

I will only add here that the machine for laying up the individual wires in the form of a strand is of the rope-making pattern.

The Insulator.

Water—and especially salt water—being a good conductor of electricity, the copper conductor requires to be covered with some substance which is a bad conducting, or insulating, medium, to prevent the transmitted current returning the shortest way to earth instead of going to the further end of the line; and the history of submarine telegraphy may, for practical purposes, be said to have started with the introduction of a suitable insulator. Previously, a number of substances—including tarred cotton, glass tubes steeped in pitch, etc.—had been experimented with for underground wires as well as for subaqueous conductors across canals and rivers.

In the case of a landline, insulation is effected more or less easily by supporting the wire on earthenware insulators at certain intervals; but with a wire laid under water, no such easy means of confining the current is possible and every inch of the wire has to be insulated.

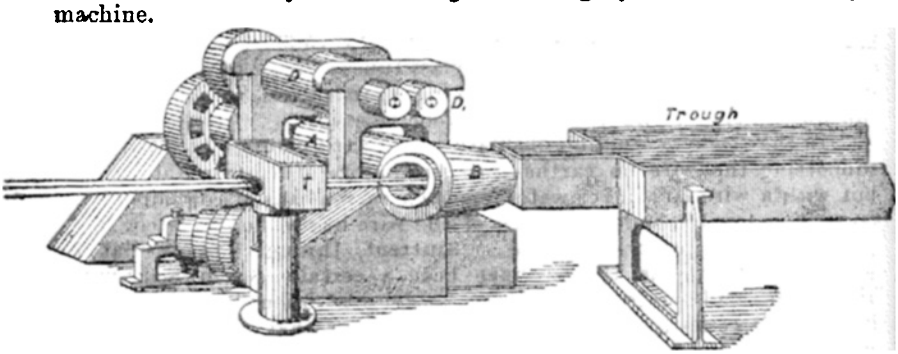
The first person to send a current through an insulated wire under water is said to have been a certain Baron Schilling. In a paper read before the Imperial Academy of Science at St. Petersburg, in December, 1859, Dr. Hamel mentions that in Sömmering's note-book (which he had himself examined) he had found it stated that a General Wolzogen had told the said Sömmering that he had seen an individual named Schilling explode mines in 1812 by a wire laid under the Neva. This, you will agree with me, sounds rather like the information Sam Weller gave at the trial of "Pickwick"; and whether it be correct or not, it is quite certain that Colonel Pasley of the Royal Engineers, at Chatham, sent a current through a wire under the Medway; and that he also blew up the wreck of the "Royal George" at Spithead in 1838, with a wire insulated with tarred rope and covered with an outer layer of pitched yarn.

Then Professor Wheatstone (afterwards Sir Charles Wheatstone) —originally a music-seller—is said to have been actually engaged for three years, from 1837 to 1840, on a method of insulation for a proposed cable across the Straits of Dover! In the latter year, however, Faraday and Werner Siemens independently pointed to the insulating properties of gutta percha; and india rubber was suggested as an electrical insulator about the same time.

To Morse we must certainly give the credit for first using a wire covered with the latter material for transmitting signals under water. At this time, the great American inventor was suffering from most dire poverty; and we find him writing:—"I am crushed for want of means. My hat is hoary with age, and my stockings all want to see my mother." Nevertheless, he succeeded in proving the utility of india rubber covered wire for signalling across rivers.

Gutta percha is the natural product, as a gum or milky juice, which oozes from certain sapotaceous, wild-growing, East Indian trees when an incision is made in the bark. India rubber is the only other substance which has been used in practice for insulating submarine conductors. Its gum is collected in the same way from a somewhat similar tree, growing in the same sort of damp, tropical climates.

Owing largely to the greater difficulty in satisfactory mechanical manipulation—though much used for underground work, for which gutta percha is unsuited—india rubber is comparatively little employed for covering submarine wires, except under special circumstances to be referred to later. Let us return, then, to gutta percha. Being sold by weight, the noble, but enterprising savage is prone to incorporate with it all sorts of impurities—including stones, and even pieces of iron, as "make-weights." Thus, on arriving in this country in solid, but irregular, lumps, the first experience the "gutta" has is that of taking a bath—in the form of a series of purifying, or cleansing processes, accompanied by what is termed "mastication," which consist mainly of a thorough kneading by a sort of devilling machine.



GUTTA PERCHA COVERING MACHINE.

One of the most successful forms of apparatus for applying the so purified gutta percha to the conducting wire is on the same principle as a macaroni machine. No doubt many of you have consumed macaroni without knowing how it is made. The view here illustrates the gutta percha variety. The gum, placed between the tops of the two rollers DD, is drawn down between them in the form of a thin sheet, to be afterwards forced along to the die by means of an archimedean screw, A. With this machine, several wires may be covered at once.

They are hauled off their respective hanks through a die-box, B, containing a sufficient number of dies of a diameter in accordance with the thickness of the coating required, and thence through a long trough of intensely cold water, to ensure the gutta becoming thoroughly hard before it reaches the collecting drum, which takes from 1 to 3 miles. The thickness of the insulating cover depends upon the length of the line for securing the desired electrical results as to speed of signalling.

I have a specimen here, in my hand, of the "core"—as the covered wire is termed—of the latest Atlantic and Pacific cables. It is the largest type of telegraph core so far used in practice.

The covering of the conductor with suitable insulation is, perhaps, the most important feature in the construction of a submarine telegraph, for so much depends on it; moreover, the cost of the insulating material forms the largest, as well as the most variable, item in the entire line.

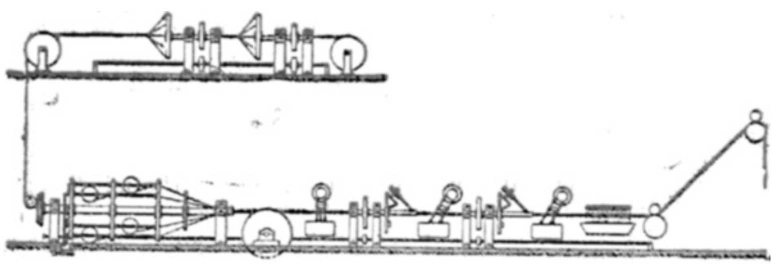
Mechanical Protection.

Once the conducting wire is satisfactorily insulated, nothing else would be required but for the necessity for mechanical protection at the sea bottom, and also to meet the requirements for subsequent recovery when repairs are found to be necessary.

The mechanical protection and strength of a submarine telegraph has—more or less from the start—taken the form of a close sheathing of galvanised iron wires similar to pit ropes. It was at once recognised, however, that if these wires were applied direct on the outside of the core, the insulation would be likely to suffer mechanically, and, therefore, the line would soon become electrically unsound. To meet this objection, the core is enveloped in a close packing of several jute yarns. These are applied by a machine on the same principle as that for laying up the copper strands.

As in the case of the conductor and the jute (or hemp) serving, the iron wires are applied helically in accordance with mechanical requirements, by a machine of precisely the same character as that employed for laying up wire ropes.

For the deep sea portion of a line the wires are nowadays usually composed of steel—with a breaking strain over 100 tons per square inch—the object being longitudinal strength, whereas that for the heavy shore end types is composed of soft iron, but of a much larger gauge for the purposes of weight (combined with flexibility), in



General View of Cable Manufacture.

order to cope with anchors, rocks, tides, etc. The galvanising of iron wires is not a complete preservative against rust in salt water; and, mainly for this reason, the sheathing is coated with a mixture of mineral pitch, tar, and silica—known as Bright and Clark's Compound—which is again applied after the cable has been enveloped in an outer serving of hemp, or canvas tape, by way of a firm binding and a further preservative.

The slide before you presents a general view of the serving and sheathing of a cable in all its operations. Here, on the upper floor of the factory, is the drum of insulated conductor, and here are two jute serving machines for applying yarns, each in opposite directions. Here, on the floor below, is the iron sheathing machine. Here, too, are different machines for applying the compound, cold first, then a layer of canvas tape, then hot compound, then another layer of tape with the reverse lay, then hot compound again, the cable finally passing under streams of cold water to cool and harden the surface before it is led to the cable storage tank, on its way to which it receives a coating of whitewash to prevent sticking.

The splicing together of different lengths of the cable is performed in the same way as ordinary hempen or iron ropes; and it is, in any case, impossible to enter upon the details of this, just as it has also been impossible to deal with the important operation of making a joint in the insulated conductor, the secret of which is care, cleanliness, and experience.

During the whole course of manufacture, the cable is kept under a continuous electrical test; and I can only add that the instruments employed therein are similar in principle to those used in the subsequent electrical working of the line.

About 35 miles is an average output of cable made at a cable factory in an ordinary working day—varying, however, with the number of machines available. Thus, as a rule, it takes from 2 to 3 months to make an Atlantic cable.

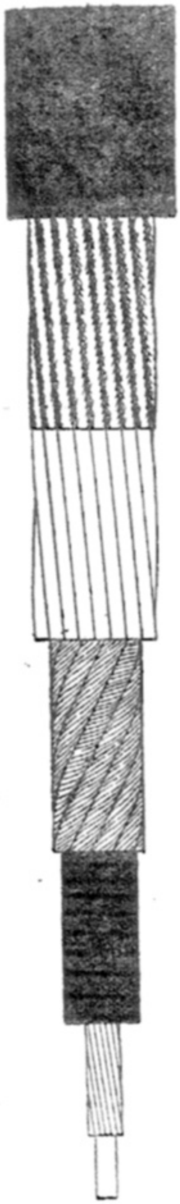
The slide before you (see p. 377) represents the different types of cable of one of the modern Atlantic lines. As you will observe, the shore end types have a second (outer) sheathing of wires. In the case of the Irish shore end, these outer wires appear elliptical. In reality, however, they are the ordinary circular wires, but being applied with a very short lay, this appearance is produced in true section.

The copper conductor is shown here, and surrounding it is the gutta percha insulator, then the jute packing, followed by the sheathing wires varying in each type, as regards their size and number according to conditions, and then the outer covering of compounded yarn.

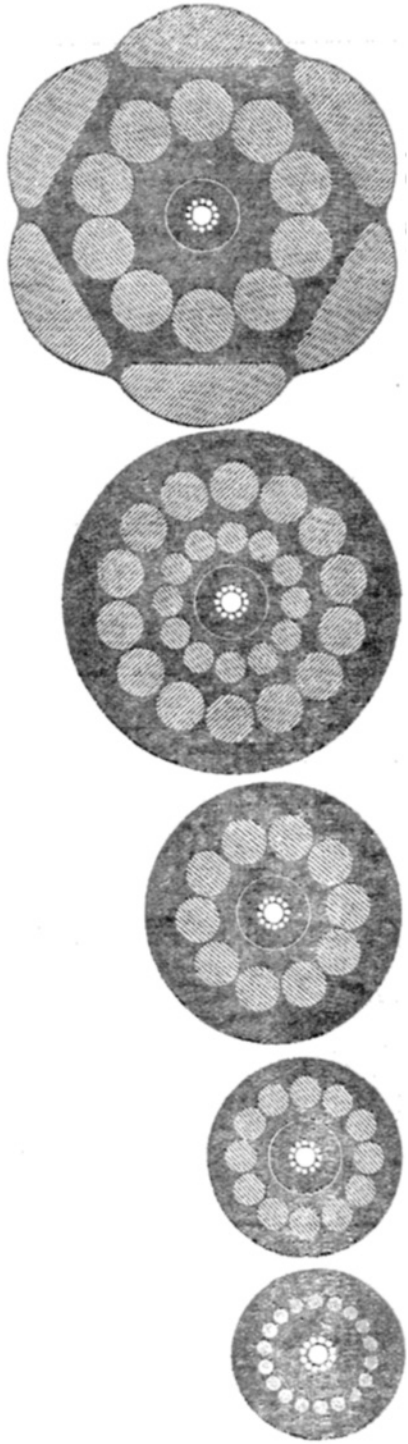
Deep sea (main type) cable of this description—for 3 or 4 mile depths—will bear a strain of 7 tons; and—its weight being only about 1 ton in water—it is capable of supporting a considerable length of itself, when in good condition. Thus, such a cable can be recovered and repaired in great depths in the event of an electrical fault.

At one time, this form of iron sheathing was called into question; and opinions were ventilated very similar to those in the middle ages about soldier's armour. It was said that when the cable had to be picked up, they would have a gutta percha core pulling up a loose sheathing, instead of the sheathing pulling up the cable. The position was likened to a man being knocked down in a suit of armour, and not being able to get up again until it was loosened. Thus, various other types of cable—some, without any iron wires, entirely dependent on hemp for their strength—have been introduced from time to time.

Such cables, however, though certainly possessing the advantage of lightness, have not proved successful in practise, and never received



View shewing the various Coverings of the Deep-Sea Cable.



MODERN ATLANTIC CABLE.
(N.B.—All types actual size.)

serious encouragement. In a type which was adopted in one or two lines—notably in the Second Atlantic Cable, a specimen of which I hold in my hand—each sheathing wire was enveloped in hemp with a view to reducing the weight, but the hemp was soon destroyed by the rusted iron wires which then remained in a loose bundle.

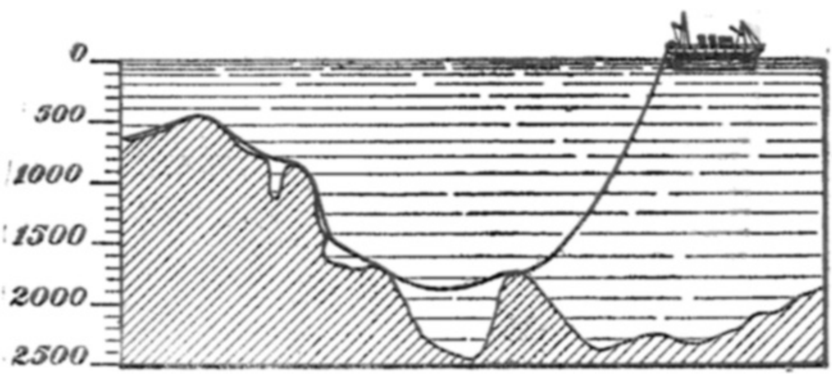
It is, indeed, a remarkable fact—peculiar in engineering—that though steady advance has been made in details, and especially in the quality of the materials used, the general type of cable is practically the same as was first determined on for the very earliest lines. As a good example, however, of the improvement in materials, it may be remarked that the available strength of the cable before you on the screen is 30 per cent. greater than that of the Atlantic cable of 1865 just referred to.

I hold here one of the deep sea (main) type cables of the enormous strength that I have named; and here is one of the heavy shore end types, some of which weigh over 20 tons per mile.

Here, too, in this case are specimens of the various types of the All-British Pacific Cable.

SUBMARINE SURVEY.

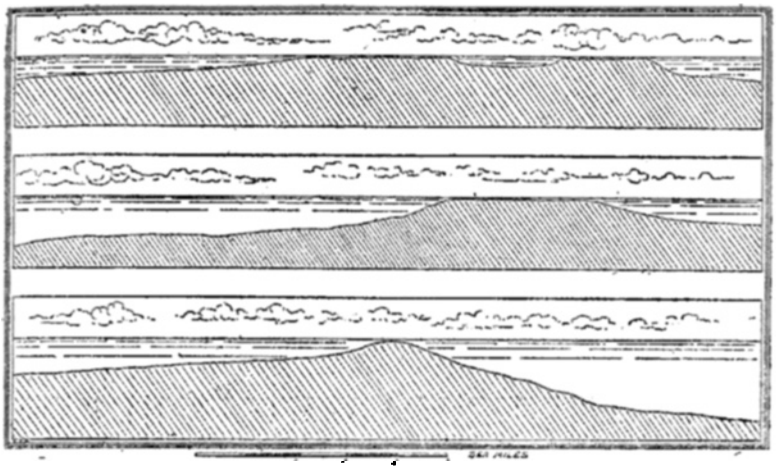
Having now dealt as far as possible with the construction of a submarine cable, I will pass on to the laying of it. Strictly speaking, the manufacture should not be embarked on until a survey of the route has been effected for determining the types to be adopted and the length of the same. In any case such a survey is essential before the actual laying takes place. A few of you may have sometimes thought that a cable floats either near the surface, or somewhere between the surface and the botttom of the sea; but that is not so, for the all-sufficient reason that it is specifically heavier than sea water; and in early days many disasters occurred owing to the lack of preliminary soundings, and the want of even a general knowledge of the bed on which the cable was destined to rest.



Cable-Laying over an Irregular Bottom.

Some idea of what happens when a cable is laid over a sea-bottom that has not been surveyed may be gathered from the slide before you. In this instance, you see, even if the cable does not break during the operation of laying, it is pretty certain to do so very soon after, due to the strain of being suspended from point to point.

Such irregularities as are here depicted would require very special precautions. They would, however, be best avoided altogether, if another suitable route could be found.



CONTOURS OF THE SEA BOTTOM.

This slide illustrates the sort of bottom that cables are laid on under normal conditions; and even then it is desirable to take soundings in advance at intervals of about 10 miles, lest there should be, as there often may be, a submarine mountain—or, on the other hand, a valley—on the route, such as must be avoided, or allowed for, in laying.

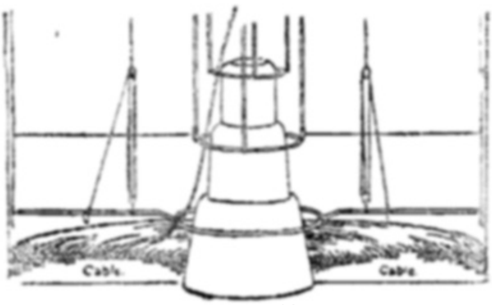
All deep water soundings are nowadays effected by means of very fine, but intensely strong, steel wire of the type employed in the treble notes of a piano, bearing a strain equivalent to 130 tons per square inch. With such a wire, and a suitable weight attached thereto, the depth is ascertained by noting the length which runs out before bottom is struck, the wire being afterwards recovered by means of a steam, or other, engine. The employment of this system enables soundings to be taken with far greater accuracy and despatch than was possible with a stout hempen line, as used in former days.

Besides measuring the depth, it is usual—by means of small metallic tubes attached to the line—to secure a specimen of the bottom; and occasionally, with the aid of a suitable thermometer, to ascertain the temperature, this also being a matter of some importance—partly in revealing the possible presence of any hot springs. Some of you may be surprised to know that the temperature at great depths is as low as 35° Fahrenheit. Thus, when surveying, or cable laying, in tropical waters, science and engineering may be combined with personal comfort by utilising a good fat sample of the oozy sea-bed for cooling the liquid refreshment of the perspiring engineer.

And here I would add that by far the most complete surveys of the ocean floor have been effected as the result of submarine cable enterprise rather than by the naval authorities of any country. This, however, is only natural; for, in our case, a thorough survey often means the difference between heavy commercial loss and complete and lasting success.

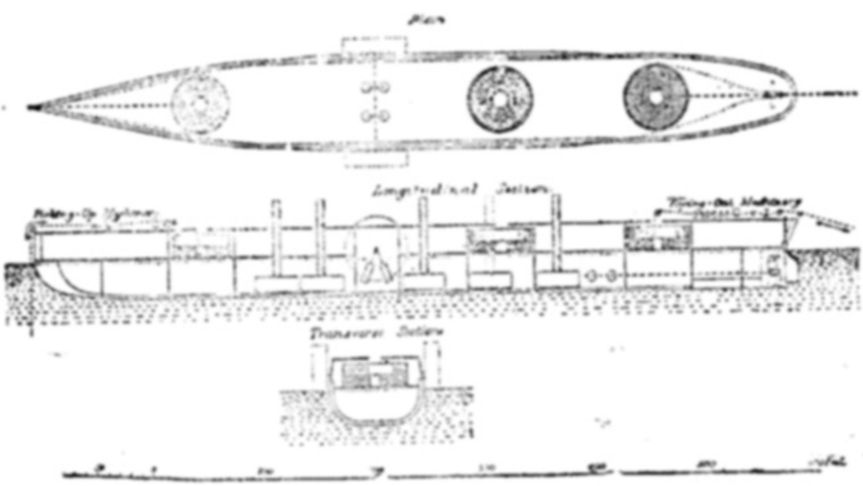
CABLE-LAYING.

Let us now return to the cable factory, where the cable having been made is being gradually shipped on board the vessel that is about to lay it on the route determined on according to the survey. People sometimes wonder how it is that an entire Atlantic cable, say, can be got into a single ship, and I will now show those of you who are least conversant with the object how this is done.



COILED CABLE IN TANKS.

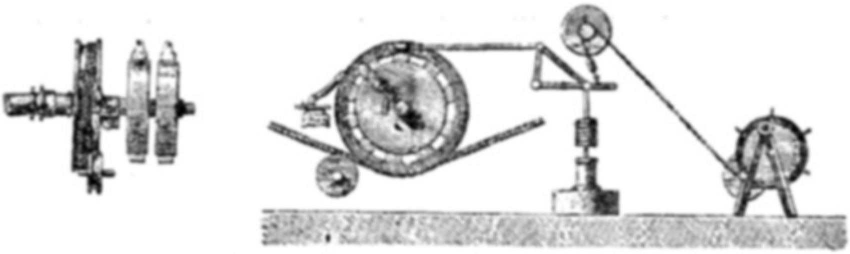
The cable is drawn out from the factory tanks into corresponding water-tight iron tanks on board—of which there may be three or four for different types and lengths of cable. The slide before you illustrates one of these, with the cable partially coiled therein—and very closely packed, as you will observe. The tank is, as you see, furnished with a frame work known as the "Crinoline." Its object, in conjunction with the conical centre piece here, is to steady the cable as



S.S. "GREAT EASTERN" CONTAINING CABLE AND MACHINERY.

it leaves the tank at a more or less high speed, and ensure it running out without accident. Mr. R. S. Newall devised this arrangement, thereby sharing with the Princess Eugenie the honour attached to the invention of a crinoline.

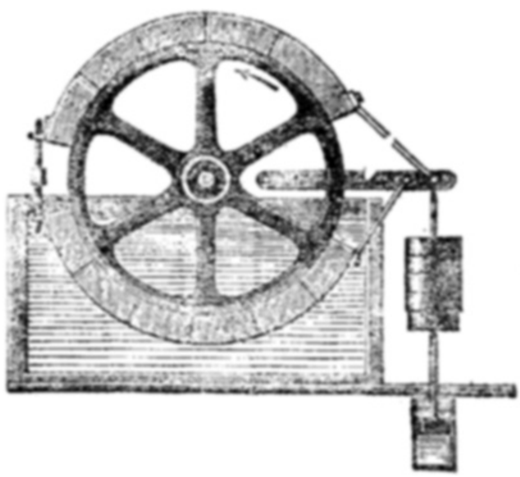
The slide before you (p. 380) illustrates the "Great Eastern" with a length of 600 feet—loaded up with the 1865 Atlantic cable. You also get here a general idea of the arrangements for paying out the cable from the stern—or picking up from the bows—of a telegraph ship. With small repairing-ships there is often no stern gear, any necessary laying work during repairs being effected by means of the bow machinery. Indeed, the picking up gear is frequently used for paying out a short length even on large vessels, to save the operation of passing the cable along to the stern after splicing on to a buoyed end.



Appold Brake and Dynamometer.

The evils of laying a cable without a proper knowledge of the contour of the sea bottom have already been dealt with; but it is almost equally bad to lay a cable without properly providing for such irregularities as are unavoidable.

This provision takes the form of laying what is known as slack cable where necessary—that is, extra cable to fill up the said irregularities, thereby avoiding suspension from point to point. This involves a due regulation of the line in its egress from the ship, in proportion to the speed of the vessel overground; and that is secured

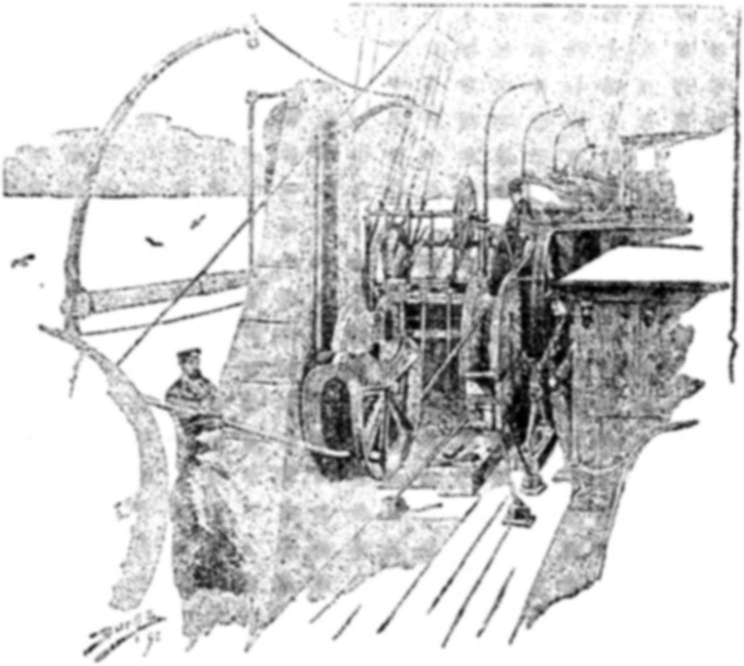


Appold Brake.

by the apparatus between the cable tank and the stern of the vessel. I have a certain filial affection for this machinery, inasmuch as it was originally introduced by my father, the late Sir Charles Bright, for laying the first Atlantic cable. The principle of the apparatus is illustrated in the next slide.

Round this drum, the cable, on its way from the tank, takes—as you see here—several turns before passing on to a sheave towards the stern of the ship. The speed at which the cable passes outboard is controlled by the speed of this drum. On the same shaft there are, you observe, two other drums.

These latter drums run through a circular friction strap, which is tightened or loosened as required, by altering the weight at the end of the lever. The winch shown in the preceding illustration provides for the entire relief of the weights should occasion require.



PAYING-OUT MACHINERY ABOARD SHIP.

In this slide you observe the engineer-in-charge. He is watching what is called the dynamometer, which consists, in principle, of the pulley here which runs loosely in the vertical slot of this frame. The cable, you notice, passes under the pulley, placed midway between two fixed sheaves; and by this means an indication is afforded of the actual strain on the cable, for, as the strain increases, the cable raises the movable pulley. As the depth varies, it becomes necessary to alter this strain by adjusting the weight on the brakes in order to pay out the amount of cable required for the irregularities of the bottom. It is obvious this must always be in excess of the distance run by the ship overground, which might be 7 miles to 8 miles of cable.

On a given line, the average surplus cable laid to provide for the aforesaid irregularities of the bottom amounts to something like 10 per cent. of the length. Thus, taking the distance across the North

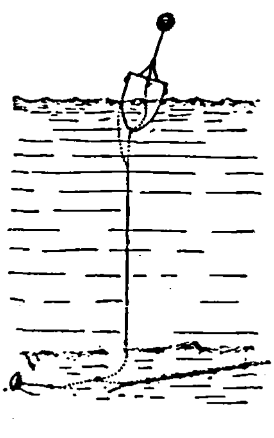
Atlantic Ocean at about 2,000 miles, the cable actually laid will amount to 2,200 miles. On this basis, and by continuous work day and night, it takes about 3 weeks to lay an Atlantic cable under favourable conditions as to weather, etc.

Testing.

While the egress of the cable is being looked after by the engineers on deck, its electrical health is being carefully tended—its pulse carefully felt, indeed—by the electricians in the testing room, who are—or should be—in continuous communication with those at the cable testing hut on the shore, where the paying out vessel has laid the line from. This takes the form of sending certain prearranged signals at certain prearranged intervals of time, accompanied by occasional interchange of remarks. If anything goes wrong—such as the cable actually breaking under a strain, or the gutta percha insulation failing under the extreme pressure of the ocean—the electricians know of it at once; and their first duty is to give notice to the engineer-in-charge, with a view to the ship being stopped and laying operations suspended.

Electrical tests for the localisation of a fault are too elaborate for dealing with on the present occasion. The skill of electricians in this most important work has been brought to a very high pitch; and, under favourable conditions, a fault can often be localised even to within a few feet—indeed, more accurately than the position of a ship can be determined. Under less favourable circumstances, and on long lengths of cable—where tests may be seriously interfered with by earth currents—localisation is sometimes very difficult, though a fault is frequently localised within a quarter of a mile in a total length of 1,000 miles.

In a similar way, navigation may, during a spell of unfavourable meteorological conditions, be equally difficult; and a ship is often not brought up to within a mile, or materially more, of what it is supposed to be, whereas, under favourable conditions, extreme accuracy is commonly secured.

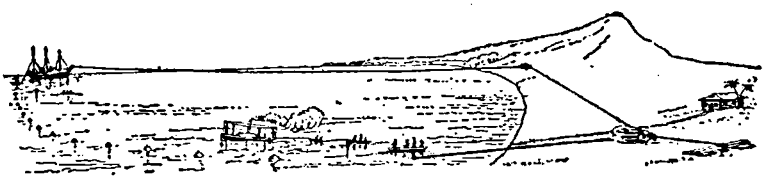


A Buoyed Cable End.

Assuming that all goes well, cable laying would be continued until reaching a point a few miles from the other shore, when the cable would be cut and buoyed, preparatory to landing it at that end. As a rule, however, the shore end has been previously landed by a smaller ship entirely occupied over this work; so that, in that case, the big vessel that has laid the main cable would approach the buoyed end of this cable.

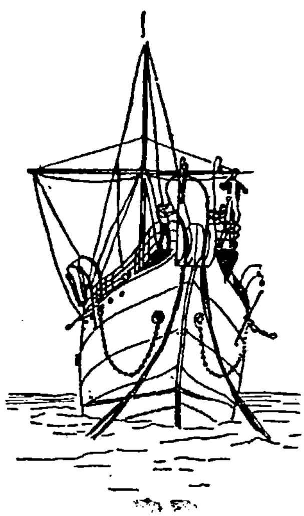
Here you have a general representation of a buoyed cable end (p. 383); and I think, as we have so far shirked the landing of our shore end, we had better turn to that, and consider that we have taken the first course—namely, that of buoying our main cable, the actual operation not being readily described in a few words, but a general idea of which you can no doubt obtain from the slide before you.

As it would be impossible to haul a heavy cable ashore along the bed of the sea, it has to be floated ashore on the surface; and this is usually done by barrels, or preferably by india rubber balloon buoys, being attached to it at intervals.



Landing the Shore End from a Telegraph Ship.

Here we have a view illustrating the method generally, showing the arrangement and tackle adopted for hauling the end of the cable ashore by means of steam gear aboard-ship.



Slipping the Final Bight of a Cable.

Let us now suppose we have laid our shore end. The telegraph ship then proceeds paying out towards the buoyed end of the main cable. Having picked this up, a splice is effected between the two cable ends. Preparations are then made for letting go the final bight of the entire line, the final operation of slipping the bight being shown.

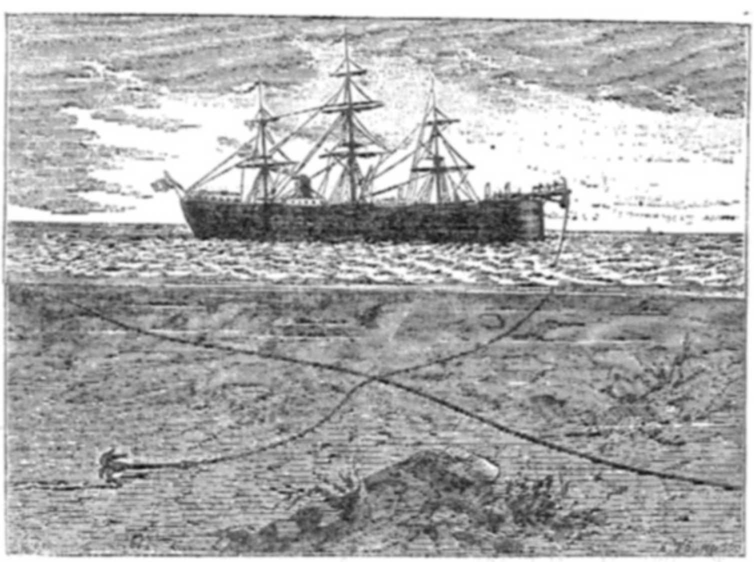
THE EVENTUALITIES OF A CABLE.

The eventualities of a submarine cable are many. It may be torn by an anchor, crushed by a rock, or seriously damaged by a coral reef, such as abound in the tropics. Some of the growths

THE TEREDO NAVALIS.

often found on a cable tend to gradually decay the iron sheathing wires. Then, again, a cable is sometimes severed by a sea-quake.

But the little animal that makes itself most objectionable, from the cable engineer's standpoint, is the insignificant-looking teredo navalis. This little beast is intensely greedy where gutta percha is concerned, working its way there between the iron



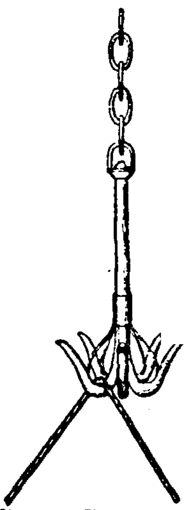
CABLE GRAPPLING.

wires and between the serving yarns. The silica in the outer cable compound tends to defeat the teredo's efforts at making a meal off the core; and this defeat is further effected by the served core being enveloped in a thin taping of brass—applied spirally during the inner serving operation, and in a similar manner. But where the bottom is known to be badly infected with these little monsters of the deep, the insulator is often composed of india rubber which has no attractions for the teredo, and possesses a toughness, moreover, which is less suited for its boring tool than the comparatively cheese-like gutta percha.

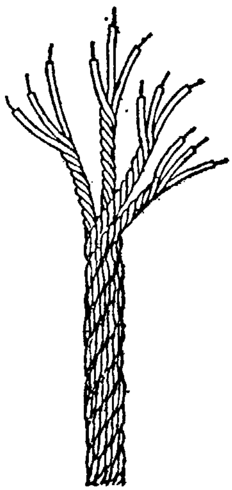
CABLE REPAIRS.

We see then that, from one cause or another, faults occur in most cables from time to time. These require to be electrically localised from the cable testing hut, on principles already briefly alluded to; and a ship sent out to the supposed position to grapple for the line, pick it up and effect the necessary repairs.

The preceding view gives you a general idea of the operation of grappling for a cable.



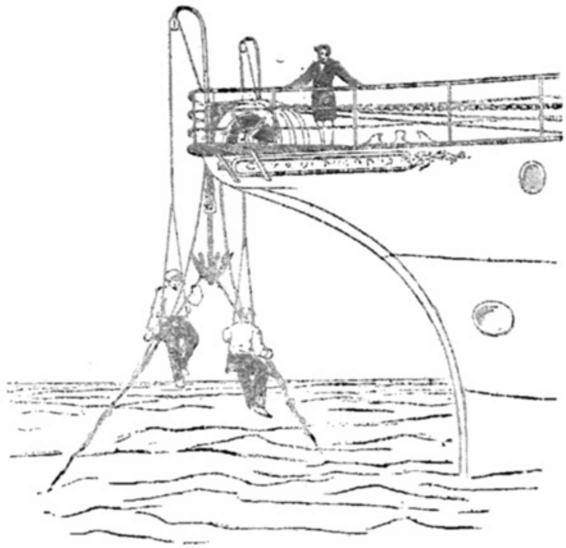
CABLE GRAPNEL.



GRAPPLING ROPE.

Here you have an ordinary type of grapnel for hooking on to the cable, and also the line to which the grapnel is attached. This is composed of strands of steel and hemp combined, and bears a strain of as much as 20 tons. There are also several other forms of grapnel, some with aprons to prevent the prongs becoming engaged with rocks.

When the cable has really been hooked and picked up—an operation which may entail several weeks, or even months, if only in waiting for favourable weather—the bight is secured at the bows, as you see here, and afterwards cut. Each end is then brought on board alternately and tested electrically. If found to be sound, the necessary repairs are then effected on principles already set forth.



BIGHT OF CABLE SECURED AT BOWS.

CABLE SHIPS.

Having briefly described most of the operations connected with cable work, I will now show you views of some worthy representatives of the telegraph fleet,[1] which amounts to 56 in all, including small repairing vessels.

The "Colonia" is the latest of the big telegraph-ships, having—with her sister-ship the "Anglia"—entirely outstripped all others in size and every other respect. This vessel, and the "Anglia," were built for the laying of the All-British Pacific cable, which they laid in the year 1902 with complete success. With a length of 500 feet and a carrying capacity of 11,000 tons, either of them would be capable of laying an entire Atlantic cable with the assistance of a smaller vessel for landing the shore ends.

The telegraph-ship "Silvertown," built in 1873, comes next in size and carrying capacity. Her beam is as much as 56 feet, and she is capable of carrying 8,000 tons, though her length is not considerable. I have had the pleasure of travelling a great number of miles in this vessel in connection with various cable-laying expeditions.

I am sorry that I am not able to show you the "Faraday"—a cable-ship of very similar dimensions, built a year later. Named after one of the greatest electricians, this vessel is of special interest owing to her design—due to that distinguished man, the late Sir William Siemens. She resembles a penny steam-boat to the extent of having bows aft as well as forward, the idea being to facilitate cable operations.

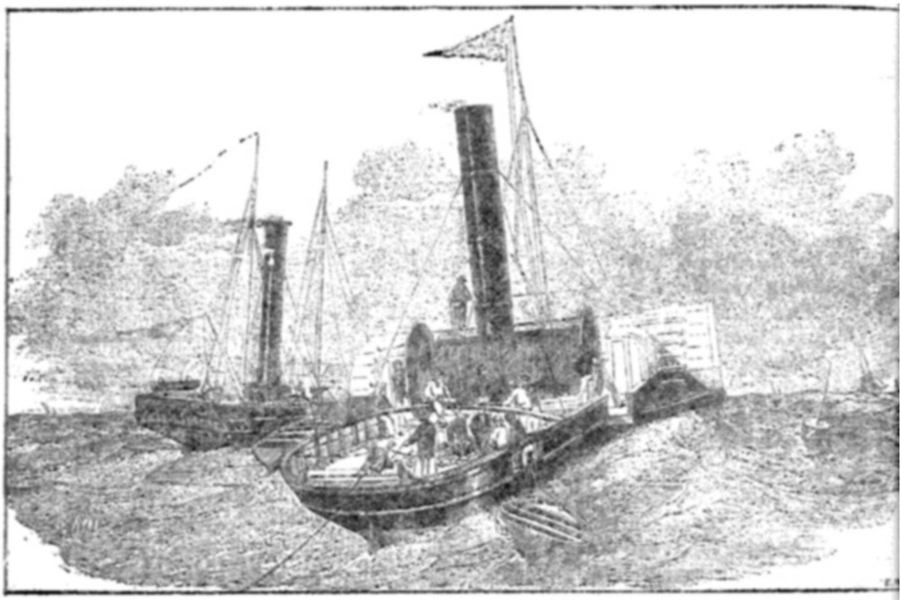
But though I cannot show you the "Faraday," I can show you the Post Office Telegraph-Ship "Monarch." She is concerned in the physical well-being of our telegraphic communication with our Irish and continental neighbours by means of comparatively shoal water cables.

[1] These views of ships appear on another page.

HISTORY.

Realistic history is a practical and interesting weapon of instruction. It commits points to memory so well. Moreover, history—with a personal touch—should surely help one to follow in the steps of those that make history. I, therefore, now propose running through some of the main points connected with the early pioneering of submarine telegraphy, most of which I am illustrating by slides of an historical nature.

Unquestionably, the *bric à brac* shopkeepers, Jacob and John Watkins Brett, were the first to deal with submarine telegraphy from a public and commercial standpoint. On 16th June, 1845, they registered a company for the purpose of telegraphic communication between this country and France; and a little later they addressed themselves to the Prime Minister, Sir Robert Peel, who did not, unfortunately, share their confidence. This move, indeed, only



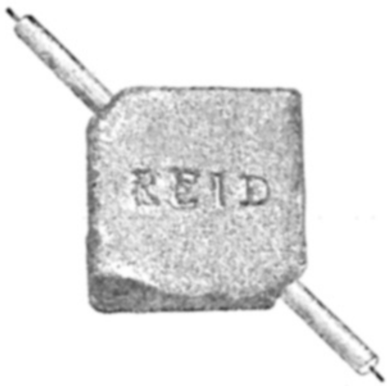
LAYING THE FIRST CHANNEL LINE.

involved the Bretts in a departmental correspondence—more academic than useful, in which they were diplomatically passed backwards and forwards from one Government office to another.

By 1849, however, the Bretts had obtained consent from the authorities of both countries to lay a cable across the Straits of Dover.

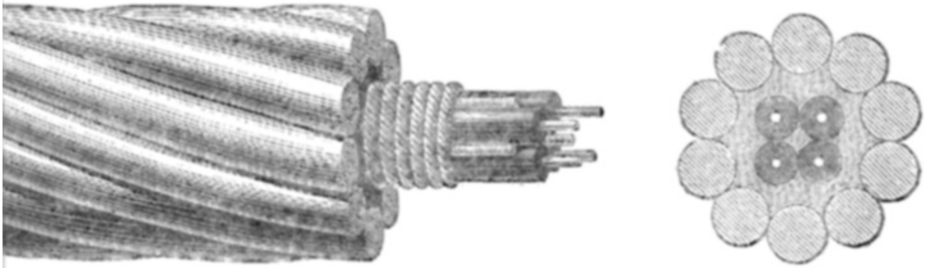
The slide before you illustrates the laying of this line from the "Goliath"—a small Thames tug with a very big name! The line only consisted of a gutta percha covered copper wire. This was unwound across the Channel from the huge reel you see on deck here, and the further end connected to a Cooke and Wheatstone needle telegraph instrument set up in a bathing machine. The carrying out of this enterprise excited little or no attention at the time. It was, indeed, looked upon as a mad freak—and even as a gigantic swindle—indulged in only by wild minds. When accomplished, *The Times* remarked, in the words of Shakespeare:—"The jest of yesterday has become the fact of to-day." But a few hours afterwards it might with equal truth have been said:—"The fact of yesterday has become the jest of to-day!" Messages were, however, certainly sent through this insulated wire.

Brett had a document, signed by twenty Frenchmen, dated 6th September, 1850, who declared that they had seen the electric telegraph working between France and England. The signals, it must be confessed, were rather incoherent; the operators at each end blamed those at the other, and tauntingly suggested that the excitement, or something else, must have gone to their heads. In any case, the glory of this telegraph was, unfortunately, short-lived, for after the first evening it maintained an obstinate reserve, and never spoke again. An attempt was then made to raise the wire; but as a leaden weight had been attached at every hundred yards, in order that it might be successfully sunk, all efforts were in vain. However, a considerable length was brought up by a fisherman in his trawl, who carried it off to Boulogne in triumph, as "a piece of rare seaweed with a pith of gold!"



1850 LINE AND WEIGHT.

Here you see the line which did such short duty with the leaden weights attached. You will observe that Mr. Reid (the contractor)



THE FIRST CHANNEL CABLE, 1851.

was determined that, at any rate, the fishes at the bottom should know of him—and that he made leaden weights!

Then, again, on 19th December, 1850, a concession was granted to Jacob Brett by the French Government, and on the strength of this the Submarine Telegraph Company was formed. But £300 was all that the public would subscribe, because it had been *proved* that submarine telegraphy was an impossibility! Yet these early pioneers, with that peculiar obstinacy that characterises inventors, actually went on believing in their own ideas.

Mr. Crampton, the well-known railway engineer, came to the rescue with £7,500 of his own and a similar amount from his friends. Then Mr. Küper, a colliery engineer, came along and said: "Why not protect your gutta percha covering by an iron sheathing?" Well, the cable with its sheathing was made, and on 25th September, 1851, a procession, with a man-of-war to lead the way, started from the South Foreland to the shores of France. All went well until they were in sight of the opposite coast, when the cable gave out. Another mile was ordered, manufactured, and laid; and on 13th November, 1851, the public sent a message through a submarine cable—the cable on the screen before you—for the first time in the history of the world. As you will observe, there were four insulated conductors covered with hemp and iron wires.

Piece of 1851 Channel Cable Picked up Later.

The cable had a very good life, and this class of armour has been adhered to ever since. The slide here illustrates how little this cable was affected by time, when picked up a good many years later.

The Bretts then applied to the Government for a monopoly to electrically connect England and Ireland. This time they were not so fortunate; for, on 10th September, the Admiralty wrote, that "they had watched with interest the progress of the experiments, but had no power to grant a right." On the 18th the "Foreign Office is directed, by Viscount Palmerston, to congratulate you upon the success of your experiment, and to state that the matter does not relate to the business of his Lordship's Department." On the same day, the Admiralty again wrote, "that whatever privileges can be granted, can proceed only from the Treasury." The next day, the Treasury "acquaint you that it is not in the power of the Lords Commissioners of Her Majesty's Treasury." They got the same answer on 28th September. On 18th October, 1850, they received the following letter from the Treasury:—"Although sensible of your perseverance in bringing the submarine telegraph about, and in view of the great public benefit likely to arise in connection . . . but it is not in their Lordships' power, etc."

Cables were eventually laid between England and Ireland; and although the first two were failures, in 1853 my father successfully connected the two islands—this first piece of cable work forming part of his honeymoon at the age of 21. I hold a specimen of this line in my hand. It was similar to the Dover-Calais Cable here referred to, but contained six insulated conductors round a heart of hemp. This particular specimen—somewhat rusted, as you see, by time—illustrates the effects of pressure against a rock.

Then followed a number of lines laid across the English Channel, in the Mediterranean, and elsewhere. Many of these early attempts either resulted in breaking the cable, or, in paying it out with so much slack that it reposed in festoons at the bottom of the sea, as there were no means then of indicating what force was being exerted by the brake used to restrain the running out of the line.

We now come to the period when a much more difficult problem was dealt with—I mean spanning the Atlantic Ocean by laying and speaking through a cable 2,000 miles in length, the depth being upwards of 3 miles. Many eminent scientists had said it would be impossible to deposit the line at all at so great a depth; and that even if laid, it would be a mathematical impossibility to transmit electrical signals through such a length. The Atlantic cable was, indeed, considered at this time (1857) a wild freak of people that were to be pitied.

Here you have the portraits[1] of some of those who were the subject of "pity." Mr. Brett had, as I have shown, already been associated with other pioneer cables. Mr. Cyrus Field was a wealthy American business man of far-seeing and enormously active character,[2] and my father had already attracted considerable attention as an engineer. These were the three "projectors," and my father was also the engineer.

There were evidently some spirits who believed in the enterprise—or in those at the back of it—for the Atlantic Telegraph Company was formed within a few days, the entire capital being raised almost entirely in England by the public issue of 350 shares of £1,000 each.

The proposed route was surveyed in what we should now consider a somewhat "sketchy" fashion; for whereas, in the present day, we sound at intervals of about 10 miles, at that time sounding every 100 miles was considered abundant. The general character of the bottom was, however, correctly arrived at from the specimens brought up, being, in fact, the usual oceanic ooze of extremely minute shells—a perfect bed for cables.

The manufacture of the cable was duly proceeded with—partly at Greenwich and partly at Birkenhead, near Liverpool. I have here, in my hand, one of the few specimens of it in existence. As you will see, on close inspection, the outer wires were composed of several strands of fine wire. Thus the entire length of wire employed was as much as 340,500 miles—enough to engirdle the earth thirteen times and considerably more than enough to extend from the earth to the moon. This stranded sheathing had certain

[1] These portraits appear on a separate page.

[2] Mr. Field had achieved a commanding position in respect to any such scheme by acquiring a concession from the late Mr. F. N. Gisborne (a well-known Canadian engineer) for communication between Newfoundland and Canada.

mechanical advantages at the outset, but has since been found by experience not to be a durable type of armour.

The Governments of the countries concerned encouraged the scheme to the extent of lending certain vessels for laying the cable, as they had done previously for the survey.

The main contribution from the United States was the "Niagara"—a splendid example of the frigates of that time. A smaller vessel was also provided by each Government to land the ends, pilot the way, and act as consorts generally.

Mishaps soon occurred; for it was only four miles that had been paid out when the cable broke. Another start was made; but, after 226 miles had been laid, it again broke—this time, however, at a depth of 2 miles. So ended the first attempt to electrically connect America with Europe. Morse, who was on board in an honorary capacity, recorded the circumstances as follows:—"The cable parted just before day-break. The machinery having stopped, all hands rushed on deck and gathered in mournful groups; their tones were sad, their voices low, as if a death had occurred on board."

The next year (1858) more cable was made, and a second expedition started with 3,000 miles. The two vessels were this time to meet in mid-ocean and make a joint, and then sail in opposite directions, laying the cable towards their respective shores. This they did, but the joint broke. They made a second, and again it broke. They made a third, and then one ship sailed towards Ireland and the other towards America.

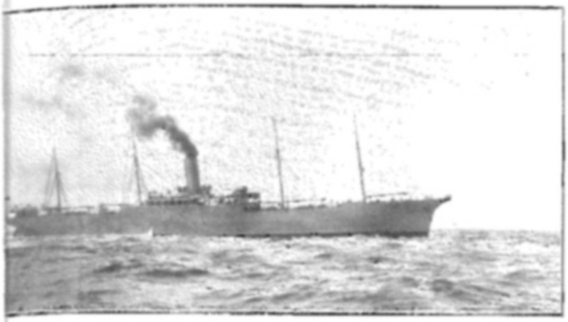
On her way, the "Agamemnon" encountered a whale, and though the ponderous monster made commendable attempts to carry off the cable, these attempts were attended with no evil result. The "Niagara," however, had not gone far before another break occurred which ended in the loss of 500 miles of cable. Sufficient yet remained on board for a third trial.

Meanwhile, however, both ships had run out of stores; and it was therefore necessary to put into Queenstown. On the way, a terrific storm was encountered, and the "Agamemnon" nearly "turned turtle." The boots, food, and crockery—not to mention the coals—got, of course, terribly mixed up; but so did the cable in the tanks, and this was a much more serious affair.

Matters were, however, righted; and after stores had been procured, the telegraph fleet again met in mid-ocean to make the splice, and again set forth on their respective work. The first expedition created considerable excitement, but when it came to the second and third, everyone—except the shareholders—merely pitied those that were continuing such a futile errand. However, the pity was now beginning to be misplaced, for this time the entire line was laid successfully.

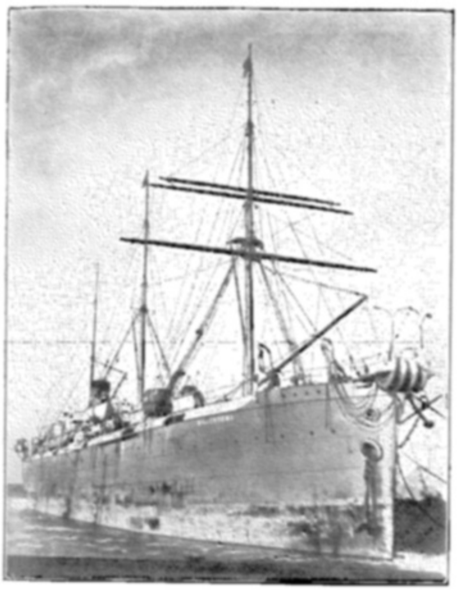
Though having little to do with the actual work, our American cousins were, as might be expected, more demonstrative on the subject, and wild excitement prevailed on the landing of the end at the Newfoundland Station. But even *The Times* remarked: "Since the discovery of Columbus nothing has been done in any degree comparable to the vast enlargement which has thus been given to the sphere of human activity."

It was on 5th August, 1858, that England spoke for the first time electrically with America. Formal and reverential were the



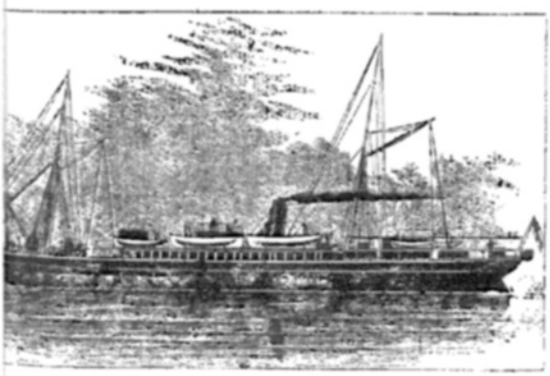
T.S. "COLONIA."

PROFESSOR WILLIAM THOMSON
(AFTERWARDS LORD KELVIN).



T.S. "SILVERTOWN."

MR. (AFTERWARDS SIR CHARLES)
BRIGHT.

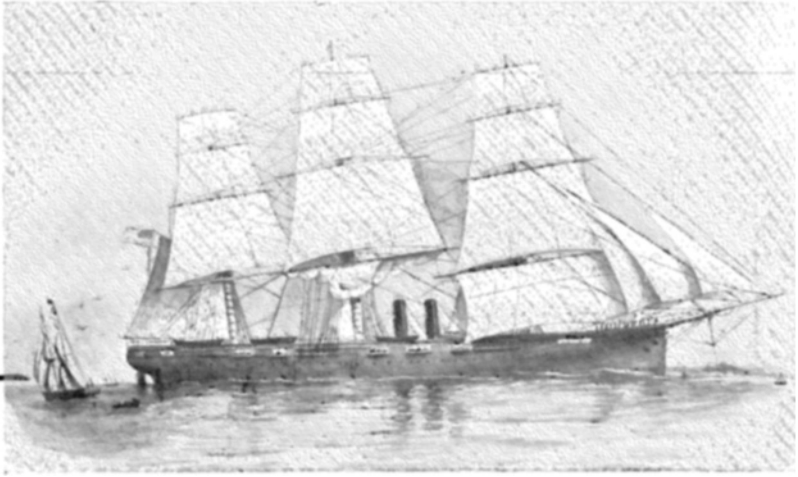


H.M.T.S. "MONARCH."

MR. CYRUS FIELD.

[P.T.

H.M.S. "AGAMEMNON" COMPLETING THE FIRST ATLANTIC CABLE.



U.S.N.S. "NIAGARA"
ENGAGED ON THE FIRST ATLANTIC CABLE EXPEDITION.

S.S. "GREAT EASTERN" PICKING UP THE SECOND ATLANTIC CABLE
AT 0.50 A.M. ON SEPTEMBER 2ND, 1866. (DEPTH 2 MILES.)

ERRATUM.

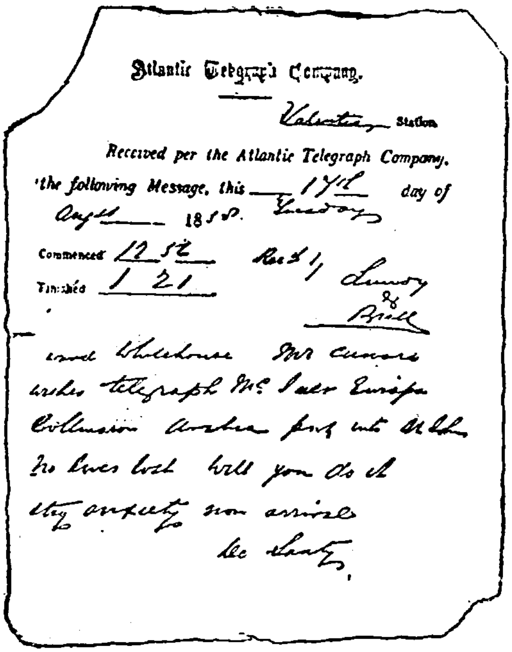
Owing to a regrettable blunder on the part of the rinters, the blocks of H.M.S. "Agamemnon" and the ..S. "Great Eastern," on Page 392, of the March 'Journal" were misplaced.

For H.M.S. "Agamemnon" *read* S.S. "Great Eastern."

For S.S. "Great Eastern" *read* H.M.S. "Agamemnon."

first words of greeting between Her Majesty Queen Victoria and the President of the United States.

It must be admitted that the cable never worked very satisfactorily from the outset; for the message from the United States' President to our Queen occupied over thirty hours in transmission, though only containing 150 words! Moreover, the utmost speed achieved was some 6 words a minute, whereas a modern Atlantic cable, with modern implements, can—as I have already mentioned—be worked up to 100 words per minute. Indeed, that is approximately an ordinary working speed.


Atlantic Telegraph Company.

Valentia Station

Received per the Atlantic Telegraph Company, the following Message, this 17th day of August 1858. Tuesday

Commenced 12 52

Finished 1 21

and Whitehouse Mr Cunard
wishes telegraph McIver Europa
collision Arabia put into St Johns
no lives lost will you do it
stay anxiety now arrival

THE FIRST PUBLIC NEWS MESSAGE.

This is the first public news message that was sent through the cable; and in allaying the anxiety of passengers after collision between two ships, it served a most useful purpose. The line also further illustrated the great utility of a cable service, by conveying two messages from the War Office to Canada, the effect of which was to countermand the return of two regiments, thereby saving the expenditure of £50,000!

But though doing useful work for some 2 months, the line was gasping under its efforts throughout, and gradually reached the sinking stage. It was suffering—and ultimately succumbed—from the effects of mistaken electrical views, in which even the great Faraday shared. The line was, indeed, an electrical failure, though a complete engineering success. It had been proved that such a length of cable could be laid in really deep water; and, though various mishaps had occurred before final engineering success was achieved, there were only due to unavoidable accident on the one hand, and lack of perfection in manufacture on the other, such as could be improved on by the experience gained. My father, the engineer-in-chief, was knighted at the age of 26 in connection with this pioneer work.

From the next cable, however—that laid by the Government in the Red Sea in 1859—nothing useful was learned. The sections failed one after the other, and it is doubtful whether a message was ever sent through the whole of the cable; but it is certain that the British public have paid, are paying, and will continue to pay till next year, £36,000 a year for the privilege of having put some copper-wire, gutta percha, and iron sheathing at the bottom of the Red Sea.

There were several other cables laid soon after—from Malta to Alexandria, to India and elsewhere, and these proved a complete success. A little later a project was mooted for an extreme North Atlantic cable, with stepping stones at Iceland and Greenland; but possibly the temperature there was not sufficiently inviting, for certainly the scheme came to nothing.

It was not until 1865 that the question of re-spanning the Atlantic took active shape. My father had, in the interval, persuaded the powers that be, that a larger and more costly insulated conductor was essential. Moreover, the electricians were also better advised in regard to the generating power and apparatus for signalling purposes; indeed, Professor William Thomson (afterwards Lord Kelvin) had not only introduced his mirror speaking instrument, but was taking a more active part in the electrical arrangements generally. There is something peculiarly life-like in the mirror apparatus on the table before you; and it proved the turning point in ocean telegraphy, both as regards signalling and testing, though now superseded by the "Recorder" for the former purpose. I am sorry there is not time for dealing with it except after my lecture.[1]

Then, again, at this stage in the history of submarine telegraphy, the improvements in manufacture, due to experience, were altogether encouraging.

The larger sized core meant a larger sized cable—the cable I hold in my hand—and this would not have got into any other vessel than the "Great Eastern," which, as it chanced, happened to be available

In the 1865 cable, several faults occurred; and it was feared they were produced intentionally by people on board sticking pins, or iron wire, through the gutta percha. They watched the tanks, but still the faults occurred, and while attempting to haul the cable back to repair a fault, the cable snapped, after 1,186 miles had been laid. For nine days they made strenuous efforts to pick up the cable; but though they grappled it many times, the rope broke, and thus the 1865 cable had to be abandoned. A new cable like that of 1865 was then made by the Telegraph Construction and Maintenance Company. This Company contributed £100,000, and undertook to make and lay the cable for half-a-million of money, whether it was successful or not, this sum to be increased to £600,000 if it were successful, and to £737,000 if they could also pick up and complete the 1865 cable. So three-quarters of a million of money was the prize;

[1] Since this lecture was delivered we have had to mourn the death of Lord Kelvin. One of the most remarkable features of his great career—that of pursuing an invention, entirely himself, up to the point of practical application—was strikingly brought out in connection with his cable signalling apparatus.

and it was won. Nowadays the prize would be only half-a-million for a cable giving, of course, far better results.

This new cable, after a few further misfortunes, was eventually laid. From an engineering standpoint, however, this was really work that had already been effected 8 years previously, with about the same number of misfortunes, though with no applicable experience to go upon. The work to come—that of recovering the 1865 cable—was, indeed, the matter of the moment.

For thirteen days they alternately hooked and lost the cable. Once they brought it to the surface; but it slipped away from them like a great eel. On lowering the grapnel, however, for the thirtieth time they succeeded—thanks mainly to Mr. (Sir Samuel) Canning, the engineer to the contractors; and thus, two good cables were laid between England and America.

On this expedition a remarkable incident occurred—that of the "Great Eastern" whilst in the act of picking up the cable, bumping against the very mark buoy put down to indicate the supposed line of the cable. This was, indeed, a striking suggestion of accurate navigation! For it we were indebted to the late Captain Henry Moriarty, R.N., who was lent by the Admiralty as Navigator.

I am sorry that I cannot show you the machine which ultimately succeeded in picking up a cable at a depth of 3 miles for the first time. This was the great achievement in regard to the second and third Atlantic cables; and with reference to this machine, *The Times* representative on board (the late Sir William Howard Russell), said:—"So delicately did she coil in the film of thread-like cable that she put one in mind of an elephant taking up a straw in its proboscis."

Other cables to the East and Far East followed in more or less rapid succession; and these, thanks to the commercial foresight and enterprise of men like the late Sir John Pender, have all proved a lasting success.

The accompanying map shows all the cables laid up to date. You will see that there are now as many as sixteen cables across the North Atlantic and several different routes to various Eastern points. You will observe further the much-discussed All-British Pacific cable to Australasia, and also the more recent American Pacific cable to Japan. Both these run over depths of 4 miles; and just as the first Atlantic cable was considered at the time a wild freak of people that were to be pitied, so also the first Pacific cable was similarly spoken of by some, mainly on account of the great length—3,458 nautical miles—of one of the sections. It was, however, laid almost without a hitch, and will no doubt serve an increasingly useful purpose.

In the present day, cables have no history. Happy is the cable without a history! It must not, however, be supposed from this that we do not have occasional minor mishaps nowadays. Even though our materials are so vastly superior to what the pioneers had at hand, there are still the usual eventualities, many of which—as we have seen—are scarcely under control; and there comes a time for all cables, when the iron wires are too decayed to permit of profitable repairs, bearing in mind the fact that a repairing expedition often costs as much as £200 a day. Most of these cables have been manufactured on the banks of the Thames—in the neighbourhood of Greenwich and Woolwich—this being the only branch of engineering enterprise that remains almost entirely British.

On the wall you will observe certain approximate data that may be of interest. As with other branches of the subject, I could well spend an afternoon in discussing the social, political, diplomatic, and strategic value of cables; and it is in the latter respect—added to that of Imperial unity—that the All-British Pacific cable may some day prove of inestimable value to the nation.

Personally, I am not one of those who believe in the early consignment of cables to the region of antiquarian museums, though having great faith in the utility of wireless telegraphy for all maritime purposes, and as a helpmate to our cable systems. Certainly, so far, there are no signs of cables being replaced by wireless telegraphy when further means of communication are required. Only a few weeks ago, whilst in Egypt, I read the record of a meeting in which the chairman of a well known cable making company stated that "Marconi had done away with the manufacture of telegraph cables." I also, by the same mail, received news that the three large cable works were particularly busy with submarine cable orders just received for various parts of the world; and, perhaps, it should be added that on enquiry I was informed on good authority that the chairman in question never expressed what he was reported to have said. As a matter of fact, some 85,000 miles of cable have been made and laid since the Marconi Company was established, ten years ago—nearly five times as much, indeed, as was made and laid during the ten previous years. Whilst I am a great believer in the future of wireless telegraphy as an aid to cables for the purpose of telegraphic communication—mainly in directions where cables are ineffective—I do not think that the wireless telegraphy that we know of at present will ever actually replace telegraphy by cables.

Though I have not been able to make and lay a cable for the purposes of this meeting, I have brought here a number of specimens of cables which have done or are still doing, good service in various parts of the world; and I may, perhaps, mention the fact that the first message sent on this cable—the first cable to India—announced your lecturer's entry into the world. But a specimen of more material interest is this one of the Atlantic Cable of 1874, which was picked up for repairs five years ago from a depth of 2,164 fathoms, and is still in splendid condition.

I am also able to show you here the electrical equivalent of a cable being worked through in precisely the same way that messages are sent through trans-Atlantic and other lines.

APPROXIMATE STATISTICS.

Total length of cable laid—257,000 miles.
Total cost of cable laid—£52,000,000.
Cost per mile, construction and laying—£200.
Useful life of a cable—30 to 40 years.
Messages conveyed by cable per annum—6,000,000.
Messages conveyed by cable per day—15,000.
Maximum working speed by cable—100 words per minute.
Percentage of code and cypher messages—90 per cent.
Maximum cable tariff—To Accra (Africa), 7s. per word.

Minimum cable tariff outside the Inland Post Office Telegraph System—By Government cables, to the Continent, 2d. a word. By Companies' cables, to United States or Canada, 1s. per word (originally £1).